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Processpatching

Defining New Methods in aRt&D

By Anne Nigten
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SMARTlab Programme in Performative New Media Arts
Central Saint Martins College of Art & Design
University of the Arts, London

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Abstract

In the context of a rapidly changing domain of contemporary electronic art practice- where the speed of technological innovation and the topicality of art 'process as research' methods are both under constant revision- the process of collaboration between art, computer science and engineering is an important addition to existing 'R&D'. Scholarly as well as practical exploration of artistic methods, viewed in relation to the field of new technology, can be seen to enable and foster innovation in both the conceptualisation and practice of the electronic arts. At the same time, citing new media art in the context of technological innovation brings a mix of scientific and engineering issues to the fore and thereby demands an extended functionality that may lead to R&D, as technology attempts to take account of aesthetic and social considerations in its re-development. This new field of new media or electronic art R&D is different from research and development aimed at practical applications of new technologies as we see them in everyday life. A next step for Research and Development in Art (aRt&D) is a formalisation of the associated work methods, as an essential ingredient for interdisciplinary collaboration.

This study investigates how electronic art patches together processes and methods from the arts, engineering and computer science environments. It provides a framework describing the electronic art methods to improve collaboration by informing others about one's artistic research and development approach. This investigation is positioned in the electronic art laboratory where new alliances with other disciplines are established. It

provides information about the practical and theoretical aspects of the research and development processes of artists.

The investigation addresses fundamental questions about the 'research and development methods' (discussed and defined at length in these pages), of artists who are involved in interdisciplinary collaborations amongst and between the fields of Art, Computer Science, and Engineering. The breadth of the fields studied necessarily forced a tight focus on specific issues in the literature, addressed herein through a series of focused case studies which demonstrate the points of synergy and divergence between the fields of artistic research and development, in a wider art&D' context. The artistic methods proposed in this research include references from a broad set of fields (e.g. Technology, Media Arts, Theatre and Performance, Systems Theories, the Humanities, and Design Practice) relevant to and intrinsically intertwined with this project and its placement in an interdisciplinary knowledge domain.

The aRt&D Matrix provides a complete overview of the observed research and development methods in electronic arts, including references to related disciplines and methods from other fields.

The new Matrix developed and offered in this thesis also provides an instrument for analysing the interdisciplinary collaboration process that exclusively reflects the information we need for the overview of the team constellation. The tool is used to inform the collaborators about the backgrounds of the other participants and thus about the expected methods and approaches. It provides a map of the bodies of knowledge and expertise represented in any given cross-disciplinary team, and thus aims to lay the groundwork for a future aRt&D framework of use to future scholars and practitioners alike.

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Table of contents

Abstract 1
Acknowledgments 4
Table of contents 6
List of illustrations 10
Preface 14
Chapter 1. 16
ARt&D; the *processpatching* context 16
1.1. Motivation 21
1.2. Scope 23
1.3. Thesis and research questions 26
1.4. Approach and methodology 28
1.4.1. Instrument for analysing the collaborative process 29
1.5. Contribution to the field 31
1.6. Structure of the thesis 34
Chapter 2. Profiles of disciplines and aRt&D methods 36
2.1. Artists are Wild Thinkers and god is a mathematician 39
2.1.1. Artists as problem solvers 41
2.1.1.1. Solving scientific problems 42
2.1.1.2. Solving social problems 53
2.1.1.3. Solving technical problems 57
2.1.2. Collaboration aspects artist as problem solver 63
2.1.3. Conclusion artists are Wild Thinkers and god is a mathematician 65
2.2. Artistic research and development methods 68
2.2.1. Related methods 69
2.2.2. aRt&D methods 75
2.2.3. 80
Problem solving or tunnelled approach: reductive method 80
2.2.3.1. Problem solving: Art context 81
2.2.3.1.1. Artist as inventors of new technology 82
2.2.3.2. Problem solving: Interdisciplinary context 86
2.2.3.3. 90
Problem solving: Science, technology and design context 90
2.2.3.4. Problem solving: conclusion 92
2.2.4. Confronting motives; the DIY method 94
2.2.4.1. Confronting motives: Art context 95
2.2.4.2. Confronting motives: Science, technology and design context 100

2.2.4.3. Confronting motives: conclusion 101
2.2.5. Connecting approach; *processpatching* method 103
2.2.5.1. Connecting approach: Art-context 110
2.2.5.1.1. Artistic innovation 113
2.2.5.2. Connecting approach: Interdisciplinary context 119
2.2.5.3. Connecting approach: Science, technology and design context 122
2.2.5.4. Connecting approach: conclusion 124
2.2.6. Examples of methods for connecting and *processpatching* 126
2.2.6.1. Connecting and *processpatching* methods: 126
Interaction and participatory design 126
2.2.6.2. *Processpatching* methods: improvisation 133
2.2.6.3 *Processpatching* techniques: algorithmic design 135
2.2.6.4. Connecting approach : FLOSS 137
2.2.6.5 *Processpatching* models 139
2.2.6.6. Third space 140
2.2.6.7. Conclusion *processpatching*, methods, techniques and models 147
2.2.7. Relevant themes for artistic Research and Development 148
2.2.7.1 User interfaces 148
2.2.7.2. Knowledge representation 152
2.2.7.3. Conclusion: connecting and *processpatching* themes 157
2.2.8. Conclusion: artistic Research and Development methods 158
Chapter 3. Case studies 165
3.1. Case studies : Artworks 167
3.1.1. Description of the *'M.U.S.H.'* project 171
3.1.1.2. Background of the team members of *'M.U.S.H.'* 175
3.1.1.3. *'M.U.S.H.'* : Methods 176
3.1.2.1 Background of the team members of *'whisper'* 185
3.1.2.2. *'whisper'* : Methods 187
3.1.3 case study 'Kurort' 193
3.1.3.1. Background of the team members *'Kurort'* 196
3.1.3.2. *'Kurort'*: Methods 197
3.2. Case studies: seminars, symposia and panel discussions 202
3.2.1. Case study *Anarchives: Connection-machines* 203
3.2.2 Case study: *Data Perception* 213
3.2.3 Case study: *Wearable Turbulence* 225
3.3. Case studies workshops 231
3.3.1.1. Method and approaches 235
3.3.1.2. Disciplinary background of the workshop participants 236

3.3.1.3. Outcome and interviews 238
3.3.2. Case study: ~worn~ 242
3.3.2.1. Disciplinary background of the participants 243
3.3.2.2. Method and approach 244
3.3.2.3. Artistic methodology 245
3.3.2.4. Outcomes 246
3.4. Conclusion case studies 248
3.4.1. Stereotypes 249
3.4.2. Outcome of the aRt&D Triangles 250
3.4.3.Outcome of the aRt&D Matrix 253
3.4.4. Co-relation aRt&D Triangles and Matrix 257
Chapter 4. Overall conclusion 263
4.1. Stereotypes 265
4.1.1. Artists as problem solvers 265
4.1.2. DIY artists 266
4.1.3. Artists as *Processpatchers* 266
4.1.4. Mixed methods 268
4.2. The artistic research and development methods 268
4.2.1. Problem solving, reductive method 269
4.2.1.1 Scientific problems 271
4.2.1.2. Social problems 273
4.2.1.3 Technical problems 274
4.2.1.4 Artist as inventor of new technology 276
4.2.1.5 Problem solving: collaboration model and domain 277
4.2.2 Self-sufficient approach: DIY method 279
4.2.2.1 Hacking and re-engineering 282
4.2.2.2. Self-sufficient approach: collaboration model and domain 283
4.2.3 Connecting and re-contextualising, the *processpatching* method 285
4.2.3.1. Relevant design disciplines 289
4.2.3.1.1. Participatory design 289
4.2.3.1.2. User-centred design 290
4.2.3.1.3. Third space and boundary object 291
4.2.3.2. *Processpatching* collaboration models and domain 292
4.3. aRt&D Methods overview 294
4.3.1. Supporting tools and instruments for '*processpatching*' 297
4.4. Future work 300
4.4.1. Recommendations for policymakers 302
5. References 303

260. " 319
6. Bibliography 321
6.1. Printed literature 321
6.2. Material on the Web 325
6.2.1. V2_ Institute for the Unstable Media 325
6.2.2. Literature studies 325
6.2.3. Case studies 327
6.2.4. Software 328
6.2.5. Related institutes and initiatives 328
7. Appendix 1. 331
Accompanying material for the case studies 331
7.1. Reader *Anarchives: Connection Machines* (part of) 331
7.1.1. '*The Sleeping Giant*' by Arnold Smeulders 334
7.1.2. '*The semantic gap*' by Ben Schouten 346
7.1.3. Report on *Anarchives: Connection-Machines* by Sandra Fauconnier 349
7.2. *Data Perception* reader (part of) 354
7.2.1. An introduction on *Data Perception* by Julie Tolmie 361
7.2.2. *Data Perception* Day schedule 364
7.2.3. Presentation by Sheelagh Carpendale 364
7.2.4. Presentation by Ben Schouten 365
7.2.5. Presentation by Zoltán Szegedy-Maszák and Fernezelyi Márton 366
7.2.6. Presentation by Brigit Lichtenegger 369
7.2.7. Report on *Data Perception* by Rens Frommé 378
7.3. Description of the *MediaKnitting* workshop 382
7.4. Affective systems reader (part of) 384
7.4.1. Presentation by Phoebe Sengers 385
7.5. *Wearable Turbulence* reader (part of) 390
7.5.1. Christa Sommerer & Laurent Mignonneau 392
7.5.2. Tom Donaldson 395
7.5.3. Kristina Andersen 397
7.5.4. Report on *Wearable Turbulence* by Remco La Rivière 400
8. Appendix 2. 403
8.1. DVD DEAF03 403
8.2. DVD DEAF04 403

List of illustrations

Fig.1.
Maxwell ARD triangle, and copy with remarks[3]
Fig. 2.
Matrix by Rich Gold, source dot-font: '*Reading into the Future*'[4]
Fig. 3.
Rich Gold's Matrix with comments by A.Nigten
Fig.4.
Variations of Gold's matrix by A. Nigten
Fig.5.
aRt&D Matrix part 1: artistic methods and matches
Fig.6.
aRt&D Matrix: Reductive method
Fig.7.
aRt&D Matrix: DIY method
Fig.8.
Screenshot from '*Patchwork girl*' by Shelley Jackson[5]
Fig.9.
aRt&D Matrix: *processpatching* method
Fig.10.
aRt&D Matrix: *processpatching* method part 2
Fig.11.
aRt&D Matrix: *processpatching* method part 3
Fig 12.
Transdisciplinary Model, '*Beyond Productivity*' Somerville, Rapport[6]
Fig.13.
Multi disciplinary Model, '*Beyond Productivity*' Somerville, Rapport[7]
Fig. 14.
Collaboration model ATR-MIC by Ryohei Nakatsu [8]
Fig.15.
Discipline view of the space between the disciplines, A. Nigten
Fig.16.
aRt&D Matrix: user centred model
Fig.17.
aRt&D Matrix: methods and roles
Fig.18.

aRt&D Matrix: methods used in *'M.U.S.H.'*

Fig.19.

aRt&D Matrix: methods used in *'whisper'*

Fig.20.

aRt&D Matrix: methods used in *'Kurort'*

Fig.21.

aRt&D Matrix: methods from presentation by Smeulders

Fig.22

aRt&D Matrix: methods from presentation by Pelhan

Fig.23.

aRt&D Matrix: methods from presentation by Carpendale

Fig.24.

aRt&D Matrix: methods from presentation by Lichtenegger

Fig.25.

aRt&D Matrix: methods from presentation by Fernelezelyi and Maszák

Fig.26.

aRt&D Matrix: methods from presentation by Schouten

Fig.27.

aRt&D Matrix: methods from presentation by Tolmie

Fig.28.

aRt&D Matrix: methods from *Wearable Turbulence* presentations

Fig.29.

aRt&D Matrix: methods from workshop *Media Knitting*

Fig.30.

aRt&d Matrix: methods from *'~worn'~*

Fig.31.

Adjusted aRt&D Matrix overview

Fig.32.

aRt&D Matrix: reductive method

Fig.33.

aRt&D Matrix: DIY method

Fig.34.

aRt&D Matrix: *processpatching* method

Fig.35.

aRt&D Matrix final overview

Fig.36.

aRt&D Triangle

This thesis contains various illustrations of the case studies. I've patched together impressions and overviews and in some occasions it was hard to trace the original owners or makers of the visual material. It has been my intention to fully credit everyone, however, if I have overlooked anybody's work or contribution I do sincerely apologise for this.

Collage 1.

Impressions of case study *'M.U.S.H.'* visuals by Montessius, Hellio

Collage 2.

aRt&D Triangle *'M.U.S.H.'*

Collage 3.

Impressions of case study *'whisper'*, photos by Sprij, visual material by *'whisper'* team

Collage 4.

aRt&D Triangle *'whisper'*

Collage 5.

Impressions of case study *'Kurort'*, photos by Sprij, visual material by *'Kurort'* team

Collage 6.

aRt&D Triangle *'Kurort'*

Collage 7.

Impressions of case study *Anarchives: Connection Machines*, photos by Sprij

Collage 8.

Impressions of case study *Data Perception*, photos by Sprij

Collage 9.

Impressions of case study *Media Knitting*

Collage 10.

aRt&D Triangle *Media Knitting*

Collage 11.

Impressions of case study *'~worn~'*, visual material by *'~worn~'* participants

Collage 12.

aRt&D Triangle *'~worn~'*

Preface

During my professional career, my work has slowly changed from practising media art towards an art and technology management practice via a combined profession of media art, management and technical facilitation. This slight detour provided me with the required knowledge for today's media, or electronic, art practice. A media art laboratory manager is a mediator, someone who needs to be able to communicate with collaborators and professional partners with very different backgrounds, intentions, objectives and work methods. Although this can sometimes be a tedious process, it is rewarding if one is able to establish enriching and unforeseen connections. This paradigm in the interactive and electronic arts offers opportunities to critique, develop and connect with other movements and developments in society.

At first, this PhD research was considered as a practice-based research in the most common way: one part would be the artwork and the other part theory. This was problematic for me, since I felt that it would be ethically incorrect to appropriate the artistic, technical and scientific work of others and label this as my 'artwork'. However, my daily practice consists of working together with artists. Therefore, my study interprets 'practice-based research' as a full theoretical research informed through my daily practice. The positive outcome of this is this dissertation: a detailed study where one can find connections to improve one's practice. I offer this PhD as a resource and possible future publication to share the experience of this research with the scholarly and practical media art communities, in the hope that it may help to foster new methods in future team working amongst artists, technicians and (computer) scientists.

Chapter 1.
ARt&D; the *processpatching* context

> *... What distinguishes electronic art is, on the one hand, that it works mainly with mechanical, electronic and digital technologies and means of communication, and, on the other, that it is always made in collaborations in which the contributions of scientists and technicians (hard- and software engineers) are as great as those of the artists who supply the ideas, concepts and in particular the motivations.*
> *(Brouwer, Fauconnier, Mulder, Nigten)*[9]

Electronic art is positioned in both art and technology contexts. As such, collaboration is a crucial aspect of today's electronic art practice. Electronic art patches together elements from the arts, engineering and computer science environments. This investigation positions itself in the electronic art laboratory and provides information about the research and development process of the artists in the collaborative context. Evidently, it takes the full research and development process into account.

Last century's media technology and the arts show that there are several examples for understanding artistic research as material exploration, examples can be found in the fields of photography, film, kinetic art, machine art, video, and, more recently, digital media. The art discourse dealing with new forms of art stems mainly from theoretical disciplines, which analyse the produced content, for example, media theory, cultural studies and critical theory. The observed shift from product or object towards process or experience as the outcome of interactive or mediated artworks has led recently to new directions in the critical discourse (Quinz et al).[10] To date, however, art discourse has paid little attention to reflect upon the research and development process of technology-based art and the artistic consequences of the collaborative aspects. The discourse dealing with the research and development process or the making of interdisciplinary art and technology practice is nearly absent in today's knowledge resources. This is a major problem for the contemporary artist who plans to work with technology; in particular those who intend to collaborate in the research and development process with other disciplines. This absence of knowledge can be traced back to the 1960s when technology was incorporated into the creation process of the artwork, which introduced new alliances for the artists and re-orientation for the art (Bijvoet).[11] This caused a gap between theory and practice, which has been a major obstacle for the establishment and education of electronic art . The critics and artists even used two different description reference sets: the art critics characterised media art in this era as chance and random, while the artists involved used terms borrowed from system theory to describe media art. These terms were far removed from the terminology used in art criticism and art history. Bijvoet repeats Walter Benjamin's [12] observation that the established art sector in the beginning of the last century was resistant to technology-driven innovation in the arts. Technologically mediated art forms, such as photography or film, opened up new worldviews in avant-garde that were opposed to established art institutions. However, the effect of technology in today's art practice stretches beyond the art establishment as it includes engaged collaboration among practitioners from various disciplines. In this respect, Guattari and

Deleuze[13] suggest that the artist is particularly well equipped to conceptualise the necessary steps for this interdisciplinary work because, unlike engineers, s/he is not tied to a particular program or plan for a product, and can change the course of a project at any point if an unexpected event or accident intrudes. I take Guattari and Deleuze's vision and investigate how this works in today's interdisciplinary art practice, for example, in relation to how the improvised artistic approach works in interdisciplinary teams.

Today's interdisciplinary collaborators create a zone between existing disciplines; a conceptual space between existing knowledge domains. This conceptual zone in between the disciplines is identified as a potential zone for innovation in the arts. For this zone or space between the disciplines I use the term *transvergence* as introduced by Marcos Novak.[14] This space serves as an 'artistic interface', providing space for cross-disciplinary experiments.[15] Currently interdisciplinary projects often become a technical challenge; the artists involved in these projects act as pioneers without acknowledging their own professional expertise. One of the goals of this research is to propose models for this collaboration in order to improve collaboration in this emerging space between the domains. It is important to state that the artistic motivation to engage with technology does not necessarily require collaboration. The artists who dive deep into the materials, the medium or matter themselves are also main catalysts for innovation in the arts. This DIY attitude and explorative research differs from single discipline oriented persons who look for collaborators to assist them (Somerville and Rapport).[16] As a continuation of the research by

Somerville and Rapport, my research unravels the differences between multi- and interdisciplinary collaborations through the motivation, objectives and background of the participants. Art history and art criticism mostly focus on a homogeneous artistic profession, where the artist works individually or with other artists. Recently the practice of art-making has shifted from an individual or homogeneous art practice towards a team practice with different backgrounds. This research focuses on the growing interdisciplinary and multidisciplinary collaboration areas, where the outspoken and analysed art methods form the basis for collaboration among team members with different backgrounds. The relevance of existing tools, concepts and knowledge from other disciplines are investigated in relation to how they support the collaboration process. In particular, anthropology, theatre and design practice bring forward relevant concepts to balance the disciplinary boundaries. In particular the boundary object[17] and third space concept (objects, materials, a vocabulary, etc. that help participants with different backgrounds to build a shared understanding) turn out to be relevant as enabling concepts for those who work in the *transvergence zone*.

I investigate the artistic research and development methods applied to different genres of electronic art through closer examination of several recurring motivations and attitudes towards technology. Based on literature and field studies, I identify a main category for multidisciplinary collaboration, one for independent and multi-professional practice and one category for interdisciplinary collaboration. All three categories comprise a collection of related methods and approaches. The three main methodological categories are: the multidisciplinary problem solving or the reductive method, the self sufficient or DIY method, and the interdisciplinary connecting and re-contextualising approach or Processpatching method. These are compared with methods from other disciplines and the outcome is connected again with the existing theoretical framework. This discourse is, just as electronic art itself, a patchwork of concepts and theories from a variety of expert fields. This explains why my research moves through time, technological disciplines and artistic disciplines, where each area is investigated for its relevant discourse and knowledge. The historical reference of this investigation goes back to the techno-mediated art forms, starting with film, kinetic- and machine art as precursors to contemporary digital art, and from there I move to the audiovisual and multimedia branches. This research investigates the missing facets in current art history about electronic art, which are crucial for the research and development process and the making of electronic art in interdisciplinary teams.

There are several useful resources from other eras in the arts that are used as a reference. For example, the handbooks and educational material by Walter Gropius and others are used as a reference to the Bauhaus[18] methodology. Theoretical studies on art and technology are used to compare different attitudes or parallels in time. A key aspect of this investigation into electronic art research and development methods is the development of the medium itself, its social acceptance, and cultural embedding. While other related artistic or cultural practices provide useful ideas, my focus is on electronic art and its specific workflow with respect to team working.

1.1. Motivation

> *'As new technologies come into play, people are less and less convinced of the importance of self-expression.* Teamwork *succeeds private effort. '*
> *(M. McLuhan)* [19]

Marshall McLuhan's prediction stems from the late 1960s and was put into practice during recent decades. This investigation illustrates that the growing importance of heterogeneous teamwork demands a clear profile and critical, analytical models for artistic contribution to flourish. This research is motivated by the need for improving team work in an artistic context. The required models demand novel approaches, as the resources needed to build appropriate models of artistic collaborative practice engaged with digital technologies do not exist in the fields of visual art history and critical theory.

The urgency of this research is driven by the considerable gap in the literature dealing with the motivation and expectations of collaboration from an artistic point of view. This is illustrated on a daily basis in my role as media-laboratory manager at the V2_ institute for the unstable media[20] in Rotterdam (NL). In the V2_Lab, artists, engineers and scientists work together on research and development of software and hardware for art and technological projects. In 1998, I introduced the term aRt&D (research and development in art) to indicate the difference between existing and familiar R&D (Research and Development) in industry and science laboratories. Art research is distinguished from scientific and technological research by the fact that it is itself a form of reflection and not a means of reflection and theory formation (scientific research) nor problem solving (technological research).[21] In a general sense, most R&D methods in industry and applied science focus on optimising measurable processes or product improvement, and work with clearly outlined targets. However, in artistic research and development, the evaluation criteria are less clearly defined and there are no unique standard for measurement. In that sense, the aRt&D process resembles some aspects of basic scientific research. While, different from basic research, aRt&D delivers working prototypes,, processes or experiences. The collaboration between computer science, engineering and art thus represents a layer of diversity and new combinations, and is therefore worthwhile exploring in addition to existing R&D. Artistic exploration of new technologies fosters innovation in the arts, and art concepts often impose demands of functionality that may lead to further R&D. Artistic research and development, although informed by technological and (computer) scientific R&D, has neither the technological or (computer) scientific tradition nor its burdens and constraints. This, however, should not be used as an excuse to mystify artistic research and development, as that generates frustrations and unintended misunderstandings among collaborators. In the arts, unlike other disciplines, clearly defined ways of working are often perceived as a limiting factor for the artistic process, or even endanger the traditionally glorified mysterious art making process. As a provocation, I therefore have deliberately decided to refer to the artistic work approaches as 'methods'; I intend to break with the old tradition and to raise awareness of the importance of verbalising one's principles of practice. Note that I use the term 'method' according to its most common meaning: a particular way of doing something. Unlike the used strictness of methods seen in other disciplines such as science, I use a wide interpretation of the term 'method' that allows for multiple interpretations, and provides enough freedom to support the artistic process and to liberate artists from the sometimes limiting and vague romantic approach. This aim is motivated by the need for artists to communicate their research and creation process, in order to experience the benefit of a raised artist's profile in interdisciplinary collaborations. This research deals with the challenge in defining an artistic method, without its limiting factors, to encourage dialogue among team members and to provide a framework of reference. The provided artistic methods are tools for support and evaluation of the artistic contribution in the interdisciplinary or multidisciplinary work processes, and thus differ from the evaluation process of the artwork itself.

1.2. Scope

This research is positioned in an interdisciplinary field where all collaborators involved bring along potentially relevant reference material. I limit the focus to software and hardware programming, computer science, software, and hardware based electronic art because these particular areas provide appropriate and accessible in-depth investigation opportunities.

Note that there is no intention to ignore the established art field, nor the historic roots of the relevant art practices discussed in this investigation.

This research focuses on the intrinsic value of electronic arts in interdisciplinary collaboration. Most literature available on the topic focuses on (partial) migration of the arts to academic or scientific environments. On some occasions this might be the appropriate route, as reflected in the observed 'problem solving' approach where experts are called in for their domain-specific knowledge. In my vision, however, the intrinsic value of electronic art research and development deserves more attention as it often does not fit into existing traditional scientific or academic structures. Stephen Wilson's[22] studies show us that this often leads to artists who have to behave like scientists in disguise. I build on Wilson's ideas, and introduce an additional model where artists are assimilated into the academic environment. I investigate the different attitudes and the interrelated implications for collaboration, which do not necessarily lead towards integration. Well-orchestrated collisions among the collaborators and self-supportive multitasking are also considered as interesting features for the arts and academia. Intended collisions are often observed in the self-sufficient approach or DIY method, which is associated with the engaged artist or cultural activist.

This investigation takes the lead in proposing a practice-based theory for electronic art research and development methods. I draw from artistic material research approaches from the 21st century and the experiments of artists in extending their practice and working in a mixed field combining art, engineering and/or computer science. I build the analyses of artistic research approaches not only on references to artistic and cultural practice, but also on references to engineering, design and science. Relevant approaches in science and technology in the area of software and hardware development and electronic arts are compared and investigated for their suitability. In particular, the potential relevance for improving the collaboration is taken into account. The research and development areas bordering this investigation belong to a range of disciplines. These bordering areas are especially relevant for the overarching electronic art method: Processpatching. Processpatching reflects the intrinsic artistic practice of connecting remote fields and re-contextualising techniques. Several shared fields of interest amongst computer scientists and electronic artists are identified, mostly in the areas of cognitive science, interface design, human-machine interaction, wearable technology and visualisation science. These shared interest fields offer space for different types of research and development approaches, as they are not yet fully shaped. These themes are common ground for shared experiments and knowledge building among the involved disciplines. The key areas are highlighted and analysed for their potential for mixed research in literature and case studies. These fields have a strong emphasis on the interaction between technology and the user or participant. The research themes require a constant interplay between technology-oriented and user-oriented research and development, which often requires different types of expertise. The collaborator's motivation to engage in interdisciplinary collaboration with other disciplines in these specific research themes is in part brought forward by the limitations of current technology, which is an invitation for a balanced collaboration.

The proposed artistic methods were compared and measured by the most significant twenty-first century scientific or science studies dealing with research and/or development methods. Most important references for this inventory of science and science studies were provided by Thomas Kuhn[23], Karl Popper[24], Paul Feyerabend[25], Bruno Latour[26] and B.K. Ridley[27]. Among the selected resources from art and cultural studies are C.P. Snow[28], Mika Hannula, Juha Suoranta, Tere Vaden[29] and Peter Lunenfeld[30]. Stephan Wilson[31], From an art-science background, Peter Weibel provides the most closely related theory, which takes the intrinsic value of the arts into account with respect to explicit methods.[32] Marga Bijvoet[33], Christa Sommerer and Laurent Mignonneau[34] provide some of the other scarce resources on collaboration in art, science and technology.

1.3. Thesis and research questions

This research is built on the following thesis:

> *Today's electronic art practice, realised in an interdisciplinary and multidisciplinary collaboration context, demands an upgrade of the artist's profile. The status of the artistic contribution will benefit from newly defined intrinsic artistic research and development methods. A reference framework is needed as a support tool for this upgrade and this will also contribute to the discourse of art-making.*

This thesis leads to the following research questions:

> *What is/are the most sufficient and appropriate research and development method(s) for artists working in art, technology and computer science collaborations?*

And related to this:

> *What are the most useful and appropriate methods and concepts from other knowledge fields for collaboration among artists, engineers and computer scientists?*

The thesis above illustrates the unsettled position of the artists in multi- and interdisciplinary collaboration teams. Artists are used to appropriating and patching together knowledge, processes, materials and techniques while often this practice is unfamiliar to their collaborators from other disciplines. The thesis also illustrates the need for the artists to liberate themselves, and manifest themselves more clearly in non-artistic contexts. Boldly stated, art criticism and reflective media and cultural studies to date do not provide information about the major, important aspects of making (researching and developing) electronic art in collaborative interdisciplinary teams. Because of this, we need to know IF and HOW artists work with technology, which approach they follow and whether it matches methods from other disciplines. The research questions of my investigation underline the importance of explicit and thorough analyses of working methods. In response to the above thesis, I argue that electronic artists, in order to be liberated, first need to be equipped with knowledge and skills to reflect upon their own methodology. From there, one is able to determine how these methods are applied in practice. This research investigates which situations require specific methods and which methods are relevant for each model. The two keys for successful interdisciplinary collaboration are the premise of this investigation: firstly, the establishment and articulation of one's own methods; secondly, the need for knowledge about the other's practice and field of expertise. This investigation proposes a set of artistic methods with sufficient space for the diversity of possible collaborators who work in the shared zones between the disciplines. This set of methods is built around the overarching, intrinsic artistic connecting and re-contextualising approach or Processpatching method. And this includes two frequently observed methods from other fields: the problem solving approach or reductive method, the self-sufficient approach or the DIY method,

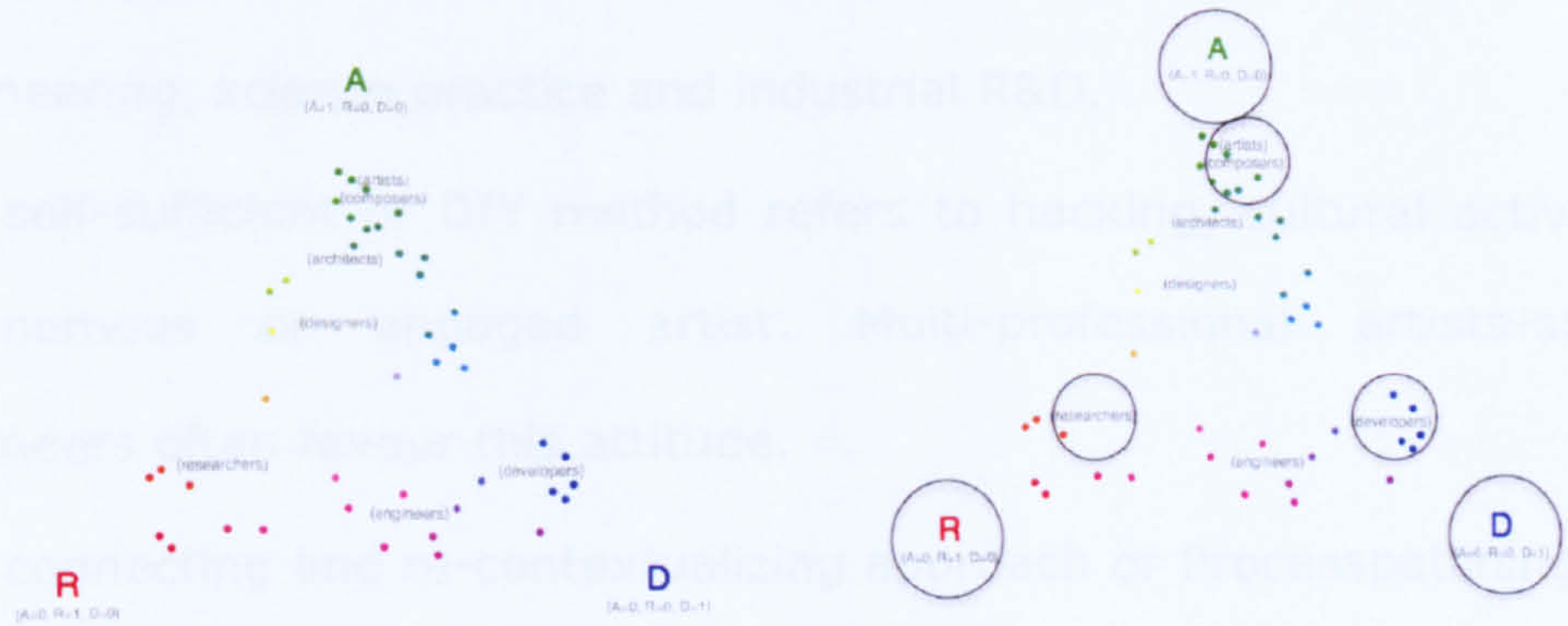
1.4. Approach and methodology

This research is based on literature studies and several case studies. These theoretical and practical components serve as material to study the work processes and the outcomes of the collaborative process.

The investigation addresses fundamental questions about the 'research and development methods' of the artists who are involved in interdisciplinary collaboration in art, computer science and/or engineering. Based on literature and the analysed case studies, the characteristics of artistic research and development are defined. The art methods proposed in this research include references from a broad field of formal methods and informal approaches (e.g. technology, media art, cybernetics, system theory, design practice, visual arts, theatre and music). In addition to the formal methods, I analyse the artistic research and development process of a range of artistic practices without formal research and development traditions. The literature about artistic research and development is complemented by an analysis of the collaborator's motivation, intentions and the expectations towards collaboration with other disciplines. I investigate the subject through comparative literature studies from different expert-fields. Stereotypes are categorised, compared and reality checked via literature from the arts and case studies. In the case studies, practice and reflections about this practice are intertwined. In addition to the research and development of electronic art works, the involved artists were encouraged to participate in dialogues and debates with representatives of other disciplines. Thus the case studies vary from debates and conferences to research and development of electronic art projects. The outline of each of the organised events included (one or some of) my research questions. While most case studies are carried out in the Netherlands, the research has an international scope through the diverse origins of the participants in the case studies.

1.4.1. Instrument for analysing the collaborative process

There are no blueprints for team composition in interdisciplinary collaboration, as these vary for each situation and each research and development objective. In order to understand the most suitable model for collaboration, a more generic approach is desired. Due to the lack of knowledge about (and thus terminology for) the artistic methods and models, a special instrument is needed for analysing the collaboration processes of the interdisciplinary teams. This research provides a tool to assist the team in the collaboration model selection process. The starting point of this tool is the Maxwell ARD triangle, which was designed as a collaborative effort by the co-editors of the aRt&D[35] book, initiated by Sandra Fauconnier.[36] This triangle refers to Maxwell's RGB triangle of additive colour mixing schemes, as is often used in audiovisual and media education. Maxwell's triangle was used as a metaphor for the RGB colours of monitors and electronic display systems as often used in electronic art . This triangle was used as a 2-dimensional notation system to provide information about the team composition of the artworks. The triangle visualised the notation rules, which described the person's role (Artistic, Research, and/or Development) and it simultaneously visualised the person's background (A - Humanities; including the arts; D - Natural; R - Social sciences).[37] The published version of the Maxwell ARD triangle (fig.1) mapped out two different things in the same diagram: the different roles as well as the background of the team members. For the purpose of this study, this approach might be misleading and/or confusing. There were too many ideas brought together in a single triangle. For this research, an instrument is needed which represents accurately the information we need for an overview of the team constellation. The metaphor of the colour mixing system will be left behind, and replaced by an aRt&D or α,β,γ triangle. The new tool is clear and useful in that it succeeds in informing the collaborators about each other's backgrounds (α,β,γ). It also visualises the distance between the knowledge domains represented by the collaborators. It indicates roles for possible mediators or multitaskers in the team and it indicates shared knowledge fields. It provides a clear map of the knowledge and expertise represented in the team, which is the basis for methodological decisions when starting a project.



(fig.1 Left: Maxwell ARD triangle Right: copy with marked double functions)

1.5. Contribution to the field

This research develops a model for (artistic) research and development methods. This research improves the way people work together in interdisciplinary teams, and it provides insights into the working methods to enhance the collaboration among all team members.

This research provides a reference framework, the aRt&D Matrix, where all investigated research and development methods in the electronic arts are listed and described in detail. This aRt&D Matrix serves as a reference framework for multi- and interdisciplinary collaborations and for self-sufficient multitaskers. The core of the aRt&D Matrix represents the three main categories of the most commonly observed methods in collaborative electronic arts.

The problem solving or reductive method relates directly to design, engineering, science practice and industrial R&D.

The self-sufficient or DIY method refers to hacking, cultural activism, the autonomous or engaged artist. Multi-professional artists-scientists-engineers often favour this attitude.

The connecting and re-contextualizing approach or Processpatching method is where different knowledge fields, materials and technologies are patched together, remixed or repurposed. This is the overarching intrinsic artistic method which links to user centred design, participatory design and often uses principles of third spaces and boundary objects to facilitate the conceptual or knowledge space between the disciplines. The other two methods are often integrated into the Processpatching method.

The aRt&D Matrix outlines the artistic aim, or objectives and its correlation with the preferred method. It gives information about the characteristics of all observed methods and their most commonly used team compositions. Each method is supplemented with practical information about the team composition and details about the observed pitfalls and advantages. Each method is complemented with references to related theory and the most frequently observed application domain and/or type of collaboration. For each artistic method, the matching methods from other disciplines are provided. The artistic aim, the artistic methods, the team composition, and the related methods from other disciplines in the art&D Matrix create the basis for multi- and interdisciplinary collaboration models. The aRt&D Matrix is a beneficial reference framework for the acknowledgement of the arts outside the art context, which emphasise the value of the artistic input in the interdisciplinary collaboration. The newly proposed term Processpatching as a placeholder for the artistic method, contributes to the emancipation of artists in interdisciplinary collaborations. It gives the artistic research and development process a name and positions it in a larger research and development context. This research provides an improved vocabulary to describe today's electronic art research and development practice. It raises the self-esteem for the electronic arts, which operates in a dynamic context outside the arts. It supplies the collaborators with an idiom to explain and discuss the possible work approaches from an art perspective, which contributes to the space and respect for the intrinsic value of art in multi- and interdisciplinary collaboration teams.

This research provides an improved and diagrammatic instrument, the aRt&D Triangle, for analysing the interdisciplinary collaboration process that exclusively reflects the information we need for an overview of the team constellation. The aRt&D Triangle is used to inform collaborators about the backgrounds of others and thus about the expected methods and approaches. It provides a clear map of the knowledge and expertise represented in the team. It also shows overlapping, or bordering backgrounds among team members, as well as the distance between the knowledge domains in the team.

This research contributes to the educational field of knowledge as it provides the basis for a toolkit and handbook for art and technology education. Future studies on this subject, as an extension of this research, should lead to an aRt&D handbook that deals with the uncovered practical details of implementing the *processpatching* method in practice. This study also provides a basis for further design of quality and evaluation criteria for practice-based master and/or doctoral studies of artists who work in multi or interdisciplinary teams.

1.6. Structure of the thesis

Chapter 2. explores the relevant literature and discusses the expectations from each discipline towards the others through the image and self-image of the involved disciplines. It deals with stereotypes and expectations from artistic, scientific, technical, design and social studies. It underlines the relevance of this study and investigates the differences between theory and practice. The expectations and imagined roles towards the other discipline(s) are compared and taken into account for their relevance to the artistic methods. Several re-occurring research themes are brought forward as indicators for future collaboration work. From there the methods from bordering disciplines, which are related to the suggested roles, are investigated. Based on the investigated roles of artists in multi and interdisciplinary collaborations, the first iteration of the aRt&D methods is drawn up in chapter two. In addition to the methods from related disciplines, the *processpatching* method is taken into account as a typical artistic method. Philosophical and art historical aspects are included in the investigation process into the roles for artists in the collaborative teams. From the literature chapter, the investigation moves to the case studies, where the outcomes from the literature studies (chapter two) are taken further as a reference for the investigation of the interdisciplinary practice. The case studies (chapter 3) provide feedback and add new elements to the literature studies based on the experience of the involved artists, engineers and scientists. The case studies provide the details for the electronic art methods, and serve as the main reference point in addition to literature. The case studies are the reality checkpoints for the results of the literature studies. The case studies also provide new insights and first person experiences. All sub-conclusions come together and provide the material for chapter 4; the overall conclusion. Here special attention is paid to the most significant artistic characteristics from the case studies. The overall conclusion ends with a set of recommendations for educators and policymakers.

Several texts from the case study's readers are bundled in appendix 1. Appendix 2 presents the multimedia material of the case studies.

Chapter 2. Profiles of disciplines and aRt&D methods

Our point of departure is an analysis of the friction between expectations and practice in collaborations in the field of interdisciplinary art, science and technology. The subject is analysed through mapping out stereotypical images from potential collaborators from the arts, science and engineering in twenty and 21st century literature and field studies. This chapter investigates firstly; the most commonly used and described stereotypes, from all disciplines involved. These stereotypes reflect the expectations and interests of the authors. These stereotyped images are compared to roles, objectives and methods used by artists. Comparative literature studies based on practice are used to describe the correlated research and development methods associated with the different stereotypes. The correlation between different kinds of collaboration strategies and types or genres of electronic art work is then analysed and compared with these of previously determined stereotypes. The methods have been determined by literature (if available) and examples from practice and theory.

I take the position that when one is able to communicate about one's expectations, objectives and method, collaboration becomes a less tedious operation. On these occasions, one cannot expect the involved partners to understand undefined expectations, objectives and methods. Otherwise, the collaborators cannot even consider a suitable artistic method for accomplishing their mission. This brings forward the risk of using other methods from remote disciplines, which do not match with the work process or aims or objectives. Often one observes a prevalence of technical or scientific methods being forced upon the artistic collaborators due to a lack of known artistic methods.

The stereotypes about the 'other' discipline(s) that occur most frequently in literature, and their accompanying preconceptions, are used as a reference for the expectations of potential collaborators. These assumptions are then compared with the artistic methods as described in practice-based literature.

This first half of chapter 2 continues with a selection of observations in literature based on practice by researchers from the art and science field. These observations add a nuance to the stereotypes as a presumed source for the confusion and it illustrates the effect of ignorance about each other's knowledge domains.

In addition to this, relevant methods from nearby disciplines are investigated for their relevance. From here several types of methods, which are applied in interdisciplinary practice, are proposed. These methods are thus based on field research, case studies and literature from other disciplines. The proposed methods will be double checked and compared with models and comparative studies of other authors from different backgrounds. The artist's objectives in contemporary interdisciplinary collaboration teams described in literature and observed in practice are taken as the guiding line for the proposed methods. Some overlap or connections with categories of methods and objectives proposed by other authors are observed through comparative studies on artistic approaches. In contrast to most of these studies, this investigation takes the intrinsic value of electronic art research and development as the main criterion for the selection of three categories of research and development: 'problem solving', a 'collisions' approach and a '*processpatching*' or 'connecting' approach. Problem solving refers to methods known from design and engineering; it is also referred to as a 'solution led' approach. The collisions approach refers to a self-sufficient or Do-It-Yourself method, which references cultural-activism and independent art practice. *Processpatching* or connecting consists of a plurality of methods not previously described as such. From here, the matches and mismatches between the expectations (stereotypes) and contemporary art practice become visible. The differences and misconceptions are shown in compared approaches and aims in the stereotypes (the assumed and theoretic roles) and the real art practice. The discussed approaches and methods are placed in a larger artistic context and include references to methods from the interdisciplinary context and nearby disciplines to complete the picture. The overview of the methods and approaches in the second part of this chapter also informs the reader about the frequently observed habit of artists to 'borrow' methods from nearby disciplines, which are re-appropriated for specific tasks or parts of their work. This *processpatching* art practice of re-appropriation and tagging together different methods and approaches, provides a framework to define a true artistic method that is clearly lacking in today's literature. This chapter on literature studies concludes with a reference-set and the characteristics of what I call the *processpatching* method, which will be investigated in detail in the case studies in chapter 3.

2.1. Artists are Wild Thinkers and god is a mathematician

This part of the investigation focuses on caricatures, stereotypes, self-images, and the motivation for collaboration, as these often reflect the expectations and motivation to engage in interdisciplinary collaborations. In publications about art, science and technology collaborations, stereotypical quotes hint at striking images of the other disciplines. In 'Beyond Productivity: Information Technology, Innovation, and Creativity', a publication where the potential of interdisciplinary collaborations are investigated, examples are given:

> *'Engineers often have little background knowledge in the arts, and look at the beauty of their 'problem solving' as art...'*[38]

In this publication, these turn out to be mild misunderstandings. The general conception and deeply rooted stereotypes are serious obstacles for collaboration. What should one think about this statement for example:

> *'Artists see science; they don't understand it; they think it is brilliant. Scientists see art; they don't understand it; they think it's dumb.'* [39]

These stereotypical ways of thinking seem to be common among artists who reflect upon scientists and engineers, and vice versa. In this chapter these kinds of stereotypes from literature are analysed to understand the image collaborators have of their collaborators from other disciplines, and what their self-image and wild assumptions are in interdisciplinary collaboration. It is often useful to stereotype the 'self' or the 'other' to make a clear point, bold statement or provocation, or to support one's main argument. However, it can also lead to a distorted idealistic image that is hard to ban from our memory. The shared interest in technology or technical tools draws artists towards computer scientists and engineers, but interestingly enough the image most scientists have about the arts has not been updated since the 19th century. The Enlightenment and the effects of the Cartesian divide between the analytic approach for science and philosophy research and the empiric approach for the arts is often disregarded. Also the more recent rigorous split between the arts and technical science as an effect of the specialisation in the 20th century industrial revolutions are often disregarded. This shows that a lack of knowledge and updated information about each other's fields works as a blindfold. The search for the Romantic artist is challenging in the context of today's 21st century art and technology practice.

Most literature sources relevant for this investigation use mixed forms to indicate professions, genres or disciplines: very outspoken specific, nuanced or precise descriptions on the one hand and very general stereotypes on the other, depending on the context, the argument and the targeted reader. Stereotypes reflect a common understanding and a sense of familiarity through the 'you know what I mean' feeling shared between the author and the reader. However, most authors and publications referred to in this section come up with clear statements on collaboration among artists, scientists and, to a lesser extent, engineers. Nevertheless, they are not so clear about which alien disciplinary branches they exactly refer to. For example, if one takes a look at 'the arts' in most scientific studies, are they referring to performing arts, visual arts, literature, music, media arts or ... ? And what is 'science' in the popular sense? Is this physics, mathematics, robotics, cognitive science or... ?

2.1.1. Artists as problem solvers

In the literature about interdisciplinary collaboration, or interdisciplinary exchange, there are several types of problem solving, from which three main categories are identified. These categories are based on the context of operation. All of these are defined from the perspective of the 'demanding' party; this is the person who is looking for a solution provided by an outsider. The first context of operation is the scientific community, in 2.1.1.1. Scientific Problems, are investigated. These scientific problems refer mostly to communication of science to society at large. These problems are mainly approached from a scientific point of view. Here a critical view is given to understand its effect on interdisciplinary collaboration and science's attitude towards art. This section is followed by Social Problems in 2.1.1.2. This is partly related to the scientific problems, though the problems, often effects of scientific, industrial and technology innovation, are manifested as unforeseen social issues. The last section, 2.1.1. 3., analyses solving technical problems. All three sections are interlinked; the last one however relates most to art practice and planned collaboration.

2.1.1.1. Solving scientific problems

Modern Western science is an established and self-sustaining scientific practice. Particular methods are in place for knowledge building and scientific progress. In spite of the positive aspects of the applied precision and detailed knowledge gathering, the scientific community experiences at irregular intervals a returning risk of isolation. The highly specialised, and thus totally zoomed-in researchers risk losing touch with society at large as mentioned in science studies such as Kuhn's 'Structure of Scientific Revolutions'.[40] The roots of this latent scientific communication problem can be explained through the reductive approach that is applied to building scientific knowledge upon existing knowledge, as outlined in Thomas Kuhn's theory of scientific revolutions:

> *'A (scientific) paradigm can (..) even insulate the community from those socially important problems that are not reducible to the puzzle form, because they cannot be stated in terms of the conceptual and instrumental tools the paradigm supplies.' (T. Kuhn)* [41]

Kuhn's theory of scientific knowledge building, does not take the role of the larger social context, nor the arts, explicitly into account. However, Kuhn underlines, in a more general sense, the importance of the scientist's environment, which enables the researcher to see or become aware of discoveries that often happen by accident. This underlines the value of fresh approaches and different perspectives to 'see' potential discoveries.[42] Those who are deeply involved in the subject matter often experience preinventions as obstacles. The inventor's environment often plays a crucial role to raise awareness about the potential or relevance of the new invention in progress. It is worthwhile taking the liberty to interpret this as an invitation to include artists in the process of scientific revolutions.

> *'They (scientists and engineers) prefer to increase control and to decrease the margin of negotiation. Instead of enrolling others by letting them transform the statement, they try to force them to take up the claim as it is. But as we have seen, there is a price to pay: few people may be interested, and many more resources have to be brought in to harden the facts.' (B. Latour)*[43]

In 'Science in Action', Bruno Latour calls for opening up the scientific community to revitalise science and to catalyse scientific innovation. Latour suggests a constant interaction between the scientific community, its authoritative traditions and its environment. Latour mainly refers to the interaction between science and its environment as an important ingredient for inventions or scientific discoveries. For Latour, the scientific paradigm needs to be broken through the invasion of outsiders, i.e. non-scientists. Like Kuhn's theory, Latour's thesis could be read as an invitation for inclusion and openness for artists and other outsiders. The role art can play here sounds more like refreshing treatment to generate new ideas and approach the subject from different perspectives. In his later writings, Latour[44] is more articulate about the mediation role of artists, as he sees the value of the semiotic interpretation taken from art history as a major repository of knowledge for scientific visualisation (a large area of interest in a range of scientific disciplines).

B.K. Ridley is even more direct in his urgent call for artists to rescue science. In 'On Science' [45] Ridley presents us, his alarming scenario where society would end up with what he calls a 'Theory for Everything'. His fear comes from the assumption that this 'unity theory' would be based exclusively on mathematical logic as the reference for interpreting all phenomena in the world (and further). In his theory for everything, god would be a mathematician. Because of this view, everything that cannot be expressed in mathematical form would be meaningless or irrelevant. There would not be space for illogical or non-rational means of expression and representation. If this would be applied in its extreme form, as the theory for everything, our society ends up, according Ridley, with scientism. Ridley continues to say that science and art are in some ways opposite sides of the same coin; science illuminates public knowledge through uniformity and art illuminates self-knowledge through unique plurality, and knowledge about the natural world connects the two. He distinguishes arts and craft by stating:

> *'craft knows where it's going and art does not'. (B.K. Ridley)* [46]

I conclude for now that Ridley warns against scientism and recommends arts, as a much needed supplementary ingredient to rescue science. This should all be read in the context of drastic changes from empirical science to theoretical science.

> *'The scientists believe that the literary intellectuals are totally lacking in foresight, peculiarly unconcerned with their brother man , and in a*

deep sense anti-intellectual, anxious to restrict both art and thought to the existential moment.' (C.P. Snow)[47]

Similar to other scientific studies discussed earlier, the 'Two Cultures' dichotomy of C.P. Snow[48] has been written in the context of a scientific controversy. Snow's main point for debate is the role of science in society. Although this was not so clear after reading his best known publication: 'The Rede Lecture' (1959). For my purpose, it is important to understand that Snow uses the term art while he refers to literature. He further refers to authors of literature as literary intellectuals. He considers scientific culture to be a culture, not only an intellectual one but also an anthropological one. Although its members do not necessarily understand each other (e.g. different disciplines in science), there are common attitudes, common standards and patterns of behaviour, and common approaches and assumptions. Snow used questionnaires to interview scientists on literature and reading, and interviewed authors (artists or literary intellectuals) about their knowledge of science. In his vision, non-scientists picture scientists as brash and boastful, and unaware of the human condition. The scientists regard artists as anti-intellectual existentialists, peculiarly unconcerned with their fellow man. Years later, in his reaction after his controversial paper Snow rephrases his motivation for writing 'Two Cultures';

'.. Persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern. This is serious for our creative, intellectual and, above all, our normal life. ...' (C.P.Snow) [49]

Unlike the science studies discussed earlier, Snow's motivation for his writings came from a critical attitude towards science. He warns against science being the sole operator and advisor for political decisions;

> *'It is dangerous to have two cultures which can't or don't communicate. In a time when science is determining much of our destiny, that is, whether we live or die, it is dangerous in the most practical terms.' (C.P.Snow)* [50]

Snow insists on the inclusion of artists as key players in the scientific revolution to counterbalance the scientific perspective on technology development. He argues that literature uses the same language resulting in an audience-oriented medium and works as a catalyst for the public-debate around the work. The latter is, according to Snow, the missing feature of science. He regards science as being too specialised in its jargon to be understood and this brings along risks for misinterpretation or misunderstanding with potentially major consequences for political decisions. These examples suggest a self-image of the authors and their community, as they seem to have a problem with their introverted and self-sustaining structure.

Peter Weibel approaches the relation between science and art from a very different perspective. Weibel explains the artist's attraction to the plurality of scientific methods, because they feel the structural similarity to the methods of art. Weibel has phrased this in 'Art@Science':

'The question how much art and science are approaching each other must therefore be answered on the level of methodology. If we could imagine an individuum, intelligent enough and comprehensively educated, this individuum could move in both universes freely.' (P.Weibel) [51]

Weibel refers to influences of science on art, stating that this assumes a dubious difference between the two disciplines, as otherwise there would not be any option for convergence. Weibel suggests looking at the disciplines as parallel universes instead which require intelligent and well-educated people to move around in both universes freely. He thus argues against the previous dualistic approach derived from C.P. Snow's thesis, which assumed two cultures. In contrast to Snow, Weibel states that there are multiple worlds, not only the worlds of art and science, which would make it virtually impossible to find an expert in all the scientific areas. Weibel states here that art and science are convergent on the level of methodology, while science is influenced by art on the level of methodologies. Due to the authoritarian or dogmatic aspects of the accepted methods, science turns to the arts and the multiple art methodologies for the renewal of its paradigm.

Paul Feyerabend, philosopher of science, provoked the scientific community with his 'Against Method' [52] as a reaction to the self-centred attitude in the scientific community. New directions in physics, such as quantum mechanics, demanded other approaches to prove their concepts, as the verification theory lost relevance when the new fields of theoretical sciences replaced the old physics. Feyerabend argued that no scientific breakthroughs or inventions can be expected as long as fact building stays in closed circles. According to Feyerabend, science should 'open up', and allow other approaches and outsiders to participate and employ other non-conventional research and evaluation methods, to shake up the scientific circles and let new ideas come in. In many respects, this is mainly a theoretic or philosophical model, which, at least today in a market driven research era, would be hard to imagine in practice. In 'Against Method', Feyerabend criticises the status of science in non-Western society and compares science with art. In the same publication, Feyerabend is more articulate as he refers to the artist as one of those outsiders who can break scientific conventions, and create fertile ground for bright new insights. Although this theory was a provocation for the scientific community, Feyerabend's theory is tempting from an artistic point of view. Artists might even interpret it as flattering; the role of the artist is important, almost like a crusader to rescue science. In this sense, his ideas are in line with the paradigm shifts of Kuhn, and rescuing the world from scientism from Ridley. However, when one takes a closer look: what exactly is the role of the artist in Feyerabend's theory? The artists are not brought onto the stage for their art making; the artistic work is not even mentioned. The artists here act as catalysts for new ideas and serve as a source of inspiration and valuable input for science. Feyerabend attributes free unconventional thinking to the artists' skill set, which he values as an approach to foster scientific inventions. Feyerabend tells us about the projection of the artistic method from an outside perspective. He refers to this as a way of thinking, and is interested in applying this to the revitalising process of science, though producing art does not seem to be relevant for the revitalising process of science. This science-centred viewpoint refers to the power structures and the patronising position of science towards art, rather than real interest or engagement in the other disciplines. Parallel to other science studies, an instrumental approach towards art is observed.

Feyerabend's ideas on methodological diversity also have been the source of inspiration to legitimate the artistic research of the Scandinavian researchers and educators Mika Hannula, Juha Suoranta and Tere Vaden. They summarise this in a metaphor: the democracy of experiences and methodological diversity. The democracy of experiences is their term to refer to omni- directional critique to enhance scientific growth, from outside the scientific community, in this case through artistic interventions or contributions:

> *'.. art (or artistic experience) can criticize science (or science experience), not to mention the possibilities of intra-artistic or intra-scientific criticism. In this sense, experiential democracy is co-terminus with the multi directionality of criticism.' (M.Hannula, J. Suoranta, T. Vaden)*[53]

The authors aim to show that diversity is one of the positive features of artistic research, but it is mainly presented as an assumed solution for the scientific problems as brought forward by Feyerabend. The special status and authority of science and research in general are typically justified by referring to the self-correcting nature of science and to the power of experience. They argue that art research can be beneficial to science, and should be positioned alongside science as a critical discourse, which can strengthen science by importing non-scientific knowledge. In this sense, they reason along the same line as Kuhn.

Another plea for diversity to counterbalance the scientific unity theory comes from a very different angle in Sandra Harding's essay 'A World of Sciences'.[54] Harding questions how European and American philosophies of science position themselves in the contemporary global arena. She investigates this through post-positivist philosophy of science and its links with multicultural and postcolonial science. Her main point is that breaking the scientific paradigm is obstructed by the drive towards unity theory, where all phenomena can be explained through one single grand theory. She questions Western science's circular, self-referencing system. Harding takes the position that the unity theory is based on one set of coherent empirical claims that constitutes the real or ideal science and thus holds the truth. Harding's main point in this text is her critique of the way Western science is constructed as a self-sustaining, isolated, Western male-dominated discipline. She brings forward that Western science builds on the Western logic (claims) and that introducing other (social science) disciplines or non-Western knowledge could interrupt the cycle and bring in new perspectives and directions to Western science. She suggests philosophical links with other disciplines such as history, anthropology and science education. She argues that Kuhn and Feyerabend opened the way to everyday life for science, but stayed in the Western scientific tradition. Indeed, particularly Kuhn's work was produced in a, rather isolated, academic scientific context. For our investigation, however, Harding suggests that creating links with other disciplines is most relevant. Arts could act as another interesting contributor for diverse knowledge growth in science. The reductive method, as promoted by Kuhn, does not allow for inclusion of social contexts or issues, which distort the reductive approach[55]. In addition to feminism and philosophy as suggested by Harding, the possible knowledge growth by the arts and cultural studies is investigated, while keeping the links to non-Western philosophy in the back of our minds.

It is common for the artist (broadly defined) to play the role of problem solver for aesthetic or even social aspects of some collaborative scientific endeavours. Artists are often called upon as communicators or mediators between the general audience and the scientific communities, in order to communicate the often dry, abstract or complex scientific research topics, in a more socially effective way. A recent initiative in Switzerland, the Artist-In-Labs project, is based upon this very concept. It turns out that science often has problems reaching society in order to account for the major investments in science. According to this vision, the arts can improve the public relations channel for the scientific community.

The Wellcome Trust initiative (UK) has a longer record based on a similar theory, though they also consider the artist's critical or different perspective as a valuable asset for scientific research. Catherine Elwes mentions in her introduction essay in 'Talking Back to Science'[56] that artists often broaden the scientist's telescopic view, raising awareness about a larger context. She also reports specifically on the valuable 'soft' or emotional assets brought in by female artists in the program. According to

Elwes, accessing the methodologies, and the generation or personal discovery of new imagery for their artistic work mainly motivates the artists. In the same program, Bergit Arends[57] refers to the methodology gap as an interesting point of collaboration among artists and scientists in the 'art-sci' programs. She refers to this as 'the messy and amorphous juncture' at the start of a project, where the artist seems to feel most at home.

Donna Haraway[58] makes several critical notes on the popularisation of science through the arts. The arts are often used as a vehicle to reach a large audience, but often without respect to the copyright holders or crediting of the artworks. Haraway thus refers to the patronising role and superiority exposed in molecular biology, as this was the area of her investigation. Haraway questions the artwork for the Human Genome Project as gene fetishism, as it is used as a vehicle to promote global power structures. Haraway links science, art and business as interlocked nodes of the human genome project, which, in Haraway's view, represents a power map. Haraway's main point of critique is the double role of science. Here art is re-appropriated by science on two different levels: obviously as a PR vehicle to communicate a rather abstract subject for a larger audience, and the heritage of the artistic tradition which is, like many other cultural heritage phenomena, embedded in the human genome map, which in turn is 'owned' by the scientific community. Haraway's thesis reflects part of the problematic relationship among the disciplines, and this can not be ignored as it reflects the status of the arts and sciences in today's Western society.

2.1.1.2. Solving social problems

> *'Who are good artists? (...) The ones who can through their work change the way society thinks and have in their work a prediction of the new developments of humankind, these are the good artists and they inspire you ... ' (M. Abramoviç)*[59]

Marina Abramoviç refers in her statement to the artist's talent for prediction and vision. This is however, a very different role from the practical problem solver or social worker as suggested by several authors in the art and technology field.

Billy Kluver, who embodies both the engineer and the artist promised, for example with the 'E.A.T.' project (Experiments in Art and Technology in the late 1960s), to increase the professional and social standing of engineers. The project generated successful 'happenings' and events, but the success rate applied mainly to the artists. 'E.A.T.' did not turn out to be the most fruitful way to promote art and engineering collaboration. Many technicians were very disappointed throughout the project as they received little credit and few benefits. Like many other programs Kluver directed, the role of the artists in 'E.A.T.' leaned towards social work. Artist as social worker in experimental research projects has often been used as argumentation to defend the uselessness of the arts in interdisciplinary collaboration projects. In reality however, this role seems to be often outside the artistic aim or interest, as artists have the making of art on their agendas. The fine nuance between the practical and visionary role is illustrated when we compare Abramoviç, Kluver and the following statement from the Soviet Avant-Garde constructivists in the 1920s:

> *'The aspirations of the new productional (constructive) art can be formulated by applying to artists K.Marx's idea about scientists: artists in varying ways have merely depicted the world but their task is to change it.' (A. Filippov)*[60]

Techno-utopian ideas, associated with several drastic technological changes in the 20th century, were not only for the constructivists a catalyst for ideas about a revised role and position for the artist. A significant number of these ideas reflect the concept of the artist as social worker. The rapid changes caused by the industrial revolution and the digital revolution, for example, brought along a series of socio-political problems which were overlooked in the haste of utopian thinking. The human factor in the industrial age is often overlooked or underestimated and in these instances there is a need for a mediator between industry and the citizens. Here the artist is called in as a problem solver for the negative implications of the industrial revolution. The most significant triggers proposing artists as social workers were related to questions raised through the impact of technology on Western society. A striking example can be found in the Bauhaus manifesto where Walter Gropius[61] states that artists will contribute to the 'settling and civilising influence on men's mind' by contributing to the standardisation of design as one of the consequences of mass-produced design. The context of this bold statement was the opposition against mass produced crafts, as a signifier of the new factory production methods in the era of unemployment and drastic industrial changes. Gropius explains the function of standards as 'a criterion of a polite and a well-ordered society'. He argues that this standardisation should not be regarded as negative or impersonal, but positive, as it will guide us to 21st century life standards. Gropius promotes his ideas for mass production through uniting the art disciplines (art and design) as a contribution to social improvement.

Social improvements are also the key for Constant and Guy Debord who propose, in their Situationist Definitions,[62] a collective collaboration among different disciplines as a solution to a gamut of modern urban life problems. For Situationists International, the artists in this collaboration work under the umbrella of urban development. They envision the collaboration among designers, artists and scientists in the so-called Unitary Town Planning as the basis for a freer society.

Jean François Lyotard refers in several of his writings to the role of the arts in the post-modern society[63]. He labels the instrumental approach of the arts as a modernist approach, including its suggested role of bridge builder, or social worker and healer for social cultural cohesion. Lyotard believes this excludes the Avant-Garde and, thus, the in-depth artistic investigation of the medium and its critical attitude about its context. Lyotard argues in favour of the Avant-Garde due to its analytic and anamorphic awareness towards its medium and context.

Recent publications about engagement and the role of the contemporary artist in a mediated society, reflect the tendency of seeing communication as a main motivator for interactive artworks. Dutch critical thinker and journalist Chris Keulemans, refers to this tendency as a new form of radicalism. He draws a parallel between the disappearing disciplinary borders, nationalities and identity, as the artist and work become one, as a new form of intimacy. [64] The work of the Dutch artist Jeanne Van Heeswijk illustrates this thesis, as described by Reinaldo Laddaga:

> *'For the idea is not only that the production of experiences be realised through the interactivation of perceptions, actions, and speech, but that this interactivation should also come into a circuit with fragments of the outside world, in a machine of knowledge, emotion and association that, for each individual, is made not only of parts of her own body, but also of parts of her environment.' (R. Laggada)*[65]

Van Heeswijk represents a growing number of artists working with mediated forms of art in public spaces. The artists (groups) design the rules, the framework, or the platform where the participants co-create the experience or the artwork. Policy makers and urban (regeneration) developers have spotted this new approach. In their scenario, the artists are supposed to contribute to a certain form of social innovation or social cohesion through the direct involvement of the audience, with participants as co-creators. The strength of these kinds of projects is the communication aspect, and the team working aspect. Indeed, I would argue (based upon evidence studies in literature) that the majority of artists held in high esteem within the communities have engaged in and reflected upon ethics and responsibility as they have played the part of 'mediators' in this new area of collaboration. Among the successful (electronic) artists and artist groups who are working according to this community approach are SuperFlex[66], Shu Lea Sheang[67], De Geuzen[68] and others.

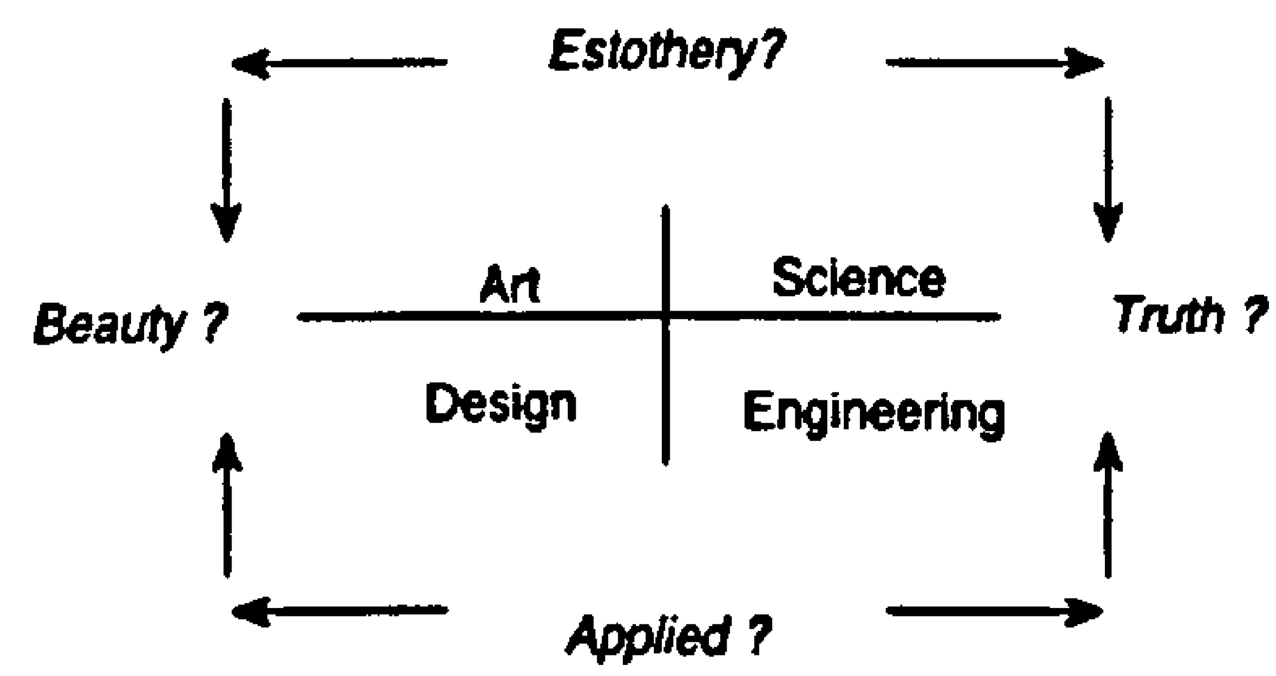
2.1.1.3. Solving technical problems

An art-science program based on problem solving is the PARC's Artist-in-Residence (PAIR) program of Xerox.[69] The program was mainly driven by the need for innovation and active participation in the digital revolution by this company. This motivation is radically different from most corporate support of the arts, where there is little interaction between the disciplines. This PARC pairing process started with a problem solving approach, and aimed at facilitating the realisation of technology-based art pieces. This stereotyped approach to the 'helpless artist' and the scientist as a 'volunteer' rescuer ended up being both inspiring and frustrating. On few occasions did the artists facilitate the scientists; here the artists fulfilled the role of decorator or promoter of the technological work, or fulfilled the role of the traditional inspiring artist by showing their work in the company's gallery. Little to no real equal collaboration among technologists and artists is observed. In the matrix below, created by Rich Gold, (the Research Manager of the PARC program) the strict division in attitude and approach among the different disciplines in the program is observed. Figure 2. depicts the obstacles or collisions or the matches between the disciplines; it implies smooth collaboration among designers and their neighbouring engineering colleagues. It suggests mutual understanding and shared objectives or working methods among the horizontal and vertical bordering professions. This implies for example, that artists and scientists, and artists and designers, share a common ground for collaboration, whereas artists and engineers use incompatible work methods and objectives. In interpreting Rich Gold's schema, one could conclude that design might be more appropriate to solve the technical problems the company is facing. Gold's Matrix brings forward a certain view where art and science are close, and art and engineering are remote disciplines, but the vision of the initiators of different art and cultural initiatives also varies to a great degree.

Art	Science
Design	Engineering

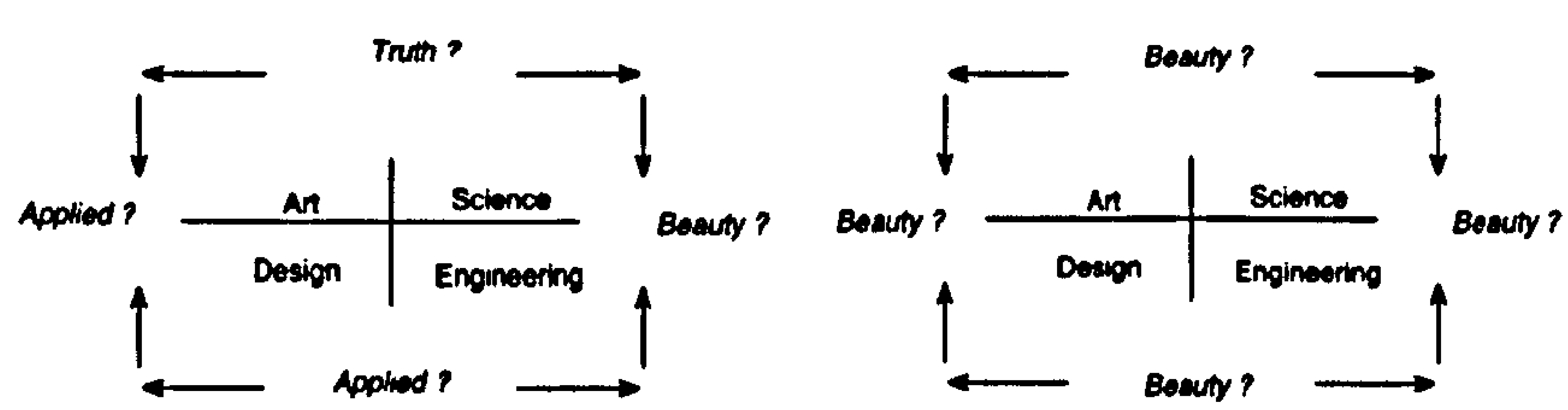
(fig.2 Matrix by Rich Gold, research manager of the PAIR program at Xerox, source dot-font: Reading into the Future)[70]

Closer investigation of Gold's ideas behind the proposed matches as laid out in the matrix above, brings forward the necessity to add some keywords to the matrix. These keywords reflect the commonalities or common motivations of the involved disciplines, and where they make a good match. It is Gold's idea that art and science find each other in the esoteric aspects of their work. While science and engineering find each other in the search for some kind of truthfulness. Design and engineering share, according to Gold, the aspects of appliance, of applicability of their work, while art and design share mainly aesthetics and beauty. This explains Gold's vision of how they relate to each other:



(fig. 3 Rich Gold's Matrix with keywords from the PAIR program inserted by A.Nigten)

Although Gold's vision makes sense in a certain way of looking at things, it is clearly one way of looking at collaboration among different disciplines. Gold's vision builds on the stereotypes as brought forward by science studies discussed before. Its arbitrary view becomes clear when the keywords are shuffled around, and one notices that many other occasions or combinations make as much sense as the original order.



(fig.4 variations of Gold's matrix with shuffled keywords by A.Nigten)

Gold's pairing, as displayed in his original schema, contrasts with other concepts of art and technology programs, such as Billy Kluver's 'E.A.T.' initiative. Kluver clearly states that artists are closer to engineers and

'Art and science have really nothing to do with each other.'
(B. Kluver)[71]

This turns Gold's schema upside down, as art and science and art and design are touching each other, but art and engineering are very far faraway from each other. This contradicts Kluver's ideas, which also represent drastic shifts. Kluver elaborates on his 'E.A.T.' project :

> *'The old assumption that the artist must know his material before he acts no longer has the same meaning, the contemporary artist is developing an attitude toward his new materials similar to that of the experimental scientist.' (B. Kluver)*[72]

Kluver continues to promote the project by listing its potential benefits partly due to the independency of artists who do not have to report to anyone, and are thus an untapped knowledge resource. In the 21st century, this reads as a debatable and patronising statement. Kluver suggests a denial of the artistic tradition, in which artists have made themselves familiar with their (new) material or have invented their own materials. The aspect of material exploration is, in contrast with Kluver's statement, a common aspect in scientific and artistic practice. The studio and laboratory show an increasing amount of similarities today. Moreover, the 21st century's artists do have to report in detail about their work, although the evaluation criteria might be vague or undefined, and depend on the funding program or market. Kluver's reasoning reflects a constantly bouncing debate about the duality of art and science and a bonding of art and engineering, and vice versa. This does not contribute to a fertile dialogue or fruitful collaboration among the three groups, who could create a splendid triangular collaboration.

The Massachusetts Institute of Technology (MIT) MediaLab, in Cambridge (USA), started from a very general art-meets-technology mission. Here art refers to a mix of design and media art. In its early days, brainstorms and wild ideas were among the main services provided to their founders and sponsors. In Being Digital[73], Nicholas Negroponte, one of the founders of MIT MediaLab, elaborates on the role of the arts in a technological environment. He believed that artists are the ones to create the real opportunities for mutation and changes in our digital life. He mentions that he is particularly interested in the digital artist for his capability to present opportunities for 'mutation and chance'. [74] This could refer to artists like William Latham[75], who introduced the concept of evolutionary and growing computer sculpture, in the IBM UK Scientific centre in the late 1970s.

> *'Computer sculpture brings together three techniques: constructive solid geometry modelling, graphical rendering, and the programming of forms.' Stephen Todd* [76]

Alternatively, Negroponte might refer to an artistic visionary role, relevant to the 'spirit of the times' when optimism dominated the techno era of the early 1990s. In line with Negroponte and Kluver, Wilson[77] argues that artists can explore and extend the conventions, focus on the cultural implications of technology and integrate disciplines. As a subcategory of his invention and elaboration of a new technologies category, he mentions real collaboration among artists and scientists and the involvement of artists in scientific research projects. Roy Ascott[78], artist, educator and theoretician in cybernetics and Telematic art, affirms Negroponte's vision and mainly refers to the artist as a visionary explorer anxious to predict future technology.

2.1.2. Collaboration aspects artist as problem solver

From science studies comes the call for artists as problem solvers for improving the communication between science, engineering and the society at large (2.1.1.1.).

In eras of technological revolution, artists are supposed to solve the socio-political problems, which are brought along by the shifting industrial paradigms. While the true social worker may not be found, there is a strong focus on artists as communicators, which in part is in line with recent developments in the interactive arts (2.1.1.2.). From a technical perspective, there are various opinions about the role of artists as conceptual innovators or as problem solvers and designers (2.1.1.3.). All categories of problem solving refer to the other discipline(s) in an instrumental way. Concerning 'problem solving', most collaborations apply a multidisciplinary approach. In the multi-disciplinary approach, the representative of a discipline, or several disciplines, bring(s) in knowledge as a facilitator to the other discipline(s). In the more traditional art forms, the technician brings the solution for material problems. In science, the artist is supposed to bring a solution for the communication problems. In technology, the artist is called in to solve social problems, etc. The motivation is discipline-based; there is no migration of disciplines and in that sense, it is rather a multi-disciplinary situation instead of interdisciplinary or cross-disciplinary. In terms of problem solving, the discussed literature studies show a traditional disciplinary divided field of stereotypes; the artist takes care of the visualisation problem, the scientist should be protected from behaving as if she/he is god, the technician goes into a tunnel to solve a detailed problem. Problem solving turns out to be a useful approach for facilitation and assistance and acknowledges each other's expertise. The suggested model for collaboration is based on the concept of commissioners and facilitators. The other disciplines are called in for their (assumed) expertise to solve specific problems. This can be a useful approach however it should not be confused with equal interdisciplinary collaboration.

The cited authors note that artists have a good sense of future technology and their contributions are valuable due to their different uses of technology compared to the technological or scientific vision. Most literature leaves space for multiple interpretations concerning the exact intended artistic contribution in art and technology innovations. This also refers to the hypothetical success stories or exciting promises of artistic inventors. Often these statements are part of a political lobby to engage artists in the booming digital revolution at the end of the 20th century. The vague promises or the undefined benefit attributed to the artist collaborators in the late 20th century reflects the desire for more experimental research, which seems to go hand in hand with the unpredictability of artistic research.

2.1.3. Conclusion artists are Wild Thinkers and god is a mathematician

There are several sub-conclusions to be drawn from the investigated literature. From the stereotypes in the literature, several roles for the artists in technology can be distinguished. The initial stereotypes refer to the artist as commentator or Wild Thinker; however, a closer observation directs us to the artist in the role of mediator. The different expectations and assumptions found in the literature can be categorised as different types of mediating roles in different types of problem solving and innovation situations.

Science studies call for artists to bridge the gap between science and the society, which is lost due to the often highly reductive approach and self-referential structures of science. Here artists are called in to re-establish communication. Besides the scientific communication problem, art is a frequently suggested catalyst for renewal of science (2.1.1.1.).

Policy makers and urban developers frequently refer to artists as problem solvers of socio-political issues that are in part caused by technological revolutions. Contemporary artists working with communication based media art often include the audience as active participants in the process of making and presenting their work in a social context (2.1.1.2).

The research community calls for artists to contribute their skills to solve technical problems, and foster innovation in the technology sector. The electronic artists, on the other side, call for problem solving in the technological field, to overcome limitations of current technology (2.1.1.3.).

Most of the problems solving roles represent an instrumental view when applied in an interdisciplinary setting. The outlined situation shows that one discipline looks for assistance from the other(s) to solve problems, which are hard to tackle in their own discipline, or by means of their own methods. In addition, the artists' role as Wild Thinker, or provocateur as brought forward by Feyerabend, refers to an instrumental approach, for renewal or revitalisation processes (2.1.1.1.). This instrumental attitude matches with a multidisciplinary approach, where collaborators are called in for their expertise without the intention of cross fertilisation, disciplinary blurring or merging of disciplines. The model for multidisciplinary collaboration has proven its quality, however should not be confused with expectations attached to interdisciplinary collaboration structures where the disciplinary borders may blur or (temporarily) disappear.

Besides the mediation role, the problem solving roles also provide valuable catalysts for innovation. The three categories of problem solving listed above relate, in a non-linear way, to two main types of innovation, which have been identified as technological innovation, and innovation in art practice. The technological innovation is directly linked to the problem solving role as mentioned previously. The inventions or innovation by artists in technology is rooted in the shortcomings of existing technology.

The innovation in the arts is more explorative, and refers in that sense directly to material research, which is motivated by renewal of the artistic oeuvre, and a search for new aesthetics or expressions. Current innovations in the arts, also bring forward direct links with social innovation. This social innovation however, stems from audience participation and artistic engagement, which might be different than the prevailing political point of view. The artist in the role of art innovator needs further investigation, as this implies a reconsideration of the disciplinary borders. Indicators were provided (2.1.1.3.) which might lead us to other yet not clearly defined spaces for collaboration and thus a redefinition of the role of the artist.

2.2. Artistic research and development methods

Following the outcomes of the previous section, this section investigates electronic art methods and their related methods with a more detailed analysis of the backgrounds of different disciplines. Firstly, the literature on related approaches from other disciplines is investigated, with a special focus on the relevance of electronic art research and development in technology, in 2.2.1.1.. After this, the recently compiled aRt&D book, which complements the existing literature, is brought in. This chapter continues with a proposal for four different categories of aRt&D methods: the undefined method, the reductive method, the self-sufficient method, and the *processpatching* method. Each method will be analysed in relation to methods from the art context, the interdisciplinary context and science, technical and design contexts. The undefined method represents a large group of artists who prefer not to work according to a clearly outspoken approach. This category falls outside the realm of this research and will therefore not be discussed in detail. The following two methods bear clear references to existing methods in other disciplines. The *processpatching* method, however, reflects a typically artistic approach.

In section 2.2.2., 2.2.3, 2.2.4., 2.2.5. of this literature study, I discuss different categories of electronic art research approaches, which are used as guidelines for defining artistic methods. Here I propose a nuanced view on artistic research and development approaches, taking into account the intrinsic qualities of artistic research as added features for interdisciplinary collaboration. These categories are based on field studies and literature from other disciplines or filtered from literature where available from the previous section. I focus on the three main artistic approaches and link to each of these the matching methods from related or involved disciplines. And from this, the typical electronic art methodological elements are derived.

In 2.2.6 the electronic art methods conclude with the missing categories of artistic research and development which in theory will inform us about the specifics of the intrinsic electronic art approach. In 2.2.7. the most relevant and frequently occurring research and development themes in interdisciplinary collaboration are investigated. In the conclusion, an overview of the proposed artistic methods, and each of their characteristics, is drawn up.

2.2.1. Related methods

Several authors from the art and culture field, try to fit artistic research and development in other established research programs: Michael Century[79], who frequently advised for the Canadian Council for the Arts, used four categories of economic innovation as his main reference; Peter Lunenfeld[80] uses the technology grid; Stephen Wilson tries to map three categories of artistic work onto the academic research network. The proposed methods build on several aspects of Wilson's categories, and complement the above mentioned publications with the intrinsic value of electronic art research and development approaches as methodological blueprints for collaboration. This results in a more nuanced view, which takes into account the intrinsic qualities of electronic art research as an added feature for interdisciplinary collaboration.

Michael Century [81] used the four categories of innovation by economist Christopher Freeman (incremental innovations, radical innovations, new technological systems, and changes in techno-economic paradigms) to map artistic innovation onto an economic framework. By doing so, Century paved the way for artists to participate in technical and scientific innovation. However, the promoted collaboration of artists and scientists in national research programs faced numerous collisions in these collaborations, partly due to the lack of understanding of each other's methods, if there were methods in place on the artistic side at all. This suggests that Century's mapping is mainly conceptual and should be interpreted foremost as a strategic manoeuvre to channel financial resources, which were available during the Internet hype in the 1990s, towards the media arts.

Peter Lunenfeld[82] tries to connect the grid of critical theory and discourses of technology, aesthetics, and cultural theory to the technology grid. Lunenfeld argues that today's artists are the product of the demo or die culture as known in the software industry and group critique (crit) pedagogic, which together results in well-trained trade show flacks, who have little to no knowledge about cultural discourse. The press agent attitude also demonstrates little to no interest in the theoretical background of computer science and engineering. Lunenfeld affirms my proposition that a solid theoretical background is missing in today's digital art practice. He searches for an approach to merge the theoretical elements of the above-mentioned discourses with the technology field. However, his approach would benefit even more from a direct relation with methodological aspects, as it otherwise risks disconnection from the research and development process in art and design.

Stephen Wilson tries to map information artwork onto the academic research network. In contrast to other authors, Wilson[83] presents us with an overview that includes three stances or roles artists can take towards the new technologies. He uses art history and critical theory as his framework; Modernist approach, Deconstruction, Inventing. Stephen Wilson[84] states that the art world is in crisis regarding its relation to technology and science, and he categorises different roles for artists to revitalise art in new directions. In line with Lyotard, he mentions the deconstructive approach as post-modern, critical art practice. Another category brought forward by him is the modified or updated modernist approach, as a continuation of the existing art tradition, building on the unique expressive capability of the artist. The last category Wilson brings forward is the one of invention and elaboration of new technologies and its effect on contemporary electronic art practice. He calls this 'art as research'. Only he regards the last category as an interesting group for interdisciplinary collaboration and migration to the academic research field.

> *'Different models of working with Science / technology:*
> *Continued modernist practice: Some artists seek to appropriate contemporary technologies to create new kinds of images, sounds, installations and performances - for example, digitally processed*

photography, computer music, or computer controlled sculptures. They see the new technologies as tools that give profound new ways of doing what artists have historically done. (S. Wilson) [85]

This first category represents the shift in production flows that have taken place in the electronic arts. The production process attached to this category includes several types of artworks using digital media in different ways. I distinguish the following categories:

- Digitised works that have been created in the analogue domain. This is usually done for archiving, documentation or publication purposes.
- Stable, static and time based artworks produced with software tools in the digital domain. These tools are commercially or non-commercially available to create and to distribute work, e.g. prints, digital paintings etc.
- Unstable and interactive artworks produced with software tools in the digital domain. There is a whole range of works that should be included here as time-based media productions both linear and non-linear. Moreover, interactive productions can also include linear video and audio productions, as audio-visual elements of interactive pieces, performing arts, etc.

Critical practice: Some artists believe that the centrality of science and technology requires a radically different response from the arts. In this they continue and update traditions of conceptual, performance and situationist non-object based art. In this view the arts main role should be to deconstruct cultural patterns of integrating science and *technology to clarify underlying meanings ignored in the overhyped flow of normal technological and commercial life. (S. Wilson)* [86]

In contrast to the previous category, this one represents the critical attitude of the artists. The artist as protestor, criticaster or 'l'enfant terrible' comes back in waves in recent art history. It reflects the voice of the underground, the counter-voice or comments on the power structures. It should be kept in mind that critical practice and critical theory as a method of enquiry refers strongly to critical theory and communication studies. This category represents the self-sufficient or independent artist.

> *Art as research: Some artists believe the most powerful response is to become researchers themselves. They attempt to enter into the heart of scientific inquiry and technological innovation to address research agendas ignored by the mainstream and to integrate commentary and play into the research enterprise. I believe this opens up enormous opportunities for the arts.' (S. Wilson)* [87]

Like the previous one, this last category represents an attitude of the artist. It deals with a new type of artist, although it is not clear if Wilson points at the self-sufficient or independent artist who turned him/her self into a multitasker, or a bridge builder between the disciplines. However, art as research refers to the shifting position of the electronic arts. It is clear that the work field of the electronic artist as described in this category has migrated from the arts to the scientific research labs. The profile as described by Wilson represents the artist who collaborates with or infiltrates scientific research with critical research questions. Wilson continues by informing us about the collisions he observes caused by this attitude towards the academic approach. However, there is no detailed information given about the kind of collisions or the exact cause of the crash or the possible positive effects this crash can bring along.

The division proposed by Wilson is a reflective one; his categories build on art history and critical theory. In Wilson's writings, concrete information about the methods used by artists in this collaboration cycle, which might be the possible cause of the problems, is missing. Wilson informs us about an artistic 'unconventional way' of making things. There is some information about the artist's position towards technology in Wilson's categories, but this is the only relevant information that refers to methods. An assumed reason of the collision might be the forced fit into the scientific academic world, as these investigated attempts to fit artistic research into other existing methods or approaches are often arbitrary and are mainly appropriate for a specific purpose. It is also observed that the researched comparisons mix up overlapping, complementary and not matching approaches depending on the purpose of the suggested mapping. These mappings are often troublesome as the authors seem primarily interested in the migration of the electronic arts to other disciplines for financial or social reasons, which requires an integration model based on the host discipline. Or in other occasions, the authors are concerned with the explanation of contemporary electronic art practice through assimilation. For this reason I propose in addition to the roles brought forward by Wilson, the electronic artist as bridge builder and team worker. Finally, I propose to draw the attention to the option of an intrinsic electronic art research and development approach, based on or derived from non-academic traditions. Here I build on Weibel's theory, who mentions in this context the innovation in the progressive (visual) arts by the artists themselves in relation to media and the consequences of interactivity, with respect to the changed role of the audience becoming participants in media art. [88]

2.2.2. aRt&D methods

In the course of this investigation, it was decided to fill the observed gap in literature by contributing to a theoretic base from which artists, researchers and educators could draw in their daily practice. In close collaboration with my V2_ colleagues it was decided to publish a book, 'aRt&D Research and Development in Art'[89], where artists and theoreticians contributed to a base for the aRt&D discourse. Compared to the current literature genres, the book is positioned between the existing theoretical discourse, dealing with concepts and themes in art and technology in a broad sense, and handbooks about techniques. It's aimed to be more or less parallel to some of the science studies discussed in 2.1., though from an artistic perspective. Without sounding too pretentious, it is aimed to be among the first books in a new category: art studies. Art studies, in this view, are positioned between art history, other reflective theoretical discourses and technique handbooks or instructive publications. In the realm of this investigation, editing the 'aRt&D, Research and Development in Art' also served as a confirmation for the proposed theory and conclusions so far. The citations from the book's introduction text are co-authored by the editorial team, with contributions by Sandra Fauconnier, the media archivist of V2_. From the introduction of 'aRt&D, Research and Development in Art' written by the editorial team:

> *'..... Somewhere between culture, science, industry and design practice, an active interdisciplinary field has thus arisen, out of which work comes forth that addresses itself on the one hand to activating the audience, and on the other to experimenting with human-machine interactions (..)*
> *Since the rise of the Internet and the World Wide Web, a whole new range of digital art forms has arisen which takes advantage of the cultural shifts that have been a consequence of the flourishing of these networks and the globalization associated with them. Computers have not only produced different work – different in terms of media use and content – but also facilitated a new way of working, that is, by collaborative groups of artists, designers, technicians and scientists.'* [90]

'aRt&D, Research and Development in Art' provides information to develop a method for coming to grips with the various forms of artistic research and development and their results. Theorists and art researchers, who have emerged in the past few years as authorities in the area, have written the essays. In that respect, this aRt&D book reflects the interdisciplinary practice and theory framework that has been established outside academia. The first and foremost important conclusion that can be drawn from the essays in this aRt&D book is that research and development in electronic art reflects diversity rather than uniformity. This diversity or plurality becomes evident in the descriptions of the work and collaboration process as well as in the topics and aims of the artworks. In the following sections, parts of the aRt&D book are used as an additional literature resource, with reference to practice. The book illustrates the research and development methods, and trends in electronic arts. This is used as one part of our reference set to position the described methods and their correlating methods or traditions in the arts in a broader context.

From the art context, this investigation moves towards comparable or related methods, which can be found in the interdisciplinary context. Furthermore, each method will also be compared with science, technology and design practice. The overview continues with an investigation of the correlation between the aim (or objective) of the artwork, the chosen method and, or the outcome. First, a brief overview of the four main categories is presented, from which the three most relevant ones for collaboration purposes will be discussed in detail in this chapter.

aRt&D method	Theoretical context / Matching approach(es)
Reductive method	engineering and design problem solving approach, traditional science and technology methods
DIY method	Post-modernism, de-construction, Avant-Garde, activism, critical theory, autonomy, relevant in multi disciplinary collaborations often autodidact multitasker, exchange with other self-sufficient operators, FLOSS development
Processpatching method	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,
	Post-Marxism, design theory, improvisation theatre / Various design approaches e.g. human centred H.C.I., Ethnography , social sciences, communication design

(fig. 5 aRt&D matrix part 1: artistic methods and matches)

The useful aspects from the analyses of the artistic approaches by Wilson and Century are integrated where appropriate in this overview above. The overview above, (fig. 5), outlines the three main methods, and investigates the parallels with other related fields in order to determine the overlaps and supplements in approaches. It is acknowledged that the overview only lists collaborative categories. Those art projects whose development is not based on any method are not included. In this 'undefined method', technology and/or science serve as a source of inspiration for the artist and in most occasions, the artist is not interested in developing a working piece of technology. Here the outcome is thus often an electronic art work produced with media or material in an instrumental way. These media are mastered by the artist and therefore do not need real collaboration with, but mainly information from, other disciplines. In some rare occasions, another model of collaboration is observed: as a consequence of the artist's disinterest in technology, the engineer, who 'assists' the artist, is given a considerable amount of freedom to co-create the art piece via her/his technical input in the creation process.

The reductive method refers to many engineering and technical scientific approaches where the application domain is reduced and the interfering noise is filtered out. The reductive method refers directly to the problem solving approach that was mentioned in earlier parts of this investigation. The problem solving approach or the reductive method can be applied in parts of a project to overcome technical obstacles or can be the main motivator for tools, and is useful for (artistic) inventions. This method refers to an instrumental use of technology, as tool or facility for production in the electronic arts, with science using a reductive method, with engineering and design approaches following the problem solving approach, as discussed in 2.1.1..

The DIY method and the hacker approach refers strongly to the self-sufficient approach or to the hacker as a subversive activist, whose aim is to raise awareness of the consequences of our capitalist or global system while infiltrating the systems and undermining the power structures through their actions. The community of 'hackers' has over the years, designed their own methodologies for creating alternative routes and systems, often collaborating in a more constructive way, as the term hacker suggests. This is the true 'hacking' or re-appropriation of existing software or hardware for other purposes than it was originally intended. Other, truly collaborative approaches, such as Open Source and Free Software, are observed, which are by now much less underground then when they started of. Although Free or Libre or Open Source Software (FLOSS) are based on outspoken ideals to design and share knowledge and information, it has stretched out way beyond the hacker community. It provides artists who have some knowledge of software development, the possibility to operate more or less independently from institutes or allows them to connect with FLOSS environments where the general idea of sharing is of crucial importance.

Finally, the *processpatching* method is listed as an electronic art research and development method that encompasses experiments and re-mixes existing methods and approaches. *Processpatching* refers most clearly to fundamental research in various fields of science. It can include or borrow methods from social sciences, gaming, the arts, computer science, and crafts. Here Feyerabend's credo; 'Anything Goes', seems appropriate. *Processpatching* and connecting consists of a process of re-mixing and experimentation joined by researchers from different background. The process or the experience is often more important than the clear-cut, useful functionality. In the *processpatching* method, people from different backgrounds are often brought together to mix their research and development and also to gain access to new experiments that would have been impossible in their respective single disciplines.

2.2.3.

Problem solving or tunnelled approach: reductive method

This section describes problem solving as the assumed approach for solving the scientific communication problem, and as a ground for artistic technical inventions. It begins to be outlined in the next paragraph, where I illustrate a utilitarian view on the collaborative aspects of problem solving in specific areas of art production. The tunnelled approach reflects a reductive method, used for problem solving research and development.

2.2.3.1. Problem solving: Art context

Ridley's statement 'craft knows where it's going and art does not[91]' is affirmed by Walter Gropius[92]. Gropius, the initiator of the Bauhaus, states that art rises above all methods. It cannot be taught, so we should therefore concentrate on crafts instead. In an art and technology context, one sees that the problem solving approach is mainly used in the preparation for a production or a specific part of a production, and as such is accepted as an indicator of the feasibility. Moreover, in terms of predictability, applied art and design do indeed often use a problem solving approach. In the realm of this investigation it is relevant to note that this section deals with the collaborative aspects of problem solving in the research and development phase for specific, or sometimes even isolated, parts of an electronic art production. On these occasions the problem solving approach is connected with the practical elements or tools to realise the artwork and not necessarily with the aim or objective of the artwork. Here problem solving is merely perceived in a utilitarian or instrumental way. One can see some overlap with the 'continued modernist practice' mentioned by Wilson[93]. He describes artists' attitudes to use digital techniques as tools to create new artworks (e.g. digital photography and manipulation, computer music, etc.). In these events, the artist focuses on creating digital artworks or objects and the required research is a tunnelled investigation before the development takes place.

Oliver Grau's research focuses on parallels between the history of illusion and immersion in art, he draws parallels from contemporary telepresence and telecommunication with technology and culture in the past. In his work, Grau analyses the technical and experiential parallels between virtual reality and panorama paintings, and the construction process. In 'Virtual Art – from Illusion to Immersion' [94], Grau refers to an instrumental approach he observed in the building of panoramic paintings. In the late 19th century, the panorama building team realised the artwork using a problem solving approach. An artist designed the concept or the sketch for the painting, and a team of craft specialists developed the project. When zooming in on the industrial panorama model, several parallel research trajectories are determined that are simultaneously performed by different persons in the pre-production process. In small sub-research trajectories, the involved (technical) specialists in a production team try to find the best possible solutions to realise the concept according to the given artistic outline. This type of research focuses on improvements in very small, focused material or technology segments. Skills in making things, training and material knowledge play a major role in this area and there are some parallels with a range of artistic and cultural disciplines; it is manifested in the detailed research areas, in those fields where technical skilled people work. Here the problem solving approach, used for small technical problems or the material research, often leads to artistic innovations.

2.2.3.1.1. Artist as inventors of new technology

In the field of art and technology, there is a great deal of technological inventions by artists. Most electronic art inventions are rooted in problem solving or material research for the renewal of their artistic oeuvre. Artists working with software and hardware often have the need for other types of software than the standard, 'out of the box' software that is manufactured for standard office use or business purposes. New genres in the arts bring along specific needs, like works that deal with interactive features. This leads to new applications or re- combinations of existing software.

Michael Century[95] refers to radical innovation as a similar phenomenon in the footsteps of Kuhn and Feyerabend. However, in contrast to Kuhn and Feyerabend, he refers more towards the artistic practice:

> *'Radical innovations are discontinuous events, going beyond variational creativity. In the oft-told explanation, no combination of horse-driven coaches could have produced the railway; so, for many artists interested in working with information technologies, the aim is often to explore or invent new media forms, as the 'unit' of innovative work, as opposed to working within established techno-cultural genres.' (M.Century)*[96]

Century promotes the idea of artists as inventors of new software and hardware applications. This was one of his arguments to encourage artistic entrepreneurship during the Internet hype in the 1990s and the available resources for research and development. Century[97] refers to several artists who have migrated (part of) their practice to solve technical problems in the field of applied innovation. These electronic artists work on technology innovation in order to design tools for artistic purposes. This sketches the context where artistic inventions often start as a reaction to industrial or office-oriented applications that do not meet the desires and needs of artists. The problems these artistic inventors try to solve are often very pragmatic. Sara Diamond, former director of the Banff New Media Institute, a well-known interdisciplinary art and media centre in Canada, affirms this approach:

> *'Artists often invent because they are hungry. Something they are making cannot or will not work. There is no one else around to solve the problem.' (S. Diamond)* [98]

Diamond refers to two issues here; she positions artistic inventions in the problem solving context, and she briefly refers to the artistic motives for technical innovation as a reaction to the limitations of available hard- and software.

In artistic circles, a well-known example of this type of invention is the 'Very Nervous System'[99] (VNS) (1986-90) by artist, engineer and inventor David Rokeby. VNS was a video camera-based motion tracking system to create interactive audiovisual spaces. In the 1990s Rokeby developed the 'softVNS'[100], the widely used software version of the system. Diamond states in her essay 'Holistic Bodies' about the artist inventor David Rokeby;

> *'Not only an artist, David Rokeby invents technologies that underlie his artworks and enable forms of experience that corporate digital media do not allow.' (S.Diamond)* [101]

This affirms that electronic art inventions can lead to new types of software approaches, hardware devices or concepts. Besides his inventive artworks, Rokeby also develops innovative tools for other artists and multimedia producers. His inventions are based on his own practice and come from the lack of certain tools he experienced, to express his artistic concepts. Rokeby has a talent for generalising the problems he solves in his own artworks so that these inventions turn out to be of interest to a larger community or set in motion other developments. Another example is 'Tx-transform'.[102] In 1998 the Austrian artist, engineer, film director and technician Martin Reinhart patented this experimental film technique that transposes the time and space axes onto each other, a technique which was used by numerous video artists over the last years. Here the artists' involvement in the field of creative technological development provides other insights and new ideas for functionality that could, as innovation, enter the artistic and technological field. Later in this research, other groups of artist-innovators are studied. For several artists in the C&CRS program (Candy and Edmonds) the limitations and awkwardness of pre-fabricated software works as an invitation to design their own software. Other artists in the same program refer to the role of artists as pushers of the medium's limits.

> *'Artists ... may ask the kind of questions (software) specialists wouldn't raise' and 'open up new lines of enquiry'.*
> *(L. Candy, E. Edmonds)*[103]

The growing number electronic artists-inventors is illustrated by the increasing number of patent holders among artists, among whom are Golan Levin (artist, inventor of 'Dialtones: A Telesymphony', and co-designer of 'Processing', an open source programming language and environment)[104], Graham Smith (robotics inventor and videoconference interface designer), Joachim Sauter (Method and Device for pictorial representation of space-related data)[105] and Netochka Nezvanova ('NATO.0+55'+3d software, externals for Max)[106].

2.2.3.2. Problem solving: Interdisciplinary context

Kluver interpreted, according to Bijvoet[107], the problem solving approach as a commonality or a conceptual space where artists and engineers could meet. In an interview with Garnet Hertz[108], Kluver defines problem solving as the motor for matching artists and engineers but he also acknowledges the differences in the type of electronic art and engineering problems; the artists bring in problems non-artists wouldn't come up with. This provides a counter balance for the rational daily life problems of engineers; the artistic acquaintance broadens the engineer's horizon. In the view of the Dutch philosopher of science, Petran Kockelkoren,[109] the engineer usually plays the problem solver in collaborations with artists in their university. One sees here the traditional picture of the engineer as a problem solver and the artist as a problem creator, where the latter doesn't participate or engage in the technical development process.

For Snow and the Artists in Labs initiative, the collaboration with art offers solutions and opportunities for the communication problem of science. For example, artistic aesthetic visualisation proved itself, throughout history, as a valid method for packaging subjects that are difficult to communicate. Abstract scientific research for example, is communicated more easily by means of 'appetising' visualisation. According to Bijvoet[110] this goes back to the shift from empirical science to theoretical science. For example, in the case of the micro-world of quantum physics, predominantly a world of mathematical formulas, the researched matter is invisible to the human eye. Communicating and explaining the research in this field is complicated due to the abstract concept that is dealt with. In the accountability process towards the general public this is difficult to overcome. In this respect, artistic visualisations have been instrumental to explain complex and abstract or theoretic research trajectories. Marga Bijvoet[111] refers to György Kepes' (founder of the Centre for Advanced Visual Studies at the MIT, USA) ideas that scientists were looking for new ways to visualise their abstract experiments and that it would be possible for artists to assist them to work out new visual models. This suggested role of the artist, as collaborator has been the subject of debate, particularly in Europe.

> *'In many cases art in this context only serves as an illustration of the laws of perception, from chromatic analysis (Seurat) to stereo cineticism (Duchamp) so that we duly can call in question its legitimation as art.' (P.Weibel)* [112]

The Austrian / German Peter Weibel underlines this and re-directs the debate to the effects of collaboration on the arts. He states that the influence of science, from natural sciences to linguistics, social sciences, psychoanalysis, philosophy etc. on the arts is obvious to everyone, although it is much harder to bring forward the influence of art on science. Weibel investigates this in his essay '*The Unreasonable Effectiveness of the Methodological Convergence of Art and Science*', where he starts from the point of view that convergence needs to be mutual. In his rhetoric about the convergence of art and science Weibel also refers to the earlier discussed attitude of science towards art as problem solver.

> *'(..) not on the level of product science is influenced by art, not on the level on references, but on the level of methods, because any time when science develops the tendency that its methods become too authoritarian, become too dogmatic, science turns to art and to the methodology of art which is plurality of methods.' (P. Weibel)* [113]

The problem to which Weibel refers is an inherent aspect of the strict and narrow scientific research doctrines. The salvation role Weibel sees for the arts is rooted in the liberty or diversity of methods in the arts. His writings are in line with Feyerabend[114] who underlines the opportunities for science to engage with the multiple or diverse methods from the arts. Weibel takes Feyerabend's 'Anything Goes' theory to a more concrete or evolved approach.

Bruno Latour firstly describes the role of the artistic expression in science[115] and religion as a mediation activity, a role which has been embedded in artistic practice throughout history. Latour refers to the functionality of a drawn map being among the best-known historical representations of territory and power zones. Latour has first directed us to the traditional role of the artist as problem solver or facilitator of science. He continues by pointing out the difficulty of the instrumental approach of science towards the arts as a tool for representation.

> *'Everyone and every detail of what art is and what an icon is, an idol, a sight, a gaze, has been thrown into the pot to be cooked and burnt*

up in the past century of what used to be called modernists art.'
(B.Latour) [116]

Here Latour brings a problematic issue to the surface: the stereotype of art as a tool for communication does not match with the practice of most contemporary artists. Latour states that contrary to visualisation in science, the characteristic of visual art is that it is subjective and does not have the pretence of providing access to truth[117]. From the electronic art and design field, this has been affirmed in recent Web-based art, where numerous artists have re-worked and re-interpreted the use of scientific visualisation software. These mapping projects reveal the artistic interest in visualising irrational processes, or in mixing subjective and objective information. Mental maps, emotional maps, knowledge maps, and associative maps are among the frequently observed genres of art projects and supporting tools for design processes. Knowbotic Research's 'IO_Dencies' [118] project, for example, visualises the results and the dynamics of public software agencies that deal with collaboration among urban developers and deprived inhabitants of the mega cities of Sao Paulo and Tokyo. The *'DataCloud'* [119] project by ArchiNed and V2_Lab represent a slightly different approach to 'knowledge maps' and representation; the *'DataCloud'* project was initially designed as a tool for urban developers and architects to gain access to 'soft' or personal information by means of an interactive visual dialogue with the inhabitants of a specific region. This process of visualising 'invisible' information illustrates the very different artistic approaches and critique of the aforementioned representation of the truth. This occupation and interest in process and experience is reflected in the aforementioned artistic interest in (visual) perception, communication and self-organising systems.

Latour gives this argument an interesting twist in that he suggests that scientific visualisation to take over this area of 'representation', as they own the computers and software to model and render their representations, while the artists are working on another area of visual and experiential electronic art forms. The above-mentioned examples from Knowbotic Research and ArchiNed / V2_Lab illustrate that this shift of interest, formally related to the two disciplines, has already taken place.

2.2.3.3.
Problem solving: Science, technology and design context

> *'What characterises the (scientific) theory is that it is offered as a solution to a scientific problem' (K. Popper)* [120]

Problem solving has a long tradition in science and technology as clearly defined by Popper. Kuhn refers to the Puzzle Solving approach, as the main motivator for engineering practice. The puzzle or problem solving approach reflects the 'normal' science methodology as mentioned by Kuhn[121]. Kuhn draws a parallel between established research fields and this narrow or detailed approach. Established research fields use reductive approaches to build new facts based upon existing knowledge, so the domain gets tinier and more detailed as more work is done in that field. As a side effect, this tunnelled research leaves no space for an extended or wider (social) context and therefore reduces the options for collaboration with other (non-scientific) disciplines.

Problem solving can be found in other practices, in particular engineering and design disciplines have in common the fact that they use a 'problem solving' approach. In theory, the tunnelled approach in technological fields reduces the application domain to filter out the noise to reach the 'true', clearly defined and solvable problem at stake. In practice however, the researcher often abstracts away from all the complicating problems, solves the abstract problem and then claims the result is generally applicable. The research is strictly directed to solve the problem; the focus is on the final development and thus the research can be labelled as 'applied'.

The Bauhaus motivates the unified art, design and architecture disciplines as a solution for a social problem. As a major representative of its generation, the Bauhaus claims to be conscious of the potential of art as something fully involved in life, which could restore 'grace and order to society'[122]. Major social issues in the new industrial era were, however, mainly approached from a design and urban planning point of view, and reflected a practical problem solving approach. In their investigation on collaboration between artists and technicians, Candy and Edmonds[123] acknowledge the relevance of information from the design field due to its overlap with digital art. They state that in design practice, one can distinguish two approaches; the problem solving or the solution-led approach, where collaborators narrow the application domain to reduce the noise around the problem, and the holistic approach. In contrast to the reductive approach, the holistic approach takes the context and multiple views constantly into account that can cause shifts in objectives. According to Candy and Edmonds, unforeseen complications arise when a changing goal and additional constraints are brought in during the design process when working with a problem solving approach.

2.2.3.4. Problem solving: conclusion

artist's attitude to sci & tech	aRt&D method	collaboration's characteristics	Theoretical contex / Matching approach(es)	Interdisciplinary output application domain
applied R&D practical	***reductive method***	Single or limited disciplinary problem solving approach, applied research, practical method	Traditional art, engineering, design, traditional science and technology methods	relevant in single- multi-disciplinary teams, techno science, empiric approach, applied R&D, artistic innovations

(fig. 6 aRt&D Matrix reductive method)

This part of the chapter concludes that the problem solving approach is most relevant in a practical context. In an electronic art context (2.2.3.1.), the problem solving approach is mainly applied in parts of the work or to solve practical (material, technical) problems. This sometimes leads to small inventions, in particular in the field of tools or instruments, as it is mentioned (2.2.3.1.) that artists come up with other types of problems than technicians would. The artist as inventor of new technology (2.2.3.1.1.) is a widely acknowledged role, though it is strange that the background or the way it is achieved is never highlighted, as the mythical aspects seem to be part of the recipe for success. The artist in the role of innovator often has a different perspective on technological issues compared to the technological research objectives in other disciplines. Often the artist's role in technological inventions stems from a fresh fascination about the technology or an artistic premise, and thus does not meet a market need. Moreover the artist's technical requirements do often not meet the required stability for mass production. In these situations, a reductive approach is used to reach the core of the problem that needs to be solved. In collaborations among artists and engineers, the engineer often fulfils the role of problem solver. Latour (2.2.3.2.) states that, in the interdisciplinary context, artists are considered as 'visualisers' of abstract scientific research, which is in conflict with contemporary art practice where artists are, since the early 20th century, hardly ever concerned with representation anymore. He suggests that scientists take over this part of the art practice. Instead, artists have 'taken over' the abstract scientific visualisation software, and critiqued or re-purposed this for critiquing or visualising 'invisible' structures and processes. Problem solving, or puzzle solving as Kuhn refers to it, in science (2.2.3.3.) has a long tradition and is based on a reductive approach. 'Normal' science deals with innovation through building upon existing knowledge and thus also applies the 'problem solving' approach, though this is debated due to the slow incremental growth of knowledge and reduced chance for real breakthroughs. The reduction of the problem domain, as reflected in 'normal' science, brings forward the risk of isolation or self-referential practice, and according to Kuhn, this demands input from non-scientists to evoke paradigm shifts and scientific revolutions. To reposition the arts, the Bauhaus migrated its methods for problem solving to design practice, where problem solving has a longer instrumental tradition. This is in line with Edmonds and Candy who also borrow those approaches from design as this matches best with engineering approaches.

The problem solving approach is directly related to the instrumental and practical aspect of art and technology. All authors refer indirectly to the multidisciplinary collaboration model where another discipline is considered as a problem solver for them and not for establishing a common practice. The disadvantage of problem solving is that it conflicts with shifting goals or objectives during the course of a project.

2.2.4. Confronting motives; the DIY method

This section describes the colliding and hacker approaches and DIY as the assumed self-sufficient method for artistic 'Wild Thinking', comments, provocations and intended confrontations.

In this section, the self-sufficient artist and the cultural activist are discussed as those who value ideological independence as a basic condition to criticise the existing power structures and raise awareness about social political issues in our technology-driven society. Their objectives and working methods are analysed and from there, parallels with hackers, FLOSS approaches and DIY approaches are drawn. The theoretical background of this approach is often rooted in critical theory and deconstruction, and the latter refers to an often-applied development approach. The colliding method is a difficult one for collaboration and collaboration is often not desired as it threatens the independency of the self-sufficient artist, unless the collaborator shares the political or activist interests.

2.2.4.1. Confronting motives: Art context

The intentional artistic provocation generates relevant study material for non-artists, in particular those who plan to collaborate with artists to generate new ideas or break conventional patterns. In the first instance, collisions may happen by accident, mainly due to a lack of knowledge about each other's domains (and jargon) (see also 2.1.) or work method. Other occasions teach us about intentional collisions, where the artist acts as a provocateur. One should be aware that in addition to Wilson's observations, the misunderstandings not only come from the lack of knowledge, but they are also rooted in artistic practice. The artistic, poetic or associative language adds diffusion and confusion when used in an expert (scientific) environment.

The intentional collision has its roots in the tradition of artist as commentator or protestor. In early mediated art practice in the 1970s the Raindance video initiative and the Radical Software magazine in the United States published the mission to free television broadcast from corporate control. They had the, now visionary, idea to open up the channels of television, by providing access to production and distribution tools to the audience.[124] In recent practice, the artist activist and hacker fulfil this role as media activists. Wilson[125] briefly refers to this as 'deconstruction as art practice', where artists become part of the technology development and from there continue their art practice as knowledgeable commentators.

Arns[126] calls this phenomenon the generation of counter-discourse in society. Arns places this analytical deconstruction approach in the context of 20th century mediated art practices. She states that this critical attitude is partly rooted in the search for more democratic mass media platforms (and the work is often turned against the existing media power structures), and partly in political deconstruction and subversive activism. The artists who are here categorised under the heading of 'social technologies' work as media activists, emancipators (who intend to free society from the restrictions of technology and its related power structures) and those who want to raise awareness about socio- political issues. The work areas for cultural activism cover the 'public domain' and tactical media that are used for independent broadcasting, etc. Over the last years, special attention has been paid to security and privacy issues, exposure of the hidden power structures through analysis and interpretation of data traffic, and digital information streams and biotechnology. As mentioned by Arns, far away and deep down, artists working with or producing social technologies also represent somehow the dream or hope that art can change society, although this might be a very different approach than that envisioned by the engineers and scientists quoted earlier (Kluver, Ridley, Kuhn).

The intentional artistic collision and hacking, or repurposing of technology, relates also to the critical theory of Michel de Certeau. De Certeau proposes to make explicit (in language) the modus operandi of consumers, which, he claims, make a 'culture'. He brings forward the intentional consumer's tactics as a cultural activity. In 'The Practice of Everyday Life' [127] he contrasts his vision of the use of products with the assumed notion that the public is shaped by the use of the product. His argument for the consideration of the empowered user as a cultural phenomenon is highly relevant for the artist-activist and hacker of consumer technology. The notion of hacking and empowered consumerism can be conceived as both political acts and works of art, while in intentional collisions it becomes clear that the borderline between those two is blurred. The method, however, is similar: the work is created according to a hacker's or DIY bottom-up approach. Over the years, artists have been re-engineering and repurposing technology both in software and hardware. Network games turned out to be of special interest because of their multi-user network components and the real-time visual aspects, in particular the popular the so-called 'first-person shooter' games, which represent a technical, political and artistic challenge. Intentional collisions are more or less the brand of the artist group Jodi, a collaboration between the Dutch / Belgian artists Joan Heemskerk and Dirk Paesmans.[128] Jodi and many others worked and re-engineered different game engines and repurposed technology to shock and confuse the user, and by doing so they also created their own new aesthetics. Among the most popular game engines for artistic collisions are the Quake[129] engine, originally written to power 1996s Quake, and the Unreal[130] engine.

Artists who re-appropriate the media channels and criticise current technology developments represent another stream of critical art practice. For example, the Critical Art Ensemble[131] (CAE) is a group of five artists from different disciplines, whose work focuses on the intersection between art, technology, politics and critical theory. The tactical use of mass media is a key aspect of their work. CAE uses mass media to reach their audience with their subversive actions and critique on the same media, political issues and power structures. The members of CAE [132] are considered to be cultural activists (known as artists), and their work is strongly related to critical discourse. Their practice is placed in a historical context of power structures and draws a parallel between net activism and the strength and mobility of nomads. In the context of 20th century art, they relate their work to Duchamp, Cabaret Voltaire and the Berlin-based Dadaists as forerunners for contemporary artistic activism. These movements have all worked upstream against the art establishment, with autonomy being an important ingredient for their operations. CAE further argues against the artist as revolutionary agent, as promoted by Andre Breton, due to its proposed idea of the poetic self as a privileged narrative and other variants which reduce activism to a resource merely for artistic exploitation. As does Arns, the CAE also refers to the Situationists International as a major source of inspiration for the cultural activist movement. In a larger context, they see cultural activism as a contemporary continuation of the avant-garde, and refer to electronic disturbance as a contemporary version of nomadic power in cyberspace with concerns about (disclosed) centralised information. The CAE authors mention[133] that the cultural activist usually operates outside and often against the official scientific institutions due to their political agendas and funding constraints, or in the eyes of the activist, debatable resources and goals.

Naimark[134] has written that 'metaphor to some is violation to others'. He refers to the artists' intentions to create 'metaphor and poetry'. According to Naimark, the artistic approach to technology collides with the technical research objective, which is often to improve technology. The most common reference for improvement of technology is the interest for representation or literal recreation of realistic experiences, as discussed earlier (2.2.3.2.). This especially happens in the field of visualisation techniques such as those used in virtual reality. Artists are more interested in building 'make believe' experiences, or focusing instead on interaction and perception. Here we witness a collision of different objectives and attitudes towards technological innovation in general. Mulder and Post also bring the positive effects of the intentional collisions and misconceptions forward:

> *' ... the rule here is that mis-understandings are the vehicle for the cultural transfer: other people will do something with your expertise you never intended it to do. Electronic art is the art of misconception; misconceptions that put every normality in disorder and make it turn against itself, with happy and illuminating results.' (Mulder, Post)*135

Mulder and Post underline that the effects of collisions is not always negative: the clash method sets processes in motion, shakes up, intervenes, exposes. The illuminating outcome of misconception or repurposing, as brought forward by Mulder and Post, varies from raising awareness to proposing a new aesthetics. In this context, these aesthetics are not limited to audiovisual components but are also embedded in the critique, the interaction design, the social interaction, the game structure and other ephemeral aspects of the work.

2.2.4.2. Confronting motives: Science, technology and design context

A variation on Feyerabend's theory was presented during DEAF04 (2004) by Bas Haring[136], who initiated an interdisciplinary science and art Masters program based on the idea of Wild Thinking. He promotes the vision that 'Artistic Wild Thinking' shakes up scientific reasoning patterns and breaks the conventional (computer scientific) research methods. These new ways of thinking and dealing with technology might be useful in research done in computer sciences. He experienced that it turned out to be an approach unsuitable for scientific research as the outcome of his 'Wild Thinking' courses was mostly 'aesthetic' projects, not something to be evaluated in a scientific context. The starting point Haring takes for his approach is in agreement with Feyerabend, who refers to unconventional thinking as a catalyst for unexpected reasoning patterns as fertile ground for invention and new scientific discoveries. According to Haring, 'Wild Thinking' works as a collision but it does generate mainly aesthetic works, not the planned impulses for scientific breakthroughs. Here some clues for Feyerabend's inquiry for 'Wild Thinking' are discovered, and the intentional clash should be considered as part of the artistic method. The artists in Haring's Masters program however, are better equipped to take advantage of these collisions and have their personal heuristic 'collision method' in place.

2.2.4.3. Confronting motives: conclusion

artist's attitude to science & technology	aRt&D method	collaboration's characteristics	Theoretical context / Matching approach(es)	Interdisciplinary output application domain
Self-sufficient	***DIY and hacker method***	Misinterpretation / re-interpretation protest / activism via alternative methods, mostly small scale	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, relevant in multi disciplinary collaborations often autodidact multitasker, exchange with other independent operators, FLOSS development	think tank or brain storm approach, engagement, Critiquing, awareness, empiric or practical approach, single person multi tasking, artist-commentator, engineering, hackers

(fig. 7 aRt&D matrix DIY method)

The intended or provocative collisions are deeply rooted in art practice, and thus have their own objectives and generate their own dynamics. With the cultural activist, we finally encountered the artist who is trying to save the world. Although the goals seem to match with the expectations of the scientists (see chapter 2.1.), obviously most artists operating in this field stress the importance of ideological independence for their actions. Because of this, cultural activism is often less suitable for collaboration due to the research agendas of larger research centres. Autonomy and tactical use of media are among the essential conditions for the cultural activist's practice.

Earlier in this chapter, the case was made that what might be called 'Wild Thinking' doesn't necessarily lead to scientific breakthroughs. 'Wild Thinking' seems to be a self-evident aspect of the heuristic artistic method, but is not always suitable as a remedy for poorly functioning science. The intended collisions, like deconstruction, are crucial ingredients for artistic social engagement. This engagement should not be confused with social work; in the given examples, it is expressed as cultural activism or as a commentary on technology or society. The cultural activist or artistic hacker is affiliated with the empowerment of the user/consumer.

Contemporary art and technology practice shows elements of the intended collision approach in artistic research where the artist is the researcher who investigates the imperfection of technology as a source of inspiration for hyper-real experiences. The repurposing of technology as a crucial part of the colliding method includes surprises or unpredictable outcomes, which indicates that this is mainly an artistic research trajectory. Wilson has also observed this; he suggests that artists could set additional topics for the research agendas, in fields overlooked by industry or academia. This implies a meta-research trajectory in the research landscape: one reads about opportunities for artists exploring new application fields or re-purposing existing research and development trajectories which could turn into interesting artworks and/or be catalysts for new scientific research.

2.2.5. Connecting approach; *processpatching* method

Processpatching is the proposed method for the artist as connector or bridge builder between disciplines. The artistic connecting approach, or the 'artist as connector', refers to artists who consider something or someone to be related to something or someone else. *Processpatching* has its roots in the arts without being formalised as a method. *Processpatching* is the new term I use for mixing and re-interpreting a plurality of methods into the artistic method. As laid out in this section, the term *Processpatching* is chosen as an associative, connecting approach, which is similar to the process it describes. This section will elaborate on the related theory and broader context of connecting and *processpatching* first as these terms are newly introduced in this study. This is followed by the art context, interdisciplinary context and science, technical and design contexts.

> *'The possibility that all this knowledge may one day be unified in a handful of mathematical formulas is less impressive than the urge that lies beneath it: to use human inventiveness to fearlessly search for ways to further promote human inventiveness itself. From this perspective all of these fascinating studies, devices and books of the past 50 years are not ways of getting a grip on the world (with all of the resulting social, political and economic control technologies), but ways to push imagination, creativity, critical sense and playful tendencies to higher grounds.'*
> *(A. Mulder, M. Post)*[137]

Mulder and Post clearly outline the difference between a scientific search for a unifying theory (Ridley.2.1.1.1.) and an artistic fascination for new connections and new meaning through re-contextualisation. It is typical of many art and technology works that they are combinations of several techniques and methods borrowed from different disciplines. This connecting approach shows us how other (non-technical) fields can be useful in working around those issues that are hard to solve with current technology or that are difficult to express in machine-understandable language. The verb 'to processpatch' is used to describe this attitude. *Processpatching* represents the less formal and more intuitive approach to research and development. It has a strong emphasis on the creation of new aesthetics, which are created via new combinations or repurposing of existing materials and methods.

Processpatching refers to the aRt&D process of electronic or interactive art, where different things are connected for the creation of an art experience, or an art project in a broader sense. The term is a blend of two words that both encompass a range of meanings and associations.

> *A Patch links to several different things, these are the once relevant for electronic art practice :*
>
> *A piece of fabric.*
> *An electrical cable (patch cord) which can be used to alter the functionality of a piece of electrical equipment, such as a musical synthesizer. This can be extended to virtual "patches" in software or electronics.*
> *A telephone patch is any connection between a phone line and another communications device, whether it be a radio, a tape recorder, a data device (such as a modem), or even another phone line.*
> *In amateur radio, a phone patch connects transmitters or receivers to the phone line for phone conversations.*
> *A set of "diffs" (differences) suitable for input to the patch program. Patches are a common way of supplying small updates to pieces of software where the source code is available.*

A fix for a software program where the actual binary executable and related files are modified.

(source Wikipedia)[138]

A *Processpatcher* is someone who pieces expertise, approaches, techniques, and materials together in an associative way. *Processpatching* is not a literal translation of the two words of which it is comprised; it is an associative new term with references to different aspects of the electronic art research and development process.

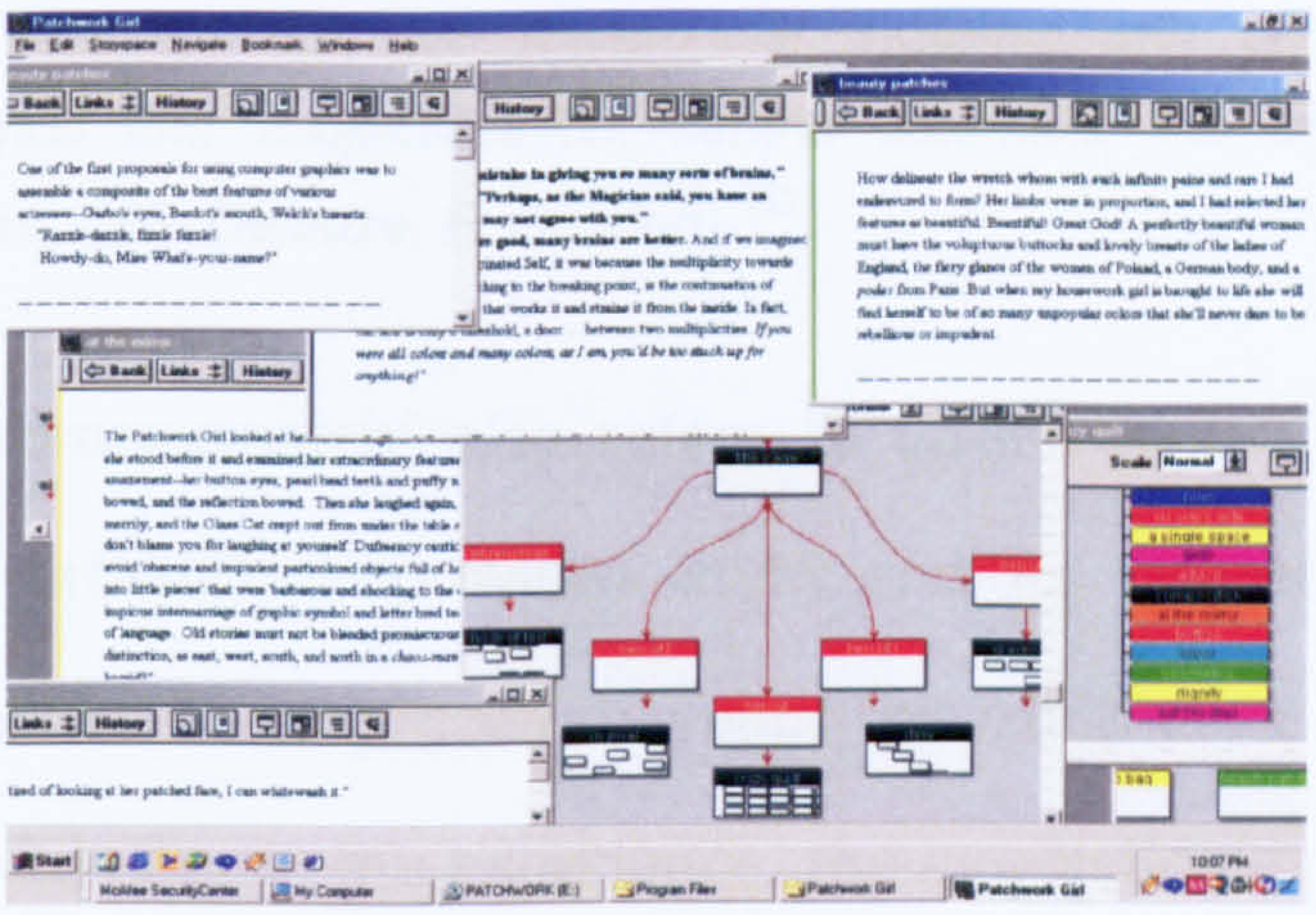
Processpatching is, in the first place, a poetic word with associations and references to the process as a series of actions, changes or functions bringing about a result, or a series of operations performed in the making or treatment of something. The term as such refers to the artistic iterative research and development process. Process refers in this context also to the (social) interaction process as part of the interactive electronic artwork, and has a strong association with experience design, rather than exclusively to 'product' design. (see also Chapter 1. *The processpatching* context) Patching, as the second part of the blended term, hints at the dynamics of software development where a patch is a piece of software code to fix a bug or to create a new, additional functionality or feature. In communication technology from the past there are other references to patching, for example, the patchboard as a matrix to establish telephone connections. Further down the ontology of *processpatching*, one finds references to patchworking. Patchworking refers to needle work, to quilting bees and sewing circles, where the creation process is a social act. From needle works, Sadie Plant's[139] allegory of weaving and computing vaguely refers to our notion of *processpatching*. *Processpatching* shares the reference to analogue and digital techniques, as well as to the associated gender of its operators. However, *processpatching* (like patchworking and quilting) differs from weaving, whose framework and boundaries are predetermined by the frame or measures of its loom. The endlessness of *processpatching* and the absence of technical boundaries or limitations fits better with our need to (electronically) stitch together whatever suits best. Nevertheless, the intuitive, non-linear, associative and communicative aspects are often associated with femininity. *Processpatching* is not thus gender related, although it bares associations with communication, creation and technology.

The *processpatching* method is a creation process where different kinds of analogue and digital materials are stitched together. This practice of stitching and patching things together has a direct link with rhizomes, as advanced by Deleuze and Guattari.

> *'The principal characteristics of a rhizome : unlike trees or their roots, the rhizome connects any point to any other point, and its traits are not necessarily linked to traits of the same nature: it brings into play very different regimes of signs, and even nonsign states.' (G. Deleuze, F. Guattari)*[140]

Deleuze and Guattari bring forward another reference to a characteristic aspect of the artistic *processpatching* method. They see a direct parallel between rhizomes and the associative artistic practice of connecting things according to a network topology, which contrasts the tree-like linear structure, the latter of which is attributed by them to science. This mix of heterogeneous regimes is translated in the connecting approach or an assemblage of different multiplicities that changes as it expands its connections. The Processpatch aesthetics are embedded in the dynamic process of connections and their endlessness. *Processpatching* also refers to filling gaps. In this case the artistic patches bridge the disciplinary methodological gaps; the artistic patches bridge the disciplines. A Processpatch is a connection, or association, and subject to constant modification. It can be torn, used or reworked by a group or an individual. The latter refers also to audience participation and the user centred aspect in interactive participatory works. Elements of this approach are comparable with the collaboration model in the 'Open Source' and 'Free Software' communities. In both cases, as in multi- and interdisciplinary collaborations, the authoring process is partly in the hands of the group.

Finally, the Patchwork Girl represents the playful feminist reference to *processpatching* like in the hypertext narrative by Shelley Jackson. This patchwork girl embodies the ultimate form of flexibility because of the user's interaction; the main character's appearance is constantly re-configured and re-constructed in a Frankenstinian way.



(fig. 8 screenshot from Patchwork girl by Shelley Jackson)

The term 'bricolage', as used by Claude Levi-Strauss,[141] also relates to *processpatching*, in the sense that it also refers to art as a bridge between, what he calls, scientific and mythical thought. However Levi-Strauss starts from a structuralism's point of view in anthropology. He claims that *'the bricoleur is adept at performing a large number of diverse tasks...'* in contrast to the engineer. Levi-Strauss' use of 'bricolage', rooted in anthropology, refers to constructivist bridge builders between different knowledge fields. He brings in references to linguistic systems and formal methods based on the constructivist's approach. The constructivist's formal method, with clear parallels to linguistics, is often problematic in artistic works as firstly, the artistic intentions are often not easy to catch in language and secondly, a formal or (specifically in the field of software based art) algorithmic format, is not the one and only ideal for artistic methods. Indirectly, this affirms Deleuze and Guattari's theory where they propose the rhizomatic approach for associative artistic work and the linear tree structure for structured scientific work and language.

'Arborescent systems are hierarchical systems with centers of significance and subjectification, central automata like organised memories. ' (G. Deleuze, F. Guattari) [142]

The verb 'to processpatch' also refers to do-it-yourself actions and to a certain free (artistic), improvised style and its related aesthetics. The importance of aesthetics goes beyond the aesthetics of an object or subject, but often lies in the experience, the interaction or the ephemeral.

'We believe that the experience of interactivity (..) emerges at the convergence of a series of paradigms which pursue the passage from an aesthetical theory of the object (visible) to an aesthetical theory of the experience (invisible, felt, 'from the inside': environmental, inclusive, participating, relational aesthetical theory) and of a technologic scientific school of thought, persisting and developing, substituting the notion of object with that of machine (systematic, cybernetic thought).'
(E.Quinz)[143]

Emanuelle Quinz represents a growing group of theoreticians who explore a suitable or updated vocabulary for interactive art. In this context, the role of the audience and participant is of crucial importance in establishing the aesthetic experience; without the participant nothing happens, or boldly stated, without the participant there is no artwork. However, the audience does not usually make the aesthetic choices. These are made in the software code; in the way things (analogue and digital) are patched together. The program or source code and the patches are where the framework for interaction and the aesthetic experience is pre-designed. The focus on aesthetics also includes references to a larger art, design, social science and technology discourse. Later in this chapter I come back to some specific aspects of aesthetics in detail. In the overview about the artist's role and methods, the *processpatching* category is an independent entity in its own right.

2.2.5.1. Connecting approach: Art-context

The connecting approach is inspired by the artistic tradition of re-purposing and re-contextualising objects as seen in the Dada and Fluxus movements.[144] Both movements in art generated a new (audio) visual language and new notions of aesthetics through mixing and combining or blending materials and concepts. Fluxus' participatory performances, happenings and installations are often seen as forerunners to today's interactive art. The pioneer of video and electronic art , and former Fluxus artist, Nam June Paik states about his explorative practice:

> *'Reaching out into the boundary regions between various fields, and complex problems of interfacing these different media and elements, such as music and visual art, hardware and software, electronics and humanities in the classical sense..' (N. Paik)*[145]

Paik represents the artist as *processpatcher*, who works on extending her/his practice through a constant skimming and exploration of the nearby fields, borrowing and exchanging knowledge and expertise, and gluing the found pieces together according to often surprising logic or intuition.

> *'Paik connected the theory of cybernetics, in which the interdisciplinary approach was a major principle, with his own*

experiments that crossed over to different disciplines. In his writings he regularly refers to Norbert Wiener's and Marshall McLuhan's theories in relation to his own ideas of the communication aspects of art.' (M.Bijvoet)

Bijvoet points us to Paik's connecting or *processpatching* practice, as an artist who draws from theory and practice from a range of art disciplines, engineering, social science and cybernetics. In the process of connecting different areas or disciplines, most artists do not limit their selection to computer science; social or cultural processes relevant to the concept are often linked into the collaboration network. In contrast to the earlier discussed problem solvers, artists often act as 'problem creators' by fulfilling a 'knitting' or connecting function, bridging different fields, from which knowledge and research results are 'borrowed' to be placed in a new artistic context. This attitude often leads to unexpected and surprising combinations. The artistic process of patching, knitting and connecting, is aimed at the creation of (new) meaning(s) of technological research and development and the impact of technology on our perception. This refers to one of the characteristics of the role, or maybe even method, of artists who work in interdisciplinary contemporary art and technology practice. There are some hints or suggestions found here and there in literature, most closely in the theory of Weibel, who calls art a method. We should note that Weibel uses the definition of a 'method' as proposed by the French physiologist Claude Bernard (1813-1878) who refers to 'method' as the experiment at large which includes the laboratory, the environment, material, personnel, the incidents and so on, which is different from Descartes who refers to 'method' as an analytical model. Connecting and patching ought to be seen in the context of mixing a plurality of methods. Weibel sees a comparable interest in the methodology of Feyerabend and art methodology, and Weibel refers to the social construct of science shown by Feyerabend in comparison with social constructs in art. One should be aware of the fact that art practice does not limit itself to working exclusively with (today's) technology, art and technology practice also draws from non-technical disciplines and traditions. In the artist's kitchen, 'fusion kitchen' is a favourite. Artistic patching and connecting generates new combinations or blends of research, art and social fields *that* inform and expose each other.

> *'The aim is to produce a new kind of information that is not introspective but combinative, outward-looking and seeking new connections, (....) in this way, artistic research can also have a meaning that is wider than its own narrowly conceived discipline' (M. Hannula, J. Suoranta, T. Vaden)* [146]

The authors elaborate on the importance of choosing the relevant and most suitable research method, though there is no mention of the *processpatching* or connecting approach as a re-mix of methods in one single art project. In their publication, they cover the arts at large. In their vision, the artist's liberty to choose from a range of methods is defined as a way to create new connections with other fields, and the authors are not outspoken about the function of connecting or *processpatching* as defined earlier in this chapter. This directs us to an important nuance in the definition of this method. *Processpatching* or connecting goes beyond 'being informed' or 'being inspired' by other fields. In the context of interactive art, it also refers to aspects of materiality, whether this is physical matter or ephemeral.

2.2.5.1.1. Artistic innovation

Processpatching directs us to another kind of artist-innovator. After the technological innovation, (2.2.3.1.1.) the second group of artistic innovators focus mainly on innovation in the arts. This is often driven by technological exploration and here the main motivator is the extension or renewal of artistic means of expression. It might be obvious that, for the multi-professional artist and inventor, there is no need to distinguish between technical and artistic motives. Art inventions are not only related to software and hardware inventions; the modern engineer, painter, animator and filmmaker Oskar Fischinger, for example, already patented his Lumigraph device (1953)[147]. The Lumigraph is a puppet theatre-like interactive projection screen, made of a stretched cloth sheet that could be pressed from behind by the operator's hands or objects to intersect thin sheets of light that were controlled by foot pedals.

The artist-inventors who work more according to the conceptual art tradition are less occupied with the pragmatic or the general appliance of their inventions. Examples can be found in the dynamic objects of the Belgian artist, engineer, physicist and inventor Panamarenko[148], who builds conceptual prototype machines that deal with concepts like space, movement, aero- dynamics and gravity; or the Dutch artist, inventor, and science educated Theo Jansen[149], the constructor of animal-like skeletons that are able to walk on the wind.

Many technical developments in the past catalysed artistic innovation.

> *'I have drawn the conclusion that the artist's approach to technology can and will lend new life to their stagnating methods, which are often in contradiction with the functions of the epoch of reconstruction.' (V. Tatlin)*[150]

Tatlin states this from an early machine-art, constructivist point of view. Here the artist is supposed to sufficiently master the technology and / or materials, and Tatlin does so for formal exploration. Examples of artistic research and development, which brought along artistic innovation, can be found in the field of photography, film, kinetic art, machine art, video, and the more recent digital media.

Commonly cited works include the experiments from the early 1920s onwards by Man Ray[151] who explored the technical potential of photography and film. Ray experimented with lighting, printing, filters and animation techniques to discover new form of artistic expression. Though he was believed to be a great technical talent Ray stated that the exploration of new aesthetics was the main motivation for his research, not the technical crafts. Ray represents a larger group of artists who study their medium, and through their experimentations, they design their own media technology, or transform known technology for entirely different purposes. This kind of experimentation, and the desire to fully understand the technological matter, has its traditions in many disciplines as the Van Eyck[152] brothers already demonstrated with their oil paint invention. In the 1970s and 1980s the introduction of the medium of video brought a new flock of artistic pioneers. Among those pioneers were Nam June Paik (2.2.5.1.) and the Vasulkas, who explored the possibilities of real time recording, the video signal, the lengths of tapes, and the camera as audience, etc.

> *'The work of 'pioneer' video artists Steina and Woody Vasulka can be characterized by a continuing inquiry in the electronic processing aspects of the medium 'video', form an innate desire to understand at first the inner workings of electronic phenomena, and alter of digital ones. In so doing, the artists have not only made a major contribution to art, but also to the development of image processing.'(M. Bijvoet)*[153]

Paik and the Valsukas also worked in a field prior to the video pioneering: music. Music and audio research was, like video and film, related to artistic research in kinetics and performance art. These experimentations also included collaborations and the blurring of disciplinary borders. In the field of audience participation and interaction, Marina Abramoviç and Ulay have been a source of inspiration for their integrated works combining video with action performance, experimenting especially with the social interaction in the audience-performer relationship.

Music (and later electronic music) took off at a much faster speed than the visual experiments, as seen in the work of John Cage, Karl Heinz Stockhausen and Pierre Boulez.[154] Parallel to these developments, artists were working with kinetics[155], machine-like art pieces embodying the industrial age's time and dynamics. In particular, elements of the material-oriented research approaches known from mechanical kinetic art (e.g. the work from László Moholy-Nagy[156] and Jean Tinguely[157]) can be found back in machine art and robotics. In the Netherlands, artists/engineers such as Dick Raaijmakers,[158] Michel Waisvisz[159] and the co-founders of STEIM[160], V2_, Institute for the Unstable Media,[161] Time Based Arts and the Appel worked as pioneers in this experimental field. All these artistic research trajectories explored new materials or new media and pushed the disciplinary boundaries led by their search for new artistic means of expression and aesthetics.

Laurie Andersen is another world famous artist whose work reflects an ongoing exploration of aesthetics, materials and genres. Anderson is pushing and redrawing the borderlines of disciplines in her electronic music, multimedia, language performances and other art projects.

> *'Her complex and multifaceted art crosses and mixes genres with witty grace (she is musician, singer, dancer, sculptor, poet, photographer, technology-freak) and renders these persistent subjects: her country - the United States - and what it means to be an American adult today.' (P. McCorduck)* [162]

Another outstanding example of this 'material' research can be found in the oeuvre of the late Dutch composer, theatre maker, painter, and visionary Jurriaan Andriessen[163], who frequently crossed the disciplinary borders in his work. His most significant multidisciplinary material research is probably Hedwig's portrait that was composed of thousands of musical notes, and each part of the portrait represented a small composition.

In general, material exploration has brought forward a remix culture in audio and music over the last decades in various branches of experimental and popular music. These experiments built on techniques from tape editing by means of audio, to later visual sampling techniques. This took off at high speed when digital means of production were in the hands of the artists themselves. The artists involved in this field mostly explored the material through their own studio experiments. The electronic music assembles such as the Art of Noise took the remix culture to an extreme, as their music is composed from samples. Mixed media expert Brian Eno[164] introduced new music genres by mixing and reworking traditional styles into new blends and directions in popular music. Also in popular music artists play with remix culture, with artists such as Madonna making it her brand. Madonna is famous for her monthly or even weekly metamorphoses in looks and style. The Dutch feminist authors Hanna Bosma and Patricia Pisters[165] bring forward a summary of the styles they observed in Madonna's musical oeuvre: pop, disco, soul, dance, funk, black gospel, classical string orchestras, noise, rap, hip-hop, house, ambient, all complimented by influences from world music such as Spanish, Latin-American, Middle Eastern, and so on. Recently the dance and club scene has brought forward a range of re-mix styles, which are often live, and created by disk jockeys (djs) and video jockeys (veejees) who often work together on audiovisual shows and have created in their work an new innovative art form. One of the currently celebrated djs worldwide is the Dutch artist Tiësto.[166]

The artistic exploration of materials and techniques brings forward unexpected approaches to material usage and re-appropriation. Michael Naimark[167] writes about the anomalies in mediated sensory experiences and how different disciplines deal with these. He refers to movie-making and montage as means of transporting people in time and space in a way that is impossible in the real world, and other make believe mechanisms from animation and film techniques (such as leaps in time and continuity). Naimark promotes the image of the artist as creator of metaphor and poetry. This artistic intention is very different from most technical research objectives as these usually aim to improve the technique or technology, with physical reality as their sublime reference. Most innovations in visual technology, for example, aim for a continuous representation of our (daily) reality.

> *'In all cases, the goal is indistinguishably from first-hand experience in the physical world: 'just like being there.' Such VR doesn't exist and may never,(..) So for now, we live with even the best sensory media having some degree of anomalies, these anomalies are not intentional, and entire industries exist to make higher resolution cameras, better synthesized lighting models and auto-stereoscopic display. The goal is not about creating metaphor and poetry but about re-creating a multi-sensory experience that is as consistent as possible.' (M. Naimark)* [168]

Here it is observed that artists repurpose technology or its shortcomings to invent or create new artistic expressions. This illustrates the gap between the different disciplinary perspectives and research objectives, artists knit together different technological areas and anomalies in technology to achieve something that is totally out of the technical realm. The anomalies and shortcomings of technology and machinery are, in a more general sense, crucial elements of artists' appreciation of machine aesthetics.

2.2.5.2. Connecting approach: Interdisciplinary context

The connecting approach in the interdisciplinary setting directs us to Marcos Novak's concept of *transvergence* as a separate space or entity located between the disciplines.

> *'While convergence and divergence are allied to epistemologies of continuity, transvergence is epistemologically closer to logics of incompleteness, to complexity, chaos, and catastrophe theories, dynamical systems, emergence, and artificial life. While convergence and divergence contain the hidden assumption that the true, in either a cultural or an objective sense, is a continuous land-mass, transvergence recognizes true statements to be islands in an alien archipelago, sometimes only accessible by leaps, flights, and voyages on vessels of artifice.'*
>
> *'Central to transvergence is speciation. We want to draw proposals that constitute new species of effort and expression and that both enact and reflect on our construction of new species of cultural reality -- not by being merely novel mutations within known areas, but by boldly challenging known areas and yet being potentially viable to the point of becoming autonomous entities -- not dancing about architecture or architecture about dancing, for instance, but dancing architecture... or, better still, something else, as yet alien and unnamable, but alive and growing.' (M.Novak)*[169]

The artist in the role of the *processpatcher* thus refers to the mediation in this in-between space that provides room for the free style of putting together knowledge and concepts from the near disciplines. The *processpatcher's* main objective in these situations is to realise a novel artistic concept, an experience or an interactive process. The innovation arises from the way methods, themes and techniques are put together or combined in new compositions. The invention of new techniques or approaches could possibly come along during the process of art making, and in turn, this could lead to renewal or re-definition of the art practice. This will be investigated in more detail in the case studies in chapter 3.

Several contributions in 'Explorations in Art and Technology' also point us to the artistic method, although this mainly refers to the way people work together in interdisciplinary settings. Dave Everitt[170] refers to his practice being primarily concerned with working with different kinds of information, and the combination of knowledge, issues, digital methods and so on, without a central concept. He refers to the iterative, explorative way of connecting different pieces and methods relevant for his digital artwork. Candy and Edmonds bring practice-based action research forward as a suitable method for interactive works developed by interdisciplinary teams. This method draws from Human Machine Interaction design, and relates directly to design practice. They consider the rapid turnover, direct feedback from the end-users or participants, and the integration of research and practice as the core advantages of this approach. The research Candy and Edmonds refer to is constituted from multiple views: the analysis of the user interaction by the collaborating parties, the participant and the external observer. This method was also used in the art and technology research programme Creativity & Cognition Research Studios, at Loughborough University (UK), run by Candy and Edmonds to obtain more generic insights in the art and technology practice. Their description provides us insight into combining practice with research, and the evaluation process that is done by the different parties while stepping back from the event to evaluate it. Although it mainly reads as a way to embed artistic research in a scientific environment, Candy and Edmonds do not refer to one specific artistic method. Their aim is to facilitate the creative process and let the artists be treated as equally as the technologists. To facilitate the communication among collaborators with different backgrounds, they work with drawing as a boundary object (see also later in this chapter).

After these literature investigations, we still lack information about a large part of today's methods applied by artists working in interdisciplinary collaborations. The few resources suggest a certain direction, but none is outspoken about the method(s) itself. One needs to take into consideration that the problem of representation of the artist is further complicated by the (recent) blurred disciplinary borders in the creative field, where an increasing number of artists work in different practices. These combined professions make it even more difficult to be exact about the role of the artists in collaboration teams with designers, engineers and computer scientists. It seems therefore relevant to study the research themes where interaction among art, science and technology most frequently takes place.

In a general sense, literature and practice direct us to the field of Human Computer Interaction as the main topic of overlap and shared interest among those working in art, technology and science teams. This field encapsulates a range of emerging subfields, such as human machine interfacing, system design, artificial intelligence, artificial life and affective computing. Below the most relevant literature available is discussed, and it deals with research and development methods in some of these subfields.

2.2.5.3. Connecting approach: Science, technology and design context

Indeed, as suggested by Weibel, mapping the connecting approach or Processpatching method to science studies, shows us interesting parallels with the 'Against Method' of Feyerabend. At first glance, this might read as a contradiction, as Feyerabend argues against (scientific) methodology. The link between the *processpatching* method and Feyerabend's theory however, can be found elsewhere. Freyerabend's publication aims to break the paradigm, to leave the general methodology and to open the field for knowledge growth, progress and innovation. In this research on artistic methods, the provocative reference to the artistic research and development process as a 'method', underlines my conviction in the positive effect of breaking the paradigm in the arts where the romantic imago of vagueness and mysterious art making processes still prevails (see also 1.1.). The variety or plurality of methods that are remixed in the Processpatching method, although achieved from the opposite direction, come close to Feyerabend's credo that 'Anything Goes'. On a conceptual level, Feyerabend's theory and the suggested theory of this investigation could intersect with each other in a Third Space or in the zone of *transvergence* between the disciplines, where the obstructing disciplinary paradigms from both sides are evened out. Ridley[171] who states that artists go further in applying 'anything goes' approaches than scientists, underlines this. Ridley mentions, in his plea to save the world from scientism (2.1.), the importance of plurality and diversity as one can see in the arts. He makes this clear by comparing what art and science have to say. Science informs us through uniformity, while art deals with unique plurality. This plurality demands a clear analysis as it also relates to the collisions mentioned earlier. The communication difficulties raised by the vagueness of unpredictable aspects of this connecting or plural approach should be looked at in the right perspective, as most artists do not intend to build facts or create 'black boxes', as Latour[172] describes scientific work. In a general sense, interactive electronic artists are establishing dynamic, fluid processes in which the aesthetics and ethics of the (social) interaction or experience is of crucial importance. It is hard to communicate these goals or intentions in a clear jargon, as we (Western art and science discourse) lack a vocabulary to describe unpredictability and instability or 'openness' as positive, valuable features of the work.

2.2.5.4. Connecting approach: conclusion

Artistic aim, objective	Method	Characteristics	Theoretical context / Matching approach(es)	Type of aRt&D, type of collaboration, application domain
re-contextualising technology, creating new connections	*Processpatching*	(re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,	Fundamental / basic research and experiments in social science ,Multi and interdisciplinary collaboration, art as method. blend of techniques and methods, anything goes, bricolage

(fig. 9. aRt&D Matrix processpatching method)

Processpatching is an informal, intuitive artistic research and development approach for interactive electronic art, where all kinds of ephemeral digital parts and (analogue and digital) materials are stitched together in an intuitive way. It has a strong emphasis on aesthetics, the social aspects in the process of creation and it is user centered. *Processpatching* is a rhizomatic, bottom-up approach, and distinguishes itself from science which has a tree-like structure. *Processpatching* bears reference to electronics, software development, feminism, interaction processes and 'bricolage'.

The (recent) interactive electronic art tradition (2.2.5.1. and 2.5.5.1.1.) provides us links to other interpretations of work from related fields, and examples were given where concepts, objects and technology were re-contextualised or re-purposed. This habit of re-contextualisation relates to re-mixing or knitting together different fields of research and development, which all bring along their own approaches and methods. The interactive electronic artist as art innovator (2.2.5.1.1.) is someone who explores technique and mixes methods and objectives to renew or innovate artistic practice, which in turn could also bring along a refreshment of the other involved disciplines. However, here the main objective is to expand or renew the art practice, which can collide when combined with technical innovation. Although there usually is a component of a material study embedded in interactive electronic art innovation, its main motive is the search for new aesthetics (generated through specific use of the medium). I used the concept of *transvergence* by Marcos Novak (2.2.5.2.) which refers to a space between the disciplines, as a separate entity, to define the work arena for *processpatching* in the interdisciplinary context. Here methods and concepts from other disciplines, tech and non-tech, can be re-contextualised and patched together in unexpected ways. The electronic artists act as mediators between the disciplines without necessarily migrating to these remote disciplines.

Ridley's plurality of methods to counterbalance the search for a unifying theory relates directly to the concept of Processpatching.
There were indications (2.2.5.3.) that Feyerabend's theory, calling for the scientific community to move away from methods, and the suggested artistic methods in this research could meet each other in a Third Space or *Transvergence* zone between the disciplines. In the next part of this section, the most common approaches, methods and concepts that are used, tagged together or remixed are investigated. The flexibility,

improvisation and focus on the process also gives some new directions for investigation of *processpatching* as an artistic method.

2.2.6. Examples of methods for connecting and *processpatching*

The following part of the literature chapter discusses the most commonly used and 'borrowed' ideas and methods from a range of artistic and various other disciplines. These methods and approaches are re-mixed or re-appropriated according to a truly connecting artistic approach or *processpatching* method.

The ingredients for the artist's kitchen are taken from performing arts where improvisation methods are studied, from design practice where ideas from participatory design are studied, from software development ideas that are borrowed from the Free Libre Open Source Software (FLOSS) approach, from interaction design we look into the concept of Third spaces.

2.2.6.1. Connecting and *processpatching* methods: Interaction and participatory design

This section deals with collaboration, research and development approaches in the creation of interactive electronic art works.

> *'Expanding on the concepts of movements such as Fluxus and conceptual art, digital technologies and interactive media have challenged traditional notions of the artwork, audience and artist, the*

artwork is often transformed into an open structure in process that relies on a constant flux of information and engaged the viewer / participant in the way a performance might do, the public or audience becomes a participant in the work, reassembling the textual, visual, and aural components of the project'
(C. Paul)[173]

Christiane Paul continues with the changing role of the electronic artist as mediator to facilitate this process of interaction and audience participation. This also affects the research and development process, where the early inclusion of the participant brings us to the most important aspect of participatory design. The process of this type of art making is a collaborative process, not only with the programmers, engineers, or scientists, but the participant in the interactive artwork also plays an active role in the design process. Design and art share the exploration of aesthetics and design of the meaning of fluid, ephemeral, interactive processes and experiences. This makes it relevant to investigate the opportunities and value for interactive experience design and (human computer) interaction design.

From the interactive art field Marina Abramoviç and Ulay were referred earlier (2.2.5.1.1) for their experiments with duration and live (often very physical) interaction. Their performance 'Imponderabilia' [174] (1977) where the two naked artists form a corridor, which the audience can only pass sideways, teaches us about the shifting role of art, artwork and audience participation in open artworks[175]. In 'Imponderabilia' the artists provided a framework or the parameters for what only becomes the artwork through audience interaction. They shift social patterns, provoke intimacy yet play with power structures resulting in humiliating reactions of the participants.

From the information technology field, participatory design has its roots in labour improving programs in Scandinavia. The trade unions wanted to empower the workers in the decision process about systems designed and used for automated work or adjustment by machines on the work floor. An important aspect of these arrangements was that the workers themselves participated in the design process[176]. This all sounds nice, but where and how should the audience and the various disciplines be included in the artistic projects? As this is one of the keys to a successful implementation of participatory design in artistic research and development, in particular because it often doesn't deal with concrete products or processes, the level of abstraction makes it difficult to predict the effectiveness of the collaboration and the participants' involvement.

Hannula, Suoranta and Vaden bring forward, on a practical level, several approaches to artistic research in a general sense. Among these they mention the collaborative case studies, with references to participatory design and action research. In their vision, researchers involved in collaborative case studies study and develop together, and the audience or participants thus become co-developers. Traditional views of research objectivity do not apply in collaborative case studies, and they formulate this type of research as an open activity.

'the goal is to improve the actual state of things through the activity of the participants, which is based on self-reflection and self-evaluation, on the basis of practical deduction.' (Hannula, Suoranta and Vaden) [177]

Nathan Shedorff and Tim Plowman[178] refer to design issues in participatory work as a bottom up process, and lead us to participatory design and participatory action design. Among other authors from the design field they compare participatory art and design with social science and suggest collaboration with ethnographers or experience designers in order to borrow methods from them. Although again, one does need to keep in mind that most participatory art intentions are usually not to solve problems and save the world but to pose problems, raise awareness and contribute to a critique or refer to social coherence.

Candy and Edmonds[179] also refer to participatory design as the most common used method in the interdisciplinary field of Human Computer Interaction (H.C.I.). They argue that the participatory design method is a possibility to escape from the urge in H.C.I. to transfer research results quickly into general principles, something that often conflicts with building scientific knowledge. The data gathering consists of various mechanisms such as field diary notes, questionnaires, interviews, and case studies. They also mention the feedback loop and the constant monitoring of the participants. Candy and Edmonds give us some clues but do not provide us much information on how the collaborators deal with the aspects of participatory design. In their field studies, this was mainly applied as an evaluation method. However, the method we are searching for is not only about evaluation. We look for information that can help us to work according to an iterative bottom-up approach with a team of different disciplines and participants. This leads us to participatory action design.

In relation to participatory design, Wadsworth[180] provides a clear overview of participatory action design approaches. This is worthwhile investigating for our purposes as this approach takes into account the (social) process rather than the product. Participatory action research is mostly used in community work and business management process. It deals with bringing the problem of the situation / action / practice to the surface in order to develop a deeper understanding to produce new knowledge and change our actions. It differs from conventional research due to its iterative and cyclical approach, and it focuses on practice and ethics. As does participatory design, participatory action research includes the participation of other human beings, other than researchers. Different from today's most applied participatory design approaches, participatory design research includes the participant throughout the whole process, from beginning to end, and allows an evolutionary role of the participants, which eventually could cause the research subjects to become co-researchers by the end of the process. For these reasons, action research should be regarded as a biased form of research, rooted in a much older tradition of anthropology (distant observer versus the participant). The latter makes it problematic for techno-scientists as this contradicts the peer-review system. The non-hierarchical and hands-on approach of participatory action research is closely related to recent movements in the interactive electronic arts, dealing with audience participation and open systems where the participant becomes the co-author.

From research in the agricultural sector, Pam Swepson[181] promotes a combination of qualitative research methods and action research, as she noticed a self-indulgent attitude in participatory action research. Her observation is based on the science practitioners' critique on the philosophy of science. This parallel is based on the science theory of Popper that, according to the author, represents an ideal or vision instead of a methodology. So far, interactive electronic artists are mainly operating as action researchers, as there is hardly any theory about interactive electronic art methods.

Schiphorst and Andersen give other examples of combined research methods[182] when they write about the design process of '*whisper*'. '*whisper*' is a new media piece based on small wearable devices and handheld technologies. '*whisper*[s]' are wearable body architectures. '*whisper*' takes place in an interactive installation space[183]. The authors write in this paper about the work process of '*whisper*'. Dream or visualisation workshops were organised to collect data from the participants. In addition, several games were initiated to understand more about social interaction in non-competitive environments. Their approach shows a typical example of an intertwined *processpatching* approach, which includes the participatory method, and which becomes most visible when they describe the workshops as part of the participatory design process, drawing at least a dozen techniques and methods from acting, theatre, choreography, a range of design practices, ethnography and communication theory, etc.. The authors refer to '*whisper*' as an initial exploration of modelling experience, not in any sense are they referring to deliverables in all small niches of research fields listed earlier. They use parts of external knowledge and knit them together in a unconventional way to achieve something very different. The artistic research objective is usually not to change scientific paradigms[184] or research programs[185]. The outcome of artistic research does not necessarily have to be 'functional' or applicable to industry directly. For this reason, it also makes sense that the research methods are not necessarily useable as instruments for evaluation or measurement. Rather, their value can be manifested as experiences, reflection, critique and an invitation for the audience/users/co-authors to participate in the process of designing an experience. The authors propose a complicated research and development model that draws from a range of art, design, H.C.I. and engineering techniques. In chapter 3, '*whisper*' will be discussed in more detail as one of the case studies.

In another paper, Andersen, Jacobs and Polazzi[186] write about their '*IF Only*' experiments, where the participants were asked to leave a message in a (physical) box for their remote beloved ones. Here again one sees a combination of approaches including participatory design. The authors wanted to design something in a technological way but used props and placebos to gather their information before designing the technology. In the '*IF Only*' experiments, the combining of the connecting approach and participatory design provided the opportunity for measurement of interaction; one can determine repetition, pattern, and interests of each individual visitor. This mixed approach of technology and non-technological objects will be analysed in more detail in the case studies in the next chapter.

2.2.6.2. *Processpatching* methods: improvisation

The element of unpredictability in the *processpatching* method suggests a connection or parallel with artistic improvisation as seen in, for example, the performing arts. The trouble with art practice is that it is often difficult to cleanly distinguish techniques from method. Howard Becker[187] outlines the etiquette or conventions of jazz improvisation, as this and other forms of improvisation are often wrongly labelled as unstructured. The etiquette of jam sessions represents a strict framework in which the improvisation takes place. In the event of more advanced players, there will be more space available for improvisation. On a last note, Becker refers to the difference between improvisation for an audience and improvisation among the players during rehearsals. As in the first instance, the reputation of the respective performers is at stake. In the creation process and the rehearsal context, improvisation refers mainly to mastering the technique. In the act of performance, it moves close to a style or a method that can be picked up by others who also master the technique.

In the contemporary context one can look at the re-mixing culture from the club milieu as contemporary improvisation. This started to flourish in the house and techno scene where Video Jockeys (VJs) and Disk Jockeys (DJs) perform and (re)invented new artistic live performance formats. In a sense, VJs and DJs are live improvisation performers who use some of the *processpatching* concepts such as recycling, re-using and recombining materials and devices. Other groups of improvising performers who work with new media technologies can be found behind their terminals at distributed locations. They are connected and play together via the Internet and perform via diverse media streams using all kinds of software.

Sher Doruff has written about artists who used the software platform Keyworx to improvise their networked performances. Doruff [188] argues in 'The Translocal Event and the Polyrhythmic Diagram' that there is no agreed theory of improvisation, only a long-standing debate regarding the compositional attitude of choice, chance and spontaneity. Improvisation has a long artistic tradition in time based arts, team working and interaction with the audience. All of these topics are more than relevant for today's art and technology field where all these elements are present though in a different context than before. In particular, in interactive works, the unpredictable audience participation and open scenarios for interaction link to improvisation. Doruff brings forward John Cage's idea of improvisation and coined the term 'structural improvisation' that links directly to software-based art and algorithmic structures.

2.2.6.3 *Processpatching* techniques: algorithmic design

As pioneers in the field of generative art, Arnold Schoenberg and Wasily Kandinsky exchanged their research on abstraction and formal rules in the visual and sonic art in the early 20th century. Kandinsky's aim was to define a grammar for a language of visual harmonies and dissonances. In the late 20th century, this inspired a group of artists working with software art. These artists recognised the mathematical method in Kandinsky's 'Lines, Points and Planes' theory and translated this into software code and algorithms for experimental generative works of contemporary artists such as Harold Cohen[189] and Ray Lauzzana and Lynn Pocock-Williams[190]. Along those lines one can observe a series of attempts to catch the artistic expression in software code, algebra or an equation, to create generative art. Recent examples of this code-based material research can be found in the field of software art and net-art. Florian Cramer[191], who takes a technical approach to the electronic arts, underlines the far-reaching effects of material research in software art.

> *'While all the works we presented can be perceived as music, net art, generative video on their own, they have in common that they don't use software as a black box, but reflect their programming and make statement about how software influences human perception and actions.' (F.Cramer)* [192]

All these artistic research trajectories explore new material or new media and push the disciplinary boundaries in a search for new artistic means of expression.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Theoretical context / matching approaches	Type of aRt&D, type of collaboration, application domain
Innovating arts, re-contextualizing technology, creating new connections	***Process - patching***	(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, **aesthetic driven,** often large scale	**Parallel and** intersecting methods and approaches, from involved disciplines	Post- Modernism critical theory, Fluxes, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	_*Participatory method*	Iterative process, design method thought from the end-user / participant's perspective	Complicated to combine with problem solving, interdisciplinary cooperation, 3-th space	Post-Marxism, design theory, improvisation theatre / Various design approaches e.g. human centered HCI, ethnography, social sciences, communication design,	Heuristic research, experience design
	_***User centered design method***	**Design method focusing on the participant's) experience**		**communication studies , cultural studies**	
	_***Re-engineering, reverse engineering***	**Re-purposing technology**		**related to DIY and hacker approaches**	

(fig. 10. aRt&D Matrix processpatching method part 2)

2.2.6.4. Connecting approach : FLOSS

Tim Berners-Lee writes about the technical variant of the *processpatching* approach that was applied to the design of the World Wide Web, where several techniques such as hypertext and the Internet were combined and patched together. He writes about his iterative and improvised approach, and about the development process without a clearly designed plan. Concerning the success of the Web, Berners-Lee is outspoken in regard to open standards, open licences and patents, as this is the conceptual backbone of the Web, while closed standards or limitations through licences can block development. Openness seems key to the concept of Berners-Lee's approach:

> *'The internet ethos in the seventies and eighties was one of sharing for the common good, and it would have been unthinkable for a player to ask fees just for implementing a standard protocol such as http. Now things are changing. Large companies stockpile patents as a threat of retaliation against suits from their peers.' (Berners-Lee)* [193]

The Web's strength and success as a collaborative effort lies in its 'open' approach. This was chosen even more deliberately after the collapse of several early Internet applications (browsers) caused by their owners' choice to change policy from 'free use' to commercial licences. Free use or a certain kind of openness turned out to be a major trust issue for industrial investment as it indicated unreliable ground upon which to base one's soft or hardware development. In a more general sense, the Web is built on the notion of sharing and co-developing. Web technology is open and freely available in the public domain, the protocols are (still) patent free and unlicensed to encourage compatibility and interoperability.

The Internet as a (partly) public space seems crucial to interactive electronic art practice for distribution and connection with an audience as well as with other disciplines. In 'The Future of ideas', Lawrence Lessig[194] takes the ideas from his first book ('Code and other Laws of Cyberspace'[195]) to the other layers of the Internet, advocating free and open commons as a basis and necessity for innovation. Lessig distinguishes three layers: the content layer (the content accessible for the audience), the code layer (the software layer) and the physical layer or the infrastructure. Although the distinguished layers are not watertight when it comes to separating each as an entity, Lessig's categories are useful for us as it shows the dependencies of open and free development in the related layers. In particular, in the layers where content and software are intertwined one needs to be aware of the structure under the Web based artworks. In combined software and content layers for example, one is not allowed to use FLOSS licences for an artwork when it uses or is built on software that is proprietary. For this reason Lessig's argument to promote open source and free software concepts is important and useful for equal interdisciplinary collaboration, in particular to foster unexpected outcomes from which all involved parties could benefit. For the content layer, the artists/developers are interested in open content or Creative Commons approaches, which align with the software code, particularly in those occasions where one can not distinguish the code from the content as is the case in generative artworks or participatory artworks where the audience is invited to contribute and so on. FLOSS approaches show us several parallels with the collaboration models we are investigating: the open structure as known from the first generation Internet and open source/free software development offers a platform for exchange and collaboration for engineers, artists and scientists. FLOSS acts as a crucial ingredient to encourage interdisciplinary collaboration, in the code layer of the internet or software development in a more general sense. It could even be regarded the open (virtual) space, free from licence constraints and based on open standards, could even be regarded as a space where people from different disciplines, and their audiences meet, interact and change roles.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Theoretical context / matching approaches	Type of aRt&D, type of collaboration, application domain
Innovating arts, re-contextualizing technology, creating new connections	***Process - patching***	(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, **aesthetic driven,** often large scale	**Parallel and** intersecting methods and approaches, from involved disciplines	Post- Modernism critical theory, Fluxes, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	_Re-engineering, reverse engineering	**Re-purposing technology**		**related to DIY and hacker approaches**	

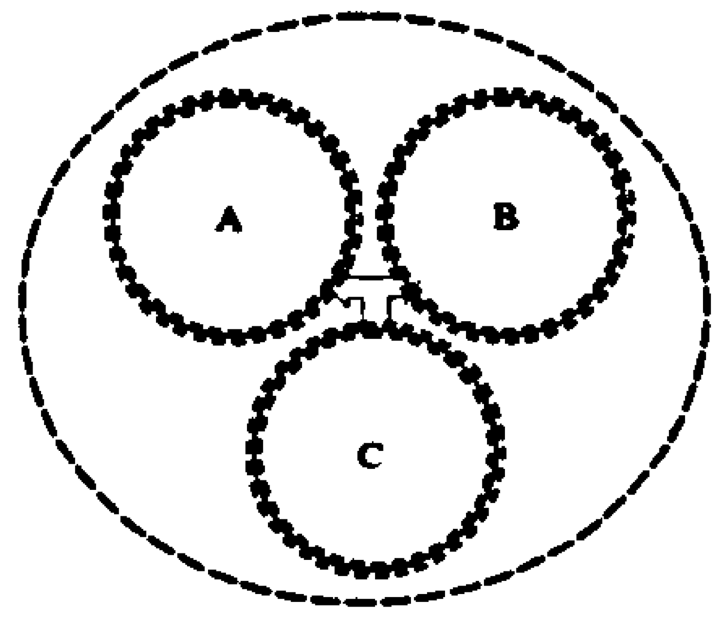
(fig. 11. aRt&D Matrix processpatching method part 3)

2.2.6.5 *Processpatching* models

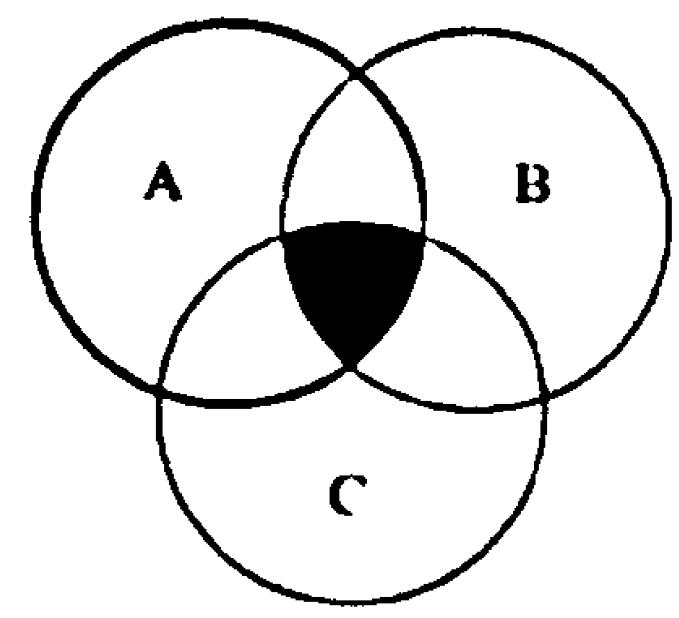
From the previously discussed frequently used methods for *processpatching*, this investigation moves towards models which could provide ideas, rules and a theoretical base for the *processpatching* method. The concept of Third space is investigated, as an option for neutral ground for collaboration. This part of the chapter provides examples and diagrams studying this space between the disciplines and how these relate to areas where disciplines converge or merge. Finally, this part of the chapter investigates the connection between this Third space and the role of the interactive electronic artist as *processpatcher* or mediator between the connecting disciplines.

2.2.6.6. Third space

In 2.2.6.4. FLOSS was briefly referred to a concept or a 'space' for collaboration and interaction. This relates directly to the concept of Third space, a term which is frequently used in design practice. Figure 12 [196] depicts a model of what the authors call trans-disciplinary collaboration; the disciplines mutate through their porous borders as each discipline is opened up for other disciplines, and a new ground in between the disciplines comes into existence. One could envision the connecting approach could use a similar model to find the suitable methods, where knowledge is exchanged or borrowed from other disciplines to renew one's own practice. The model also shows a hybrid (or third) space where the disciplines can meet and negotiate the language, methods and aims. (See also the section about participatory design 2.2.6.1.).



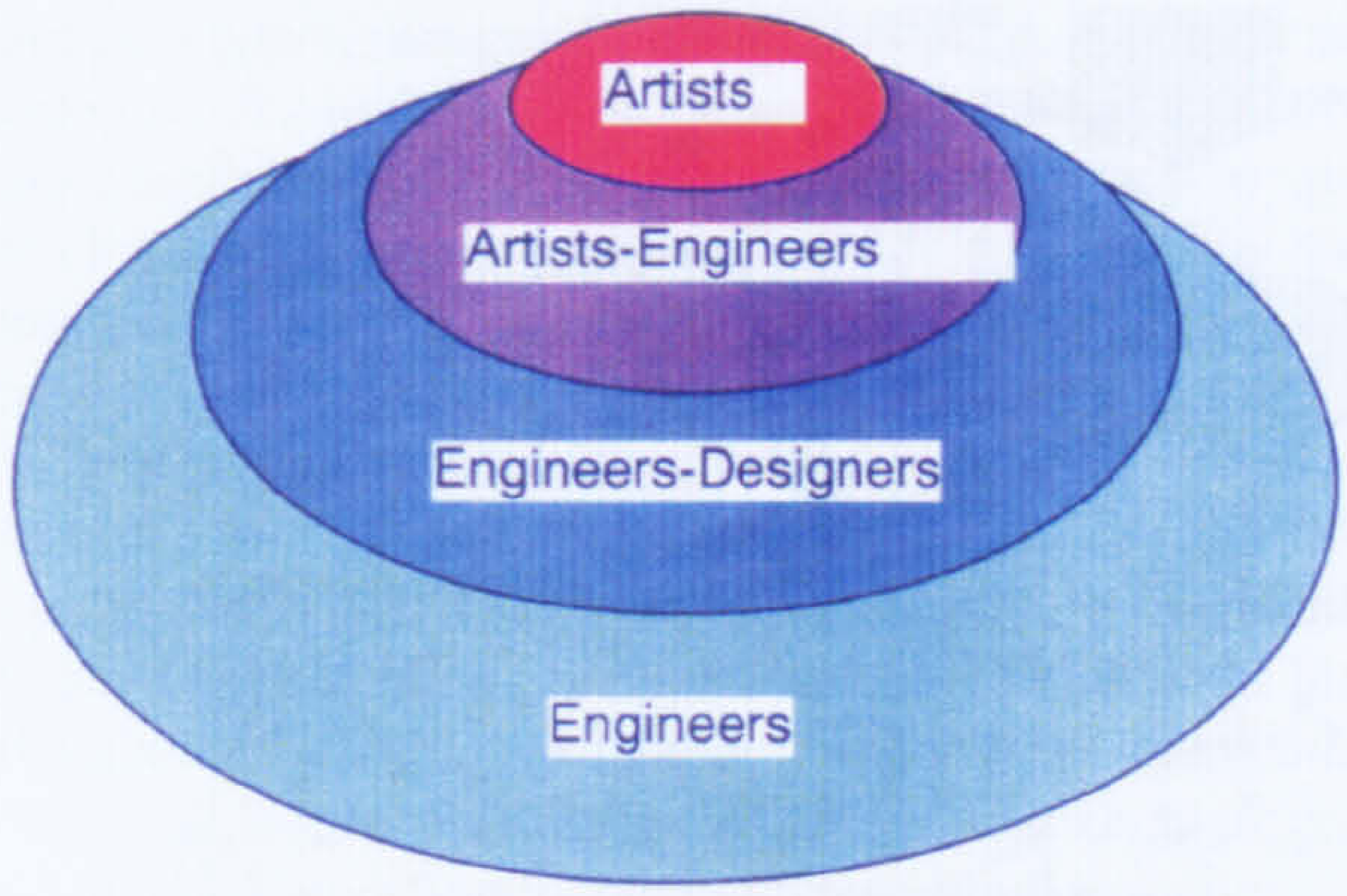
(fig 12. Transdisciplinary Mode)l



[197]

(fig.13. Multidisciplinary Model)

The transdisciplinary model (in fig. 12 transdisciplinary Model) is expected to lead, in contrast both to Wilson's theory and the cross disciplinary model (in fig. 13 multidisciplinary Model), to new fields where methods are mixed or given new input, and where all disciplines benefit, and take the relevant parts of the generated knowledge back to their own disciplines. This will inform their disciplines, (Temporary) migration to other disciplines is possible but not the main objective. The transdisciplinary model is in line with Marcos Novak's *transvergence* concept and the space between the disciplines as a separate entity. The multidisciplinary model, however, facilitates temporary migration from different disciplines toward a shared area, without influencing the established disciplines and knowledge in each respective discipline. Ryohei Nakatsu[198] refers to the multidisciplinary collaboration model for electronic art and engineering as proposed by the ATR MIC lab in Japan, a research and development lab for artists and engineers. In the very coarse ATR MIC model below, the collaborators stay in their own disciplinary domain, there is no accommodation for a shared zone for collaboration in between the disciplines.



(fig. 14 Collaboration model ATR-MIC, source art@science)

Based on the transdisciplinary or interdisciplinary model (*fig.12.*), a 'project' perspective is proposed as an overview on a meta level, where the space in between the tree disciplines is visualised. The interdisciplinary model as depicted below (*fig.15.*), now represents a team with participants who are all positioned exactly in between the disciplines. In the space between the disciplines, the Third space or the *transvergence* zone is located where the merged collaboration is expected and a new 'discipline' emerges. The original disciplinary colours represent the background knowledge that is brought in by all participants. In the middle space, one finds the persons who bring in knowledge from all three classical disciplines. In theory, a team with participants who would all be positioned exactly in the middle should not have a problem in deciding which approach to follow in the research and development trajectory as they all have all disciplinary knowledge. In our visualisation, this is the point where all visible components have been absorbed by the total mix of tints.

(fig. 15. Disciplinary view of the space between the disciplines)

Muller[199] provides an overview of the role of a hybrid space in participatory design practice that enables new relationships and understandings. For interdisciplinary practice, the idea of a hybrid or third space is of major importance as this could be the terrain where software engineers, artists, end-users meet. One can read this Third space as the space for negotiation and agreement about the workflow, aim and method. Muller refers to this as a valuable approach for collaboration among different disciplines. This space can function as a neutral ground for negotiation about work methods, terminology and relationships in the project. He aims to achieve an increased emphasis on collectivism in this third or hybrid space. As an example, Muller also refers to storytelling or drama as ways to occupy those Third spaces in workshops.

Sara Diamond[200] refers to Third space as the model she applied to position the Banff New Media Institute outside of the art world, outside of the corporation, outside of the traditional research lab. Diamond creates this Third space for the BNMI hoping that this gives room for immersive experience and space for another, non-disciplinary specific, quality of discourses and strategy.

Crawford brings forward interactive storytelling, which he considers the backbone of computer-game development, as the key area where large groups of people with heterogeneous backgrounds collaborate and where bridge-builders, multitaskers or *processpatchers* are needed. Chris Crawford brings forward the need for common ground for the sequential thinking of technicians and scientists, and the pattern-recognising thinking of artists and humanists, to meet and collaborate. Although Crawford presents us with a stereotyped vision in relation to the expertise of the referee, this is a call to think about tools, or concepts to create a zone where people from different backgrounds can collaborate. His call reflects his interest to include artists in emerging industries and to bridge the disciplinary divide between engineers, scientists and artists, humanists.

> *'Although his (Snow's) thesis caused a sensation and triggered much subsequent discussion, the problem has grown worse. Scientists, engineers and mathematicians are not just unschooled in the humanities; they actively dismiss the arts and humanities as soft-headed wastes of time. The arts and humanities people have gone just as far in the other direction: they simply refuse to have anything to do with the sciences and disparage science as linear thinking.'*
> *(Chris Crawford)* [201]

He analyses today's 'Two Cultures' divide in the field of interactive storytelling as he feels this is the field where both cultures should come together, as interactive storytelling can't be established exclusively through linear thinking or logic. He observes a recent growth of the gap between the 'Two Cultures' as mentioned by Snow. He underlines the need for artists who straddle this divide and for adjustments in the educational system to support truly cross disciplinary works. A Third space or neutral zone could help artists to truly engage with technicians and scientists and vice versa.

Vicoria Vesna[202] refers to artists working with technology as bridge builders between C.P. Snow's 'Two Cultures', which could eventually lead to the creation of a third culture, something in between the existing domains. She refers to electronic artists utilising tools familiar to scientists and collaborating with the science community, while having the freedom to make assertions that are beyond the rational and beyond the necessary methodology of proving a thesis. This makes both worlds accessible to them and connects theory and practice. Vesna's thesis is partly in line with Chris Crawford's call for bridge builders and artists to acquire programming skills. But she also refers to the connecting approach as well as to the need of a Third space, a space for negotiation, where the disciplines can meet.

From an engineering perspective, Kathryn Henderson[203] brings 'drawing as a boundary object' to our attention. 'Drawing as a boundary object' in her vision, (not to be confused with illustration), facilitates the collaboration process and communication with engineers. In addition, she suggests conscription devices that are used to support the process and are in that sense the tools to create the product (the boundary object). The boundary object should have enough flexibility to support the communication based on different interpretations of the boundary object, though there is always a certain cultural value attached to the boundary object. Media as boundary object is something that might be useful to investigate in further detail, as it is often the binding factor in art and technology collaboration.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)	Type of aRt&D, type of collaboration, application domain
Innovating arts, re-contextualising technology, creating new connections	*Process patching*	(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualisation, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	Participatory method	Itterative process, design method thought from the end-user / participant's perspective	Complicated to combine with problem solving, interdisciplinary cooperation, 3-th space	Ground for co-operation, experience oriented applications, difficult to combine with problem solving	Post-Marxism, design theory, improvisation theatre / various design approaches e.g. human centred HCI, ethnography, social sciences, communication design,	Heuristic research, experience design
	User centred design method	**Design method focussing on the participant(s) experience**		Focus on end-user/participant	**communication studies , cultural studies**	

(fig. 16. aRt&D Matrix: user-centred design)

From the perspective of design practice, the opportunities of a Third space were investigated as a 'neutral' space for collaboration. This Third space provides interesting options to set a new ground for collaboration, but one should consider an extension for sheltering all the different participants in the research and development process. This could enrich the knowledge exchange about each other's fields, vocabulary and intensions. The Third space should not only include participants (end users) and designers, it should also include other technical disciplines and collaborators from different backgrounds, to establish the communication flow between the back-end and the front-end of the project. Further study is required into the options of different types of media as boundary objects for communication among the different collaborators and participants.

2.2.6.7. Conclusion *processpatching,* methods, techniques and models

Improvisation (2.3.2.) has been identified as a frequently used method in processpatching. It is often used as a method in the creation process but, especially in interactive electronic art works, it is often used as the method of presentation. Improvisation as a mode of presentation relates to participatory design (2.3.1.) because of the participant's active involvement in the process of design and creation of one's own (or common) temporary experience. The next sibling in the family of participatory approaches I looked at, is participatory action research, or another variation the practice-based action research. Both should probably be combined with other approaches or more concrete methods relevant to artistic research and development in interdisciplinary settings. The concept of a Third space (2.3.4.1.) was investigated as it offers a neutral ground for technicians, artists, audience and designers where collaboration can be fostered between the disciplines. A Third space fits very well in the concept of interdisciplinary collaborations space as a separate entity as depicted in the transdisciplinary models, unlike the multidisciplinary models where collaborators merge their disciplines temporarily. As a tool, the boundary object was discussed, as it provides an object as a vehicle for discussion and understanding of other disciplinary habits and tools. FLOSS and collaborative software development (2.3.4.) offers an interesting approach that fits well in these so called Third spaces. Recycling and repurposing the developed software, with credit to its original makers, is among the common habits in this area.

2.2.7. Relevant themes for artistic Research and Development

To compensate for our limited literature resources from an artistic background, the next sections study some distinct key areas from the field that show relevance for artistic involvement, because of on-going artistic interest or calls for artistic or cultural involvement by concerned parties. From this literature, I might be able to propose some requirements or suggestions that can lead to the needed artistic methods.

2.2.7.1 User interfaces

> *'I'm convinced that art which dramatizes the interface as a border between the one and the other is the only way to reach a quality of connection which distinguishes itself from a simple decision for the one or the other.' (S.Zielinski)*[204]

User interfaces have played a crucial role in artworks over the last decades, as they are the membrane in establishing the connection between human and machine, or the physical and virtual realities. Many interactive electronic art experiments deal with hardware or physical interfaces as machines for multi sensorial experiences, as well as graphical interfaces. The latter has received most attention during the early years of the World Wide Web.

From early Web design onwards, a main area of research in the field of GUI design dealt with communicating the logic of the structure and the navigation of the Web. The complexity of visualisation issues increases when the 'browsing a book' metaphor becomes insufficient, when information is dynamic, in particular through user participation or through multiple options to mine, display and thus contextualise the data. As mentioned earlier (2.2.3.2.), there is an ongoing interest in the art field to expose the invisible; the process underneath the surface. These experiments have brought forward a new genre of research and process oriented electronic art works, taking a less functional or causal approach. The attention is often re-directed towards the process, the interaction itself, or the technical infrastructure of which the participant is becoming a part. Here one sees the migration from the associative or mental map from the field of visualisation, towards interaction, the process to be communicated via the interface. Artists and artist groups have worked over the last decades on projects examining the potential of networked environments in regard to of community building, knowledge exchange systems, and tools to investigate opportunities for social cohesion. Moreover they have investigated the connection and the relations between networked environments and physical reality. Interfacing the networks and our physical environment via associative or mental maps teach that special attention is paid to contextualisation: the flexible gamut of meaning. This brings along a combined or morphed research method informed by different domains such as linguistics, philosophy, biology, system theory, etc. with a strong emphasis on on-going change and flexibility. The constant flux requires a certain degree of openness within the given framework. For many artists and designers, the autopoietic[205] or self-organising system theory has been a main source of inspiration for the design of this framed openness.

The user interface also represents shifts in the Human Computer Interaction paradigm, from technical towards personal or emotional. Formally the interface was regarded as an extension of the machine, but recent research focuses on the interface as an extension of the body.

> *'For if digital information in its raw state – as digital data (strings of 0s and 1s) inside the computer – has no direct sensory interface with embodied perceivers and cognizers, then the role of the human computer interface becomes crucial.' (M. Hansen)* [206]

Tactile user interface research pulls one into the field of interaction, narrative and (im)material research. As Hansen states, this is the field where the different disciplines merge or collide, where the importance of interaction and embodiment comes into play. Here interactive electronic art distinguishes itself from 'object' oriented art forms; interaction is a crucial element in the experience. Multimodal experiences are established through the interface. The tactile interface is the connection or the field of activity where human and machine forces interact. The interface is the filter between the machine and its operator; the software code determines the density and specificity of this filter. Thus the nature of the experience or interaction is embedded in software code and hardware design. Tactile interfaces have been a major field of artistic experimentation. Over the years, all kinds of user interfaces were designed for multimodal experiences. Distributed (interactive) artworks used different kinds of network connections to carry out experiments over phone lines, radio frequencies, ISDN lines, Local Area Networks (LAN), etc. Besides the technological component, tactile or multimodal user interface research is informed by knowledge and experience from multiple artistic and cultural practices. Brenda Laurel drew, in 'Computers as Theatre'[207], the parallels between the interface and the stage. Several other studies in the field of drama and narrative also show the relations between the different artistic and cultural disciplines represented in this field of artistic research. The user interface as experience mediator is one of the fields within artistic research where different artistic disciplines blend via technology. Experiments in experience design are main catalysts in artistic, tactile interface projects. Similar to other research themes favoured by electronic artists, the artwork's intention is not to solve a problem (2.2.3.1.) or to achieve strictly defined functionality. Counter-intuitive or a-logical interfaces based on the artistic interpretation of biometric information can be found along the lines of this artistic research theme. Arjen Mulder and Maaike Post wrote on the role of the interface for artistic purposes:

> *'It is about learning to sense the sensibilities of these machine elements themselves and your own sensibilities. It is about mobilizing your own and the machine's sensibilities through the interface.' (A. Mulder, M. Post)* [208]

Thecla Schiphorst underlines this statement in one of the introduction papers for the *'whisper'* project:

> *'This project focuses on the development of a language of interaction based on affect space and the semantics of caress. In order for interactive systems to genuinely model intelligence, we must enable the development of interactivity that can recognize, understand, and even express non-rational states such as emotion or intention.' (T.Schiphorst)* [209]

The attentive interface described by Schiphorst incorporates a range of artistic and scientific research fields such as neuroscience, cognitive science, somatic disciplines, technical research (such as e.g. signal processing) and material research in the field of smart fabrics. She chooses for a typical artistic research approach; an iterative and explorative research, intertwined with the development process. Her approach mixes interface design with the experience design paradigms as outlined by Bill Buxton in *Experience Design v.s. Interface Design*.[210] The suggested research could be summarised as a hybrid of methodologies incorporating body practices.

2.2.7.2. Knowledge representation

> 'The informal aspects of communication between humans are far from understandable for today's computers and devices that work on symbolic models. The programming languages that shape most or our communication in electronic media are based on formal, discursive or digital communication. This creates a semantic gap, since most informal means of communication have no descriptive taxonomy.' (A. Nigten)

I refer here to the semantic gap that characterises the difference between two descriptions of one object or instance by different languages or symbols. In computer science, this often refers to the difficulty of translating natural languages into formal or programming languages. This difficulty touches the essence of the electronic artist's desire to communicate mediated emotions, ethics and aesthetics. In the fields of knowledge representation, there has been an evolution from the old school, machine-oriented, artificial intelligence vision to, more recently, human-centred approaches. The old school vision, promoting the super-computer brain, and modelled after the human brain with the intention to replace it, has been increasingly criticised over the last decades. N. Katherine Hayles, one of the most influential authors in the cultural sector, stated in her conclusion of 'How We became Post-Human' [211] that we don't have a choice whether or not we want to participate in our technology-dominated society, we are already part of it. Hayles reminds us that we became post-human ages ago. Consequently, the question one is confronted with now is: are we happy with the technical aspects of post-human design and its visions that are imposed upon us? Hayles[212] refers to the importance of the body as an essential, active entity to convert data into knowledge and by doing this the body thus creates meaning. Her thesis brings forward two essential aspects of embodiment; its, cultural related, specifics to make meaning from information as the individual who constantly interacts with his/her surrounding to give (time specific) meaning to information. Secondly, Hayles suggests here a theoretical counterbalance to the widely used scientific concept of the body as a cocoon or placeholder of information, without other tasks or relevance in the information production chain. In this tunnelled scientific model, which is widely used in artificial intelligence, the contextual and cultural noise is filtered out to demonstrate the controllable, codified human being. Hayles provides another link to the artistic interest for embodiment in artistic experience design approaches, were 'meaning' is a key issue.

On the other end of the spectrum, is the MIT Medialab (USA) in the 1990s. Here the wearable group interpreted the concept of participatory design very literally as its members started a cyber life, integrating wearable computers in their daily life as a 'living experiment'. This group showed a mix of artistic and scientific research from MIT. Like several other researchers and artists, Steve Mann[213], a member of this research group, pushed the human machine envelope, and blurred the interface borders between the virtual and the real. Their approach was utopian and advertised as a new approach to social problems, but most importantly to further personalising one's view of the world and moving to the next step in becoming a cyborg. They were mainly concerned with the technical aspects of ubiquitous computing (embodied virtuality, computers inhabited in our direct surroundings and clothing, etc.) and mixed reality (the ability to experience various 'real' and mediated realities simultaneously). More recently, Phoebe Sengers et al wrote about the possibilities for audience or user participation in affective computing. In an interactive evolving system one can grow or come into existence through a constant feedback loop to learn for its participants.

> *'User experience, in this model, cannot be understood without reference to interpretation. We understand user interpretation as the process by which people use meaning-making to make experiences real for them in their own lives. In particular, we are interested in how users create experiences of complex technical systems.' (P.Sengers)* [214]

The human experience is the main factor of interest provided by those who can deliver it best: human beings. This approach turns out to be of interest for open (slightly unpredictable) affective systems. This also fits in the participatory action design approach discussed earlier, as the participant stays in the co-development or co-authoring loop throughout the life cycle of the project. Rather than mimicking human emotions, like the psychotherapist impersonated by the Doctor scripts of Eliza by Joseph Weizenbaum in the 1960s, the participant plays an active role in the creation of the affective states of the system. Senger's approach suggests collaboration between the participant and the machine. The measurement, calculation and mapping of emotions for an affective experience into a language that the computer can understand (in terms of formal or symbolic representations) is a major research and development challenge, in particular because current computers are primarily designed to work with formal languages or symbols. This approach is relevant to everyone who tries overcoming the current obstacles with machine intelligence and emotional experiences.

In his writings about the semantic Web, Berners-Lee[215] also refers to the delicate combination, and the search for a balanced interplay, between human qualities and machine qualities. Berners-Lee hopes it can be achievable to have a combination between the collective intuition and distributed logic. He refers to this as a web of people.

> *'This machine-understandable Web will come about through the implementation of a series of technical advances and social agreements that are now beginning.' (Bemers-Lee)* [216]

According to Berners-Lee, the Web is more a social creation than a technical one. He refers to the role of machines to support humans in creative roles. He furthers this idea by suggesting that computers can do more with their analytical power to make sense of human discourse on the Web. In the semantic web this would be the case; the data is put on the Web in a way machines can understand, or can convert it (direct or indirect processing by machines). Here one sees a combination of heuristics (answers to open questions) and strictly logical systems. In this situation, non-logical, intuitive, creative, emotional approaches as special human qualities become even more valuable, but approaches need to be designed to enable computer processing of these features (indirect processing). The question however is how and what one defines and thinks about the right parameters for emotional computing from a cultural and artistic point of view. Here artists from different backgrounds can bring in valuable knowledge to build a combined machine-human understandable vocabulary.

2.2.7.3. Conclusion: connecting and *processpatching* themes

There are several research and development themes that relate directly to electronic art practice such as user interfaces (2.3.6.1.), interaction issues, and knowledge representation. The culture- oriented theoretical discourse from the field of knowledge representation (2.3.6.2.) calls for critical reflection as a counter balance to the prevailing reductive techno-utopian approach, particularly concerning interface design and embodiment. Interface design is a consistent field of interest in art and technology projects, and connects with a range of Human Computer Interaction issues which are of concern for interactive electronic art practice, such as experience design, aesthetics and empowerment. Another angle that was discussed is embodiment as an overarching term indicating a characteristic aspect of artistic interest, and which counterbalances the approaches in the field of cognitive computing. Under the embodiment umbrella, I discussed affective computing as being an actual example showing the gaps in formal languages as a major concern, in an attempt to model emotions in current machine languages. A participatory approach, where computable (formal) and non-computable informal means of communication are combined, seems therefore appropriate. The latter issues could be interpreted as an invitation for artistic involvement to 'patch' the analogue and digital together in a post-human, empowering manner. Although a considerable amount of information was gathered about the methods and approaches from which to draw, one still misses out on information concerning how this all can be set in motion. In the case studies, (Chapter 3) I investigate how it can be put into practice.

2.2.8. Conclusion: artistic Research and Development methods

In the table below (fig.17), the roles from chapter 2.1 are mapped to methods used by electronic artists, in different kinds of collaboration strategies. This part of my investigation elaborates on the literature resources underlining or disagreeing with the methods. The problem solving method has proven effective for a range of works and matches partly with the roles and stereotypes I investigated. With some minor differences in the communication and mediation roles, this seems pretty much in line with the expectations. Surprisingly, the electronic artist-inventor also seems to fit seamlessly into the problem solving approach. The stereotype of the artist in the role of commentator or protester is referred to in art and technology literature but turns out to have a very different interpretation or meaning in the art field compared to the science field. Artists play here with the confusion about roles and expectations with references to hacker culture and cultural activism. As one might guess, this collides with the expectations of the social worker or the artist who is expected to rescue poor functioning science. These collisions are intentional, and shock, raise awareness and criticise our technological environment but are in essence difficult features for collaboration. It is, of course, important to avoid confusing these strategic collisions with the unintentional collisions caused by either unfamiliarity with the subject, or language confusion (as discussed previously).

The short description of each category will be followed by an analysis of the co-relation with the role we can imagine the artists to play by analysing the intentions, aims or research objectives for the work. References bring me to the artistic context, design practice, and (techno) science studies. The few (mostly recent) relevant publications dealing with electronic art research will be included as a reference to contemporary practice. In some occasions, one sees some overlap or connections with the economic innovation categories of Century and the three stances proposed by Wilson.

The blurred borders and the lack of relevant literature from the electronic art research field, direct us to literature studies from related fields such as design and collaborative interdisciplinary research. The investigation into this missing category thus leads to a plurality of methods from a range of technological and non-technological disciplines, remixed and re-used by artists in what I call the *processpatching* method. This is dealt with in the last section of this chapter and will be tested in the case studies in Chapter 3.

Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)	Type of aRt&D, type of collaboration, application domain
Reductive method	Single or limited disciplinary problem solving approach, applied research, practical method	Technicians as facilitators, artists as engineer in single / limited disciplinairy situation, no improvisation	Sharp goal, clear aim, useful for tool development, no-divergence, lineair, predictable, assistance or facilitations rather than co-operation	Traditional methods in art , engineering, design, science and technology	Empiric approach, applied R&D, relevant in single- and multi- disciplinary teams, techno science, artistic innovations
DIY and hacker methods	Mis-interpretation / re-interpretation protest / activism via alternative methods, mostly small scale	artist as enfant terrible, catalyst for creative thinking, innovation of artistic oeuvre (the latter relates to DIY)	Surprises, new perspectives challenges, critical view, new insights, reflection, awareness, Critique, confusion, shaking up the teams, intuitive, steep learning curve to become self-sufficient	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, relevant in multi disciplinary collaborations often autodidact multi-tasker, exchange with other independent operators, FLOSS development	Thinktank or brain storm approach, engagement, Critiquing, awareness, empiric or practical approach, single person multi tasking, artist-commentator, engineering, hackers
Process patching	(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualisation, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
Participatory method	Itterative process, design method thought from the end-user / participant's perspective	Complicated to combine with problem solving, interdisciplinary cooperation, 3-th space	Ground for co-operation, experience oriented applications, difficult to combine with problem solving	Post-Marxism, design theory, improvisation theatre / various design approaches e.g. human centred HCI, ethnography, social sciences, communication design,	Heuristic research, experience design
User centred design method	Design method focussing on the participant(s) experience		Focus on end-user/participant	communication studies , cultural studies	
re-engineering, reverse engineering	re-purposing technology			related to DIY and hacker approaches	

(fig. 17. aRt&D matrix part 1: methods and roles)

An observed gap in the literature relevant to electronic art, science and technology collaboration has been plentiful in this plenary study. The best this thesis can contribute sets out to fill this gap. Some authors call it poetry production or exploration, or unconventional research, or experimentation. One reads about not-so-successful attempts of mapping the artistic research and development to other research grids, however one clearly misses the acknowledgement of an art-specific method(s) or approach(es). Consequently, these mapping attempts ignore the positive value of the unpredictable aspects of the electronic art process, and take assimilation or integration of the arts into other disciplines as their main point of departure, for many reasons. In a more general way, I conclude that these mappings are trying to map fuzzy and undetermined electronic art approaches with precisely described methods that often lead to frustrations and filter out the refreshing, inspiring or critical, but most importantly, artistic vision.

On another note, the lack of knowledge about whose recent history can cause major trouble in cooperative teams, and the lack of acknowledgement in the arts towards new developments in this discipline makes things worse.

This chapter looked into a plurality of methods from the arts and nearby fields. The mapping of the roles teaches that, at a first glance, the roles show similarity with the stereotypes that were studied in the previous section, but in practice there are several significant differences. In general, most literature directs to a practical approach from the artistic side, and the deep philosophical or theoretical approaches are missing. This also uncovers the connections with the design and engineering disciplines. Problem solving (2.2.3.) turned out to be useful for specific parts of an art project and for artistic invention emerging from shortcomings of existing

software and hardware. But the applied approach for problem solving works with a reductive approach, which is often regarded as an obstacle to artistic practice in re-contextualising technology to create new meaning. Problem solving in electronic art practice turned out to be a very different type of problem solving as suggested earlier for revitalising science. Multi-skilled electronic artists often work according to a problem solving approach to renew their artistic oeuvre and bring forward technical innovations.
Besides the earlier discussed unintended collisions, there are the intentional collisions as part of the confronting motives (2.2.4.). These are rooted in art practice and currently mainly expressed in cultural activism and art-hacker practice. This approach disassociates itself from the role of social worker, although its intention is social engagement it is usually channelled by raising awareness and provocation in independent (non-institutionalised) settings. The deconstruction approach is mostly used for this type of artwork, where artists become familiar with the technology, and use it for commenting on the technology and its related social factors. Dutch experiments taught us that the Wild-thinking approach, mentioned in the previous section, turns out to be a natural part of the heuristic artistic approach, but is less suitable for scientific innovation. The last variant of confronting motives represents the re-purposing of technology and the investigation of the imperfection of technology, to indicate other uses or new areas for artistic and technical development.

Studies were conducted into what might be seen as the 'intrinsic artistic approach', furthering Weibel's thesis that states art is a method. Weibel's approach is very broad, and still leaves considerable gaps for understanding artistic working methods. However, in the context of this research, his references to media art seem most specific, despite the limited information about its specifics. Therefore the *processpatching* method (2.2.5.) is proposed as a concept that captures a heterogeneous and changing constellation of techniques and methods. For the connecting approach or *processpatching* method, a range of design and technical methods were investigated, all of which are somehow related to Human Computer Interaction as this seems to be the connecting area where different disciplines come together and audience involvement is of crucial importance. This leads to participatory design approaches, where the audience becomes part of the design and development process, which turned out to be especially relevant for interactive user centred design, wherein the audience becomes co-author. These shifting roles link directly to the FLOSS approach, which demonstrates the opportunity for sharing and exchange as an approach from collaborative, open and free software code development. The open approach of sharing generates ideas for audience participation for co-authoring and large scale dissemination. The virtual community is useful as a common space for collaboration for those familiar with programming. The involvement of an increasing number of participants, with very different backgrounds, in the creation process directed me to the concept of Third spaces, where collaborators can meet on neutral ground to co-determine the way they should work together. Some (new occurring) fields were also studied, as these suggest an invitation for artistic research and development. It reflects parallels in art practice to knit together tech and non-technological means of expression: interfacing and embodiment. Interfacing includes a range of aesthetic issues and socio-political references to different states of empowerment, but it also connects directly to embodiment and experience design. As the actual sub-field of embodiment, affective computing were identified, where modelling emotional or informal means of communication are of crucial importance. The following case studies therefore investigate the way this can be done, and how the connecting method works in more detail through the analysis of interdisciplinary work processes. From here, the research moves toward the next phase and will take a close look into the case studies to investigate the practical implementation of this connecting or *processpatching* method. The connecting approach and *processpatching* method also brought along the *transvergence* zone in between the disciplines, where a new practice comes into existence. In this new zone, all methods discussed earlier are brought in, and a new practice emerges. This chapter has provided background information about the most commonly used methods and the motivation to enter this new space. In the next chapter the investigation will continue with an examination of the methods used by practitioners who work in this space between disciplines.

Chapter 3. Case studies

In the literature studies (chapter 2), the first part of the overview of identified research and development approaches and methods in the electronic arts was provided. In this chapter, I analyse a series of case studies that were developed and / or presented at V2_, Institute for the Unstable Media. The case studies are used for further analyses of the proposed methods and completion of the overview. I analyse the electronic art research and development methods and visualise these in a α,ß,γ triangle, which is the graphical representation of the collaborator's background. In addition to the visualisation, I describe the applied methods, as outlined in chapter 2, of each case. In addition to this, I investigate the possible correlations between the artists' backgrounds, the concept or aim of the work, the technical aspects, and the applied methods. The correlation between the backgrounds of the involved and the preferred methods leads to project specific aRt&D Triangles that depict the effects or traces of the participant's original disciplinary background and the preferred methods applied in the space between the disciplines. The α,ß,γ triangle is a useful tool for mapping out the represented knowledge field among collaborators in a project. The case studies show that these proposed triangles are indeed useful and that these provide relevant information about the work process. Independent from this, the case studies provide key information on the most suitable methods for the collaboration process based on known practice and 'in between' the disciplines. A circle in the middle area of the triangles represents this 'in-between' area. The project's aRt&D Triangles show that the most successful cooperation happens in this centred zone between the disciplines. Furthermore, the case studies provide information about the types of artworks, the artist's attitude towards science and technology, and success or failure of the chosen methods. In approximately the same timeframe, (2001- 2005) representatives from different backgrounds were brought together to discuss and compare their work. Several workshops were organised to study the short-term collaboration process among people from different backgrounds, and a variety of artistic, technical and scientific representatives participated. The outcomes of all case studies, and how they affect the methods in an interdisciplinary landscape, are presented in the conclusion.

The case studies form the backbone of the structure of this chapter. In the first section (3.1.,3.1.2.,3.1.2.) the work processes of three interactive electronic art projects are analysed. The second section (3.2.1., 3.2.2., 3.2.3.) deals with reflections on artistic and scientific work processes, aims and (partly) with stereotypes (see also chapter 2). All presentations are accompanied by parts of the aRt&D matrix where the presented work process is outlined. The last set of case studies (3.3.1., 3.3.2.) are workshops, as investigations into short term collaborations. In some cases, there was additional information available to draw up a project specific art&D Triangle as well. The chapter concludes with the compared outcomes of the case studies' aRt&D Triangles, the aRt&D matrix parts and their co-relations. I end with adjustments and iterations of the proposed methods as outlined in chapter 2.

The events are documented in different ways. All reflective events were, accompanied by readers and some papers were or still are, available online. The workshops are documented via video recordings, online chat environments or work documents. All available material is stored in the V2_ online archive, and parts of the printed material are included as an appendix to this thesis.

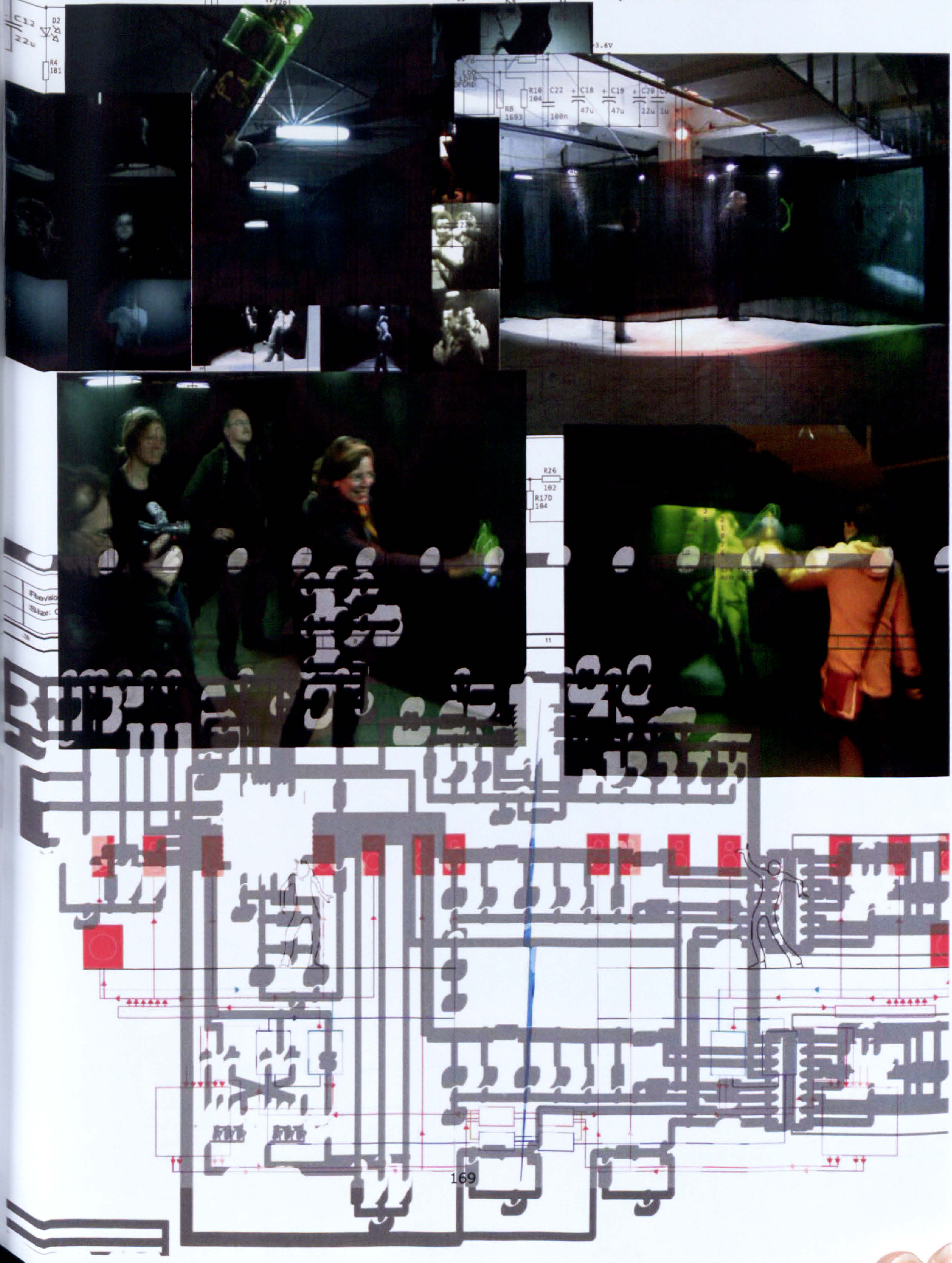
3.1. Case studies : Artworks

The basis of the case studies consists of interactive electronic art research and development projects, where teams of designers, technicians and artists worked together to research and experiment with technology, and develop an interactive electronic art piece. As the media laboratory manager, I observe and mediate between the involved team or participants to find the most suitable method for working together. These observations are reflected in the overview of the teams and the applied work methods. Each of these case studies provide a brief description of the concept and the aim of the artwork, followed by an overview and background of the involved people. The technology and how the team members used it, and which methods were used for the specific iterations or trajectories within the development process, are also described. I conclude each artwork case study with a brief investigation of the suggested correlation between certain types of artworks and the applied methods or approaches. In the included parts of the aRt&D Matrix, the correlations between the artist's attitude towards technology and the used method(s) or approach(es) are summarised.

TEXT BOUND INTO

THE SPINE

Collage 1. Impressions of M.U.S.H. by Joachim Montessuis, Eléonore Hellio visuals by the artists and Stock / V2_Lab




collage 2.
α
β
γ
1.
2.
3.
aRt&D team map M.U.S.H.

3.1.1. Description of the *'M.U.S.H.'* project

'M.U.S.H.' [217] (Multi-User Sensory Hallucination), by Joachim Montessuis and Eleonore Hellio (FR), was developed and produced in collaboration with V2_Lab. The text below describes the artists' backgrounds, the conceptual and technical background, and the numbers after their names refer to the aRt&D Triangle below. The project description is written in close collaboration with the artists and the involved V2_Lab team members.

'M.U.S.H.' is a dual site telematic installation with one room in each location. Each visitor enters a closed room and faces a black image on a video screen. The person is provided with a wireless *'M.U.S.H.'* device, equipped with accelerometer sensors, when they enter. The room is quiet but as soon as the person starts to move around the *'M.U.S.H.'* device, their movements control the sounds and visuals. This exploration of the space causes a sound composition and works simultaneously as a synchronisation tool for telecommunication between the two sites. The system captures each person's movements to generate a sound and visual 'partition' and 'orchestration' in real time that becomes the 'carrier wave' for telecommunicated experience. *'M.U.S.H.'* is a digital collision space where a chance is given to share an experience together (or alone). This will first depend on one's ability to fully explore and interact in its multi-sensory environment. The synchronicity of behavioural patterns is what may trigger the appropriate feed-back for a tangible link to occur. If both participants 'excite' the *'M.U.S.H.'* room at the same time, in the same manner, they will increase their chances of meeting each other through

virtual space. The sound acts both as a subversive and immersive element. The image is considered as both place and language. A visual dialogue that doesn't follow the usual rules of videoconferencing will define the feeling of tele-presence or tele-absence.

The sound environment consists of different layers of sinusoids, infra-basses, drones and granulated samples that react to the movements of the device in terms of intensity, frequency and loudness. *'M.U.S.H.'* offers the operators a complete stage for jamming. As one conquers the system, the flickering image may become more precise and give a chance to the other operator to appear on the screen.

The main conceptual research objective in this project dealt with various aspects of the real-time telematic user experiences. The artistic research is informed by theory and concepts for real-time performance, as has been topic of research in the area of music instruments in Ircam in Paris (FR) and Steim in Amsterdam (NL). Michel Waisvisz's [218] research into gesture controllers for electronic music is most closely related to the interface concept of *'M.U.S.H.'* Furthermore, *'M.U.S.H.'* has been informed by concepts of space-time discontinuity in cybernetics, a re-occurring artistic research topic, which lead to networked experiments by numerous artists over the years, among them earlier telematic art pioneers like Roy Ascott with his slowscan telematic videowork 'Organe et Fonction d'Alice au Pays des Merveilles' [219] (1985) and in 1991, Paul Sermon with his Telematic Dreaming [220] project where voyeurism and a telepresent body and reality were mirrored over each other via ISDN telephone lines and a video conferencing system. The artists themselves refer to more recent French art theory on time-space discontinuity in telematics:

> *'...Le temps réel ne résulte pas seulement de l'augmentation de la vitesse de circulation des informations. Il correspond à la façon dont des réalités autonomes developpent en leur sein et dans les échanges qu'elles entretiennent avec leur environnement, des processus d'adaptibilité, de transformation, d'exploration dans la recherche de situations d'équilibre toujours suceptibles d'être modifiées...Il ouvre sur des temporalités multiples... Il consiste au contraire dans l'ouverture, le tâtonnement, le surgissement du nouveau...' Jean Cristofol, Fabrice Gallis, Guillaume Stagnaro.* [221]

The Beta version of *'M.U.S.H.'* was presented during DEAF04. In an interview about the work, Eléonore Hellio explains the project from the conceptual, user-oriented angle. In the same interview, her collaborator formulated the question or problem in relation to the technical development of the interface device:

> *'We wanted an interactive wireless device, that was the main goal of this project, to have a tool completely as a wireless system. We worked with Stock, the engineer who created this device. He worked for 6 months to create this and I worked for six months on the most important part of the sound patch. We just worked with this device and all this interactivity problems.' (J. Montessuis)* [222]

The artwork becomes alive through the participant's movements with the device. The first version of *'M.U.S.H.'* demonstrated the potential of the device's interactive vocabulary. The next version of the wireless device is developed by V2_ in the context of a major Dutch National research program; MultimediaN.[223] The directors of the program received the demonstrator of the recent version very positively. In particular the *'M.U.S.H.'* device's features for training gesture and movement interpretation via a neural network, based on the indicators from the artists, were seen as a valuable user-oriented technology innovation. V2_Lab continues to adapt this interface-system as a generic device for various other applications and artworks.

The technologies used are high bandwidth videoconferencing facilitated by Polycom Ipower PT 680/685 Codec's, MAX/MSP, Jitter and the Very Nervous System (VNS). Joachim Montessuis programmed the Max/MSP patches and Jitter in collaboration with V2_Lab. Stock, V2_Lab's hard- and software engineer, developed the wireless *'M.U.S.H.'* handheld device that is based on two accelerometer sensors to measure acceleration of movement in 3 dimensions. The prototype device in the first version includes a basic-stamp and uses the Bluetooth communication protocol to transmit the measurements to a computer. This was developed and used as technology in other projects in the past, and although it was known to have considerable shortcomings, it provides a working prototype for testing with a live audience. In Max/MSP, the device's measurements are decoded into a set of vectors representing the device's perception of the Earth's gravity, and its relative movements. This M.U.S.H. device is tested and improved in prototype version 3. This interface employs a neural network as the core gesture-recognition element. This version of the device is based on the Logitech Cordless Rumblepad2 game-controller. For more details and evaluation see '*The M U S H environment Prototype Version*

3' by Stock Plum and Michel van Dartel, V2_Lab.[224]

3.1.1.2. Background of the team members of *'M.U.S.H.'*

Joachim Montessuis (1. in collage 2) has an artistic background in electronic sound, often applied in combination with video. His interactive work explores the boundaries of feedback and the audience's perceptive tolerance. He initiated the *Erratum Musical* a Besnaçon, an irregular music release. Eléonore Hellio (2. in collage 2) studied drama, focusing on the experimental, in the State University of New York. In the 1990s, she became one of the main co-operating artists of the Electronic Cafe International. She is now the head teacher of the Digital Lab at the Strasbourg School of Visual Art (ESAD) in France. Stock (3. in collage 2), electronics designer at V2_Lab, who has an electro-technical, sound and music background, developed the *'M.U.S.H.'* hardware device. Joachim Montessuis programmed the *'M.U.S.H.'* software in MAX/MSP, Jitter and VNS with assistance from Stock. The team is small and thus overviewable, and the backgrounds and expertise are mapped in the aRt&D Triangle in collage 2. The project manager of this project is not included in the diagram, as several people worked on this in the course of the project, due to staff turnover. In the first phase, an all-round project manager dealt with the test setup and the evaluation of the user tests. In the second phase, a project manager with a physics background brought in the research component, and in the last phase, the technical reporting was done in close collaboration with a project manager with a computer science background.

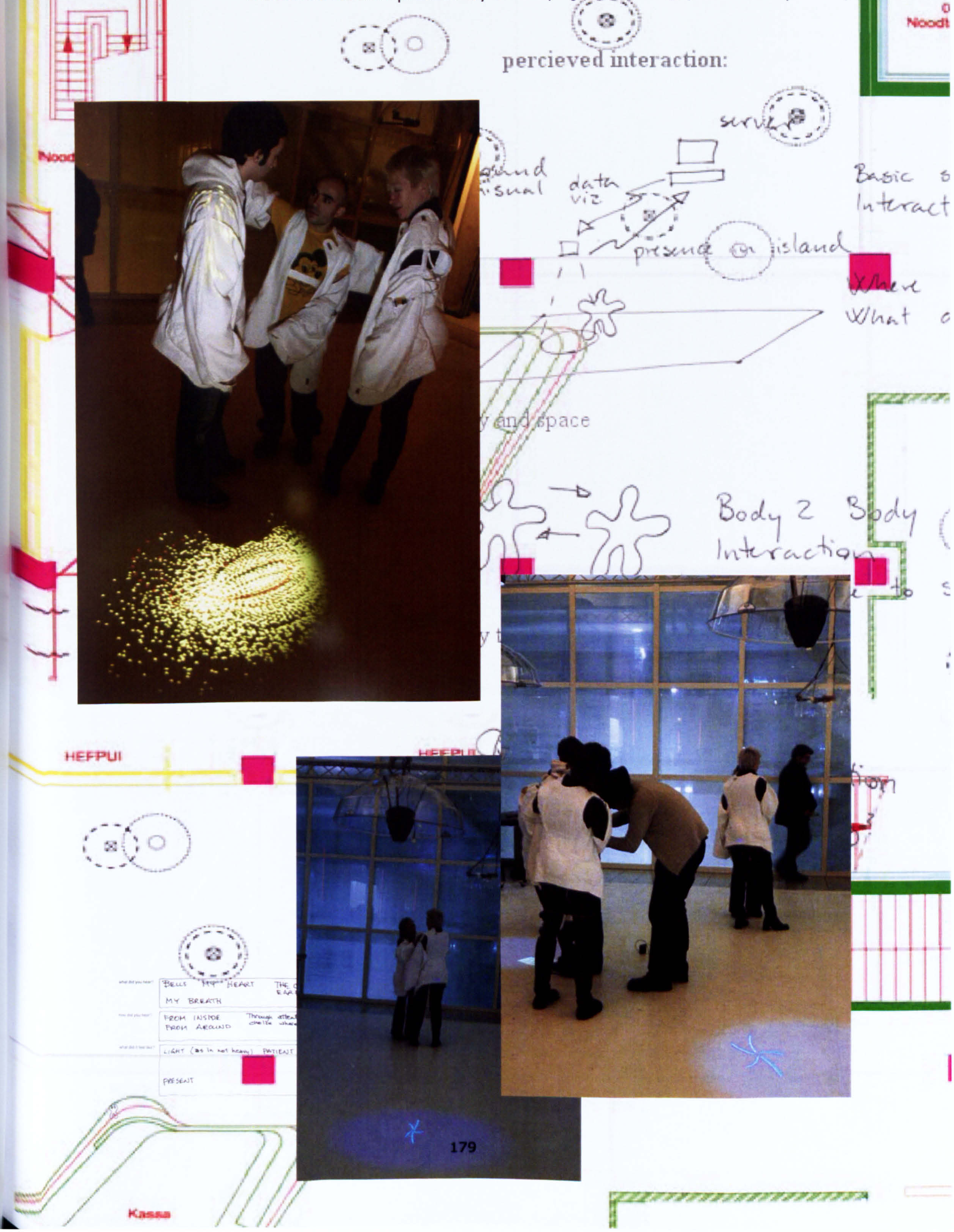
3.1.1.3. *'M.U.S.H.'*: Methods

The *'M.U.S.H.'* installation is developed according to a standard H.C.I. work procedure. The artists undertook exploratory studies in the field of gesture controllers and telematic environments. V2_Lab developed the prototype version in software and hardware, which was used for testing with a live audience. The artists and V2_ evaluated the test set-up and this provided the technical and artistic requirements for the next version. The last phase consisted of two parts; first Stock applied a DIY approach to investigate a hacked version of the *Logitech Cordless Rumblepad2* game-controller. The last version (v3) was designed according to the posed problems in the evaluation report with new and robust components. The way Stock worked was based on a reductive method and DIY. In consultation with Montessuis, he designed and developed a solution for the missing wireless device. The main development issues concerned technical development, although the requirements were determined by the concept. Stock's work for the installation was based on a clear defined goal; a wireless device was needed to explore and activate the music and visual landscape. The conceptual decisions were embedded in patches for the audio composition and created by Montessuis. For the complex software development, Stock and Montessuis worked according to a master and student model. Montessuis was responsible for programming the interactive audio and video effects, which were fine-tuned according to a participatory approach during the beta demonstration of the project. Montessuis and, to a lesser extent Hellio, worked on these parts in a rather self-supporting way, with some assistance from Stock. After the first phase of development, other collaborators were brought in for the non-technological works such as the design of the two spaces or stages. The installation was tested (as a beta version) in a well-designed setup, while iterations and adjustments were performed on the spot. The small scale of the project, and the limited amount of disciplines represented in the team, were crucial aspects of the success of the collaboration.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages
Problem solving	*Reductive method*	**Single or limited disciplinary problem solving approach, applied research, practical method**	Technicians as facilitators, **artists as engineer in single / limited disciplinairy situation**, no improvisation	**Sharp goal, clear aim, useful for tool development, no-divergence, linealr, predictable, assistance** or facilitations rather than co-operation
Selfsufficient, selfsupporting	***DIY and hacker methods***	Mis-interpretation / re-interpretation protest / activism via alternative methods, **mostly small scale**	artist as enfant terrible, catalyst for creative thinking, **innovation of artistic oeuvre (the latter relates to DIY)**	Surprises, new perspectives challenges, critical view, new insights, reflection, awareness, Critique, confusion, shaking up the teams, **intuitive**, steep learning curve to become self-sufficient

(fig. 18. aRt&D Matrix with Methods used in 'M.U.S.H.' bold)

Collage 3.
Impressions of whisper by Thecla Schiphorst, Susan Kozel and team
Documentation photos by Jan Sprij © for V2_ , visuals by whisper team



collage 4.

aRt&D team map whisper

3.1.2 Description of the *'whisper'* project

'whisper'[225] is an interdisciplinary project that resulted in a participatory installation exhibited at DEAF03 in Rotterdam. *'whisper'* is a project initiated by Thecla Schiphorst and Susan Kozel and developed by the *'whisper'* team. In an interview conducted during this presentation, the aim of the participatory project was mentioned:

> *'What we're hoping is that as the whole trajectory of the piece will take people somewhere (...) and there will be the sense of having crafted something as a group, as a community.' (Susan Kozel)* [226]

The description of the work below is written in collaboration with Thecla Schiphorst and the editorial team of DEAF03. Several team members worked together in a residence at V2_.

'whisper' is an acronym meaning wearable | handheld | intimate | sensory | personal | responsive | system. *'whisper'* was a working title for an electronic art piece based on small wearable devices and handheld technologies. *'whisper'*(s) are wearable body architectures. Participants enter an exhibition space, which can best be described as a networked ecosystem containing small intelligent devices that emanate their state based on the wearer's movement and intention. Up to 12 participants may move and browse the space with access to a set of devices that were sewn into garments. *'whisper'* devices were networked to a central *'whisper'* database server that constructed the system-state visualisation and transmitted to the projection surface in the space. The *'whisper'* devices

create their narratives based on the interaction body they presently inhabit, and their own past lives.

'*whisper*' was based on creative and collaborative processes that include collective first person methodologies and the artists' version of the 'sewing circle', the phenomenon of participatory installation as an emergent, non-hierarchical performative form, the aesthetic that emerges directly from the materials (sensors, electronics embedded in the garments and the body) in a play across the opaque, translucent, transparent; and the reconfiguration of attitudes toward the body that allows for sensory experiences to be seen as fluid, networked and dynamic systems linked to networked devices.

The '*whisper*' project critiques, in a mildly poetic way, the aesthetic and ethical aspects in today's trends in wearable technology. This critique grounds the idea of connecting and mixing concepts of artistic experience with system design, fashion design, industrial design, interaction design, communication design, ambient intelligence, affective computing, and hard and software design. '*Whisper*' mixes today's art practice with other knowledge fields, like related work from artists who mix work e.g. in the field of art-smart fabric design (Joanna Berzowska, CND [227]) and art-fashion ecologies (Maja Kuzmanovic, NL/B [228]) and art-biometric interface design (Sommerer and Mignonneau [229]). On the technical and scientific side '*whisper*' explores the potential of today's research as carried out in Artificial Intelligence fields, in the context of an artistic experience.

> *An 'affective wearable' is a wearable system equipped with sensors and tools which enables recognition of its wearer's affective patterns. Affective patterns include expressions of emotion such as a joyful smile,*

an angry gesture, a strained voice or a change in autonomic nervous system activity such as accelerated heart rate or increasing skin conductivity.... Affective wearables provide a perfect opportunity to bring powerful computational methods to bear on testing emotion theories. *(Rosalind Picard, Jennifer Healey)*[230]

Besides the soft-critique of *'whisper'*, one could also look at this as the artistic response to a broadly acknowledged concern about a lack of design, aesthetics and ethics in software design and hardware system design (Buxton [231]). These ideas are expressed in *'whisper'* in poetic texts, ironic garments and aesthetic, subtle visuals. The project builds on a large body of knowledge from phenomenology, performing arts, theatre, installation art, cultural studies and human centred H.C.I. practice.

Technologies used in *'whisper'* are small wearable computers and blue tooth wireless computer communication protocol, MAX/MSP, mathematic visualisation software. The project builds upon physical practices such as dance improvisation, and manifests cultural and scientific theories of embodiment. *'whisper'* borrows from biofeedback techniques to shift attention back to the intimacy of the autonomous self. This piece uses wearable devices, which resemble a cross between theatrical costumes and body sculpture.

The project was shown at various sites in Europe and further developed partly by a different team. Based on the initial *'whisper'* design of user-oriented concept of wearable technology and interaction, the successor of the *'whisper'* project, (working title: *'Move-Me'*) is included as the V2_ contribution to *Passepartout*, a large European research project. Interactive television manufacturers and interactive television producers initiated *Passepartout*. The: '*Move-Me*' project continues to explore interface design and interaction patterns that are based on 'personal' or biometric information. Based on the previous experience, the team is downscaled and works in smaller clusters. We (V2_) work mainly on improvement of our previously developed technology, so the project can fully concentrate on the design and development of the interaction and the modelling of the user experience. For optimal team working with the other involved researchers, scientific researchers, software and hardware engineers and Thecla Schiphorst, the leading artist, we are working closely together, starting from a problem solving approach and moving towards a user-centred iterative approach later in the process, once the technical 'problems' are solved.

3.1.2.1 Background of the team members of *'whisper'*

'whisper' brings together researchers with a range of backgrounds in human computer interaction, mathematical visualisation, industrial design, haptics, real-time distributed systems, media theory, electrical engineering, visual arts and performance, digital image and audio processing, and music. Thecla Schiphorst (1. collage 4) has a background in media art, performing arts and research; Susan Kozel (2. collage 4) has a background in the performing arts, writing and philosophy; Kristina Andersen (3. collage 4) has a background in media art and interaction design; Julie Tolmie (4. collage 4) has a background in mathematics and physics; Norm Jaffe (5. collage 4) has a background in software engineering; Sang Mah (6. collage 4) has a background in software engineering; Andruid Kerne (7. collage 4) comes from applied mathematics, computer science and music composition; Jan Erkke (8. collage 4) has a hardware engineering background; Robb Lovell (9. collage 4) has a background in computer science and interactive art and technology; Laetitia Sonami (10. collage 4) has a background in electronic music; Grant Gregson (11. collage 4) is educated in electronic art; Diana Burgoyne (12. collage 4) has a background in electronic art; Maryan Schiphorst (13. collage 4) is trained as an applied linguist; Stock (14. collage 4) has an electro- technical, sound and music background; and Ruben de la Rive Box (15. collage 4) studied design. The aRt&D Triangle shows a plurality of backgrounds, and some clusters worked together in a reductive way. The blue cluster represents hard- and software engineers. This cluster is most closely related to electronic music and electronic art on the alpha side, and

mathematics on the beta side. The hard- and software engineers shared software knowledge and knowledge about electronics with the artists from electronic music. The artists with a performing arts and visual arts background are clustered together in several parts of the research and development process and shared improvisation techniques from theatre and social science in their work process. The interaction designer acted often as a mediator between this artists' cluster and the hard- and software engineers. Another mediator was the person with a mixed background in electronic arts and computer science. The other person with a mixed background in applied mathematics, computer science and electronic music was a multitasker who worked in more of a self-sufficient way. The overview of the listed participants is provided in the aRt&D Triangle displayed in collage 4.

3.1.2.2. '*whisper*' : Methods

> *'With a research team of over a dozen individuals, one size does not fit all. 'whisper' builds art research through techniques of body. But what does that mean? Does this 'work' as we work... softly, softer, whispering, shouting, weeping, dissolving, and re-emerging our strategies, technologies and techniques. (......)Our work of designing and testing experience models borrows methodologies from the performance practices of theatre, dance and the filed of somatics, expanding work in the area of computationally centered design techniques as well as the rhetoric of user-centered design, experience design , and participatory design.' (T. Schiphorst)*[232]

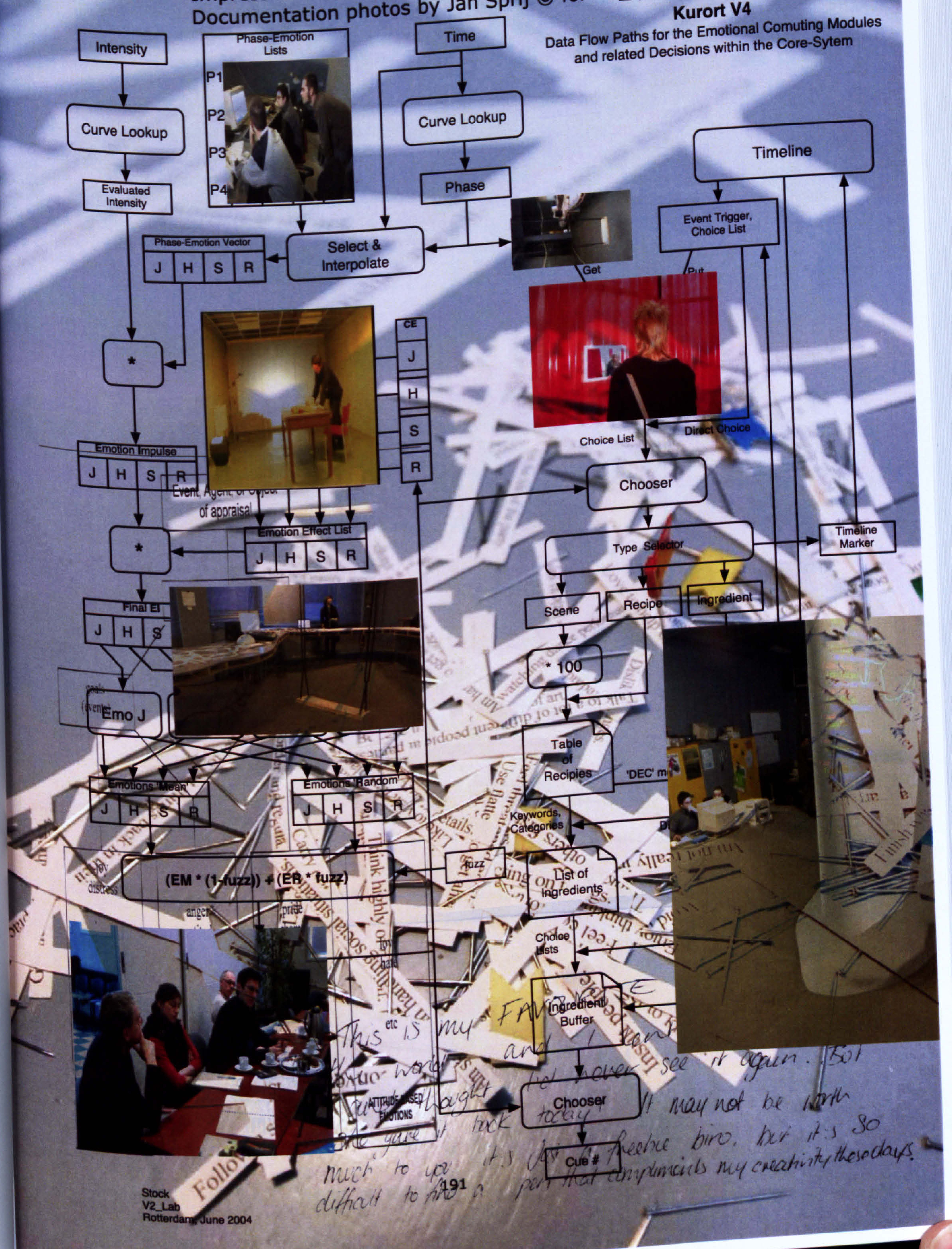
'*whisper*' was researched and developed using the *processpatching* approach. In addition to this, a reductivė or problem solving approach was introduced during the work process for the hardware engineering trajectories. Initially, the project aimed at new collaborative research techniques and processes, with innovative strategies for sharing design and development methodologies between the sciences, technologies and the arts. In the early phases of the research process, participatory workshops were organised based on improvisation techniques as taken from movement theatre and dance performance. The makers aimed for an iterative design process with constant feedback and input of the users/participants when they interacted with the data and the devices. An example involved designing and prototyping the wearable devices in collaboration with user-centred iterative development processes.

The '*whisper*' team had two members with a mixed background of multiple disciplines; one person who has a combined background in mathematics, science and music composition (7) acted in a more or less self-sufficient and independent actor in the process. The other person with a multiple background in computer science and interactive art (9), acted often as a mediator between the other team members, and whose background and methods were sometimes alienated. The team members with a mixed background represent self-sufficient artists and a mediator. In addition, Kristina Andersen (3), whose background is also a bit mixed, acted in several situations as a mediator between the hardware developers and the performing artists.

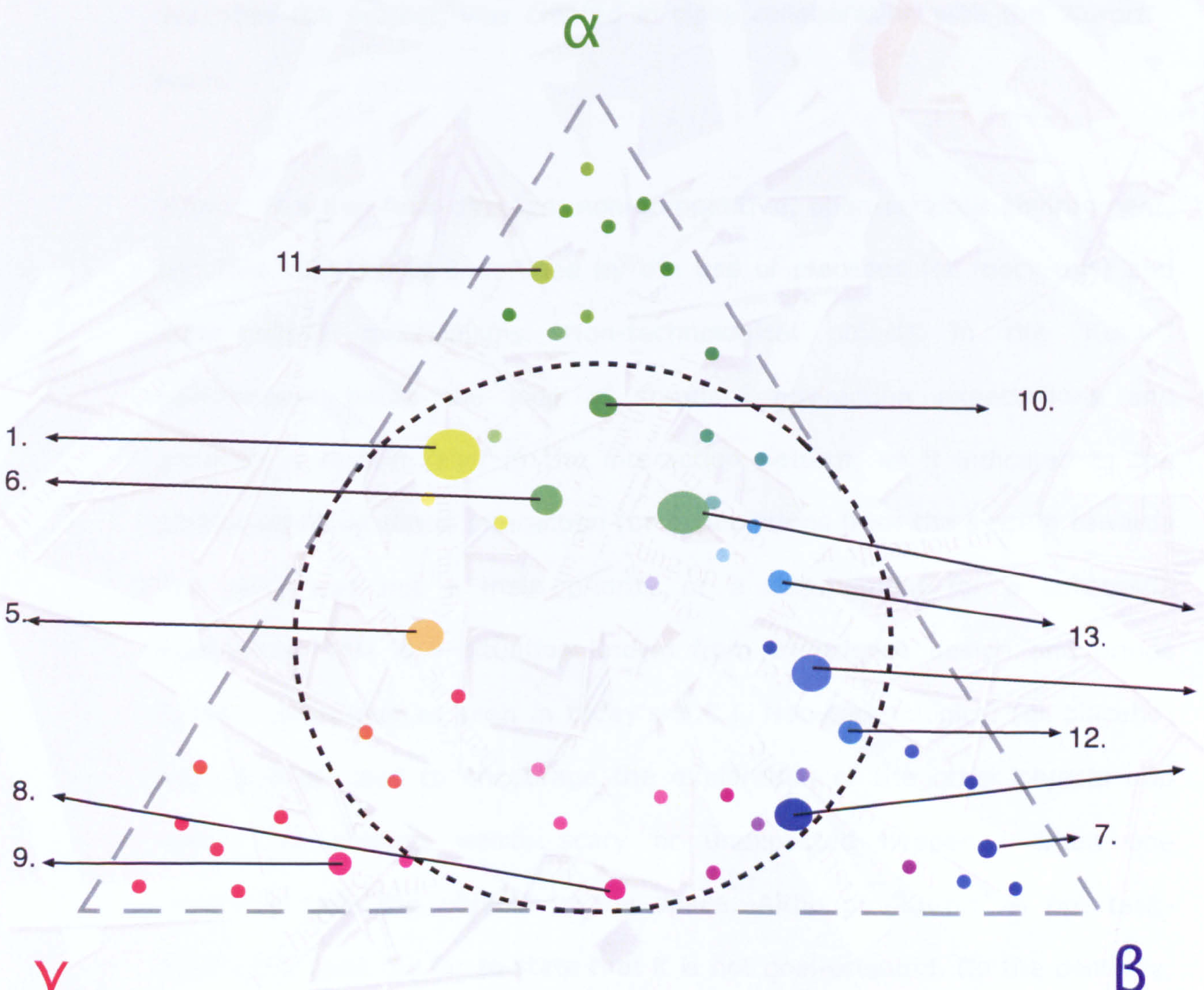
The aRt&D Matrix below shows the difficulties experienced when the software, hardware and the physical vocabularies were developed in parallel. This brought along a complex process of unpredictable features and obstacles. The obstacles were experienced in the shifting objectives, causing collisions among the collaborators and their related disciplinary traditions. In the iterative process, the project went through a shifting focus on the output, which distorted the technical development trajectories and some of the scientific objectives, while the artistic intentions remained the same. In *'whisper'*, like in other interdisciplinary projects, the artists had the need to use parts of, or re-purpose the software that was brought in by the collaborating scientists. This obstructed the scientific aims or goals, as the ownership of the software or hardware came into play. Tension arose among the team members when software or hardware was used for different purposes or as an illustration of an idea rather than a functional prototype. A combination of methods, in different parts of the project, turned out to be the best approach. For example, the hardware designers worked according to a reductive or problem solving approach and the concept team worked according to improvisation techniques. The different parts and approaches were knitted together by one of the software engineers and the interaction designer, and this was done in a freestyle, associative, artistic way.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages
Problem solving	***Reductive method***	Single or limited disciplinary problem solving approach, **applied research, practical method**	Technicians as facilitators, artists as engineer in single / limited disciplinairy situation, **no improvisation**	**Sharp goal, clear aim, useful for tool development,** no-divergence, lineair, predictable, assistance or facilitations rather than co-operation
Selfsufficient, selfsupporting	***DIY and hacker methods***	Mis-interpretation / re-interpretation protest / activism via alternative methods, **mostly small scale**	artist as enfant terrible, catalyst for creative thinking, **innovation of artistic oeuvre (the latter relates to DIY)**	Surprises, new perspectives challenges, critical view, new insights, reflection, awareness, Critique, confusion, shaking up the teams, **intuitive, steep** learning curve to become self-sufficient
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	Parallel and intersecting methods and approaches, from involved disciplines	**Freedom to change methods re-**contextualisation, space for cooperation, ground for new discoveries and innovation,
	Participatory method	**Itterative process, design method thought from the end-user /** participant's perspective	**Complicated to combine with problem solving, interdisciplinary cooperation, 3-th space**	**Ground for co-operation, experience oriented applications, difficult to combine with problem solving**
	User centred design method	**Design method focussing on the participant(s) experience**		**Focus on end-user/participant**

(fig. 19. aRt&D Matrix with methods used in 'whisper' (Bold)



Collage 5.
Impressions of Kurort by Angelika Oei and René Verouden
Documentation photos by Jan Sprij © for V2_ , visuals by Kurort team



aRt&D team map Kurort

3.1.3 case study 'Kurort'

The *'Kurort'* [233] project is based on the health spa phenomenon also known as *'Kurort'*. A *'Kurort'* traditionally offers visitors individual mental / physical relaxation and recuperation in a sensual healing environment. In this interactive technology augmented version of a *'Kurort'*, Angelika Oei and René Verouden, in collaboration with the V2_Lab team, create a space for relaxing the mind and recuperating memory. The text below, which describes the project, was created in close collaboration with the *'Kurort'* team.

'Kurort' is a non-task-directed, non-competitive, open-scripted environment, and this intention is underlined by the use of placebos (or mock-ups) and make-believe mechanisms. Non-technological objects in the 'Kurort' environment break the loop of standard interaction expectations and generate a certain relief in the interaction pattern, as it indicated to the participants that direct interaction (or expectations from the system towards the user) was not a main priority or a requirement for a successful experience. This is a situation known from experience design and brings forward difficulties as seen in today's H.C.I. Non-technological (or placebo) objects were used to encourage the exploration of the other objects and spaces, as nothing weird, scary or unexpected happened when one interacted with the objects in the space. Although 'Kurort' is not task-oriented, it goes too far to state that it is not goal-oriented. On the contrary, 'Kurort' has a clear goal. The artists' goal is to develop a synthetic identity called Lizzie that resides in the digital system and that is able to communicate and express itself in forms of subjective human experience, such as thinking, feeling and mood. In other words, inspired by the psychotherapist impersonated by the Doctor scripts of Eliza by Joseph Weizenbaum in the 1960s, Lizzie mimics an intense human experience. In the different prototypes, a series of crucial ingredients associated with a 'Kurort' experience were set up, tested and evaluated, such as feeling at ease and the level of comfort in an unknown situation. In the latter case, simple rules were effectively implemented; for example, the participant is always alone with the system without other people. The system's synthesised voice was what could be called a comforting 'friendly' voice (calming timbre). These elements were all implemented in a subtle way (theatre and stage design) to create a suitable context and atmosphere, enabling play with specific dramatic elements. Oei's research is inspired by Jennifer Healey and Rosalind Picard's [234] measuring devices to record facial expressions and differences in physical states that are interpreted for specific feedback in the device's behaviour. From an artistic perspective, the project builds on a long-standing tradition of staged, participatory theatre. In the Netherlands, experimental and avant-garde theatre flourished in the period of 1965-1991 in the Mickery theatre, where experimental, participatory theatre work by ensembles like the Wooster group [235] was shown; at Time Based Arts[236], and at De Appel where creative minds with multiple professions such as Ulises Carrion [237] experimented with lectures, location-based and mobile performances, and video. Related contemporary artworks include those in the field of mediated participatory theatre and gaming, such as Desert Rain by Blast Theory. [238] The concept of the 'Kurort' space, which embodies Lizzy, links to emotional and interactive architecture and stage or space design. Architects such as Kas Oosterhuis and his studio with 'Parascape' [239], or NOX and QS Serafijn with their D-Tower [240] project represent forerunners in this field of emotional and responsive architecture. Other mediated interactive and responsive environments include electronic participatory theatre as seen in the work of the Belgium theatre maker Eric Joris [241], and mixed media interactive art with references to ubiquitous computing such as Polar[242] by Marco Pelhan and Carsten Nicolai, and TGardens[243] play spaces by Sha Xin Wei and TGarden team.

The *'Kurort'* system is built in Max/MSP in a modular fashion and is visible to the visitor as a series of interconnected spaces where he/she can lounge and explore; each space is designed for a (set of) unique interactive experience(s). All prototype environments included real and 'placebo' elements for interaction and measurement. The visitor's movements were tracked through a video motion tracking system, built in Max/Jitter, and various other activities were measured through sensors or standard input-devices (Wacom-tablet, microphone, webcam). The visitor's appearances in front of the webcam were captured and stored on a disk, to be used as feedback for subsequent visitors. For the voice of Lizzie, the Mac-OS Speech System was re-purposed, but the intention is to use recorded fragments of a real person speaking in the next environments.

3.1.3.1. Background of the team members *'Kurort'*

The Rotterdam based artists Angelika Oei and René Verouden are the initiators of the *'Kurort'* project. Angelika Oei (1. collage 6) has a background in the performing arts, choreography and audiovisual work; René Verouden (2. collage 6) started his artistic career as sculptor and migrated his practice over the years to media art. The artists designed the experience concept and co-developed *'Kurort'* with the engineers of V2_Lab; the electronics designer in V2_Lab, Stock (3. collage 6), who has a electro- technical, sound and music background, developed the system's main software structure and hardware interface, which was further developed by Rene Verouden and Angelika Oei. Erik Kemperman (4. collage 6), the artificial intelligence software engineer in V2_Lab with a mathematics and information science background, developed together with Stock the algorithms for real-time analysis & comparison of the user's actions (using statistical analyses techniques). The representation of the system's emotions was inspired by Ortony, Clore and Collins. The algorithms for making decisions were influenced by the 'system's emotions', and the decisions were made onto actions of the system towards the visitor. The exchange workshops and development trajectory were managed by Lobke Hulzink (5. collage 6), who has a design and marketing background. The team's advisor was Scott deLahunta (6. collage 6), an internationally acknowledged researcher in dance and technology at the Dartington School of the Arts (UK), and the Amsterdam School for the Arts (NL). During a series of workshops, experts from computer science (7. collage 6), cognitive science (8. collage 6) and experimental psychology (9.

collage 6) were brought in, as well as dancers with (10. collage 6) and without (11. collage 6) experience in technology, in addition to hardware and software engineers (12. collage 6) and media artists who also (co-)developed their own software systems (13. collage 6). The team members' backgrounds and expertise is visualised in the aRt&D Triangle in collage 6, the size of the dots refer roughly to the input and involvement of the represented persons, as this affects the impact of one's role in the research and development process. The main team members are thus represented by large dots, while those who brought in knowledge and expertise via the workshops without further involvement are represented by smaller dots.

3.1.3.2. '*Kurort*': Methods

The '*Kurort*' project is created according to a truly *processpatching* approach. As a general design approach, it was decided to use a design method inspired by participatory design. The most important aspect borrowed from participatory design is the early inclusion of the participant; this was done by means of early prototypes where the audience could interact with the work. The artists and the team undertook studies into brain function research and neural networks. The core development of the system was dealt with by Stock, the engineer for the V2_Lab, in close collaboration with Verouden, who was also the mediator, on a technical level, with Oei. Verouden, who has a mixed background, represented the mediator in this team. On a conceptual level, the emotions for Lizzie were based on dramaturgical values selected by the artist. As mentioned earlier, in this phase of the project, several approaches, such as the implementation of non-technical elements, were used to circumvent the shortcomings of the system. These physical and analogue parts bear references to 'bricolage' aesthetics. The *'Kurort'* concept is focused on the experience; it doesn't work according to a clear set of technical requirements, that could be solved by the technicians in the team. In a sense, the *'Kurort'* project shows most resemblance to experience design, although this does not make it easier in terms of design approaches, as experience design is a relatively new branch in design practice. In H.C.I. practice, it is possible to distinguish roughly two approaches to technical development; either the engineer solves a clearly defined problem or the engineer realises a system design plan. The latter approach is usually based on a design prototype. For the engineers in the *'Kurort'* case, it was difficult to build something when the idea was not clear. This is partly caused by the problem that emotion theory still does not provide us with communication concepts to translate emotions into a computable language (see also 2.2.7.2.). Moreover the lack of 'problems' or clear technical requirements caused a vacuum for several of the *'Kurort'* engineers, who preferred to work using a problem solving approach. In the research and development process, it was decided to re-phrase the project's objectives. The artistic objective is thought of from a user's perspective; this needed to be translated into the requirements for the technical backbone of the system. The project manager and the V2_Lab coordinator took the initiative to re-formulate the artistic concept and the engineers had a problem to solve: how can the system convert or translate the actions of the participants into emotions? Although this was still a rather abstract problem, it turned out to be a better approach for the engineers. The disadvantage of this 'problem creating' approach though, is that it doesn't really acknowledge the value of the 'connecting' or 'knitting' artistic method(s), and this might be something worthwhile to solve, as practicality isn't the only valuable asset in art nor in technological progress. Moreover, the 'problem creating' approach does not fully support the importance of the participant or audience as a key player in establishing the experience. I conclude with another aspect that is often experienced in participatory design, and which was briefly mentioned in the previously discussed *'whisper'* project. The coinciding trajectories of software testing and user-testing cause trouble as the test results are useless and the software tests are carried out in unreliable ways. This was confirmed by Scott deLahunta, the mentor of the *'Kurort'* project.[244] Furthermore the test report by Johannes Birringer [245] shows us the difficulty to communicate the goal and the testing event to the testers, as testing the environment does not resemble the known concept of user testing (of new products), neither does it resemble a try-out situation (as in theatre). This turned out to be a source of frustration by some of the audience members as well as for the engineers and artists. Also Birringer confirmed that the test results in this case are far from useful, as it is impossible to distinguish the technical short-comings from the interaction flaws. It is however, not recommended to separate the technical from the artistic or conceptual interaction aspects entirely as this might lead to more obstacles for future integration of the two. A stable working low-tech prototype for testing purposes is suggested as the most efficient and effective approach to take. (See also the hacked prototype for the *'M.U.S.H.'* device as described in 3.1.1.)In these situations, a chronological development trajectory is recommended, as was applied in the *'M.U.S.H.'* project. In the aRt&D Matrix below, the conflicts between problem solving and connecting are listed. The reductive method demands a sharp goal and no divergence, while the *processpatching* method demands space for user-centred iteration and improvisation.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages
Problem solving	***Reductive method***	Single or limited disciplinary problem solving approach, **applied research, practical method**	Technicians as facilitators, artists as engineer in single / limited disciplinairy situation, **no improvisation**	**Sharp goal, clear aim, useful for tool development,** no-divergence, lineair, predictable, assistance or facilitations rather than co-operation
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	**Parallel and intersecting methods** and approaches, from involved disciplines	**Freedom to change methods** re-contextualisation, space for cooperation, ground for new discoveries and innovation,
	Participatory method	**Itterative process, design method thought from the end-user /** participant's perspective	**Complicated to combine with problem solving,** interdisciplinary cooperation, 3-th space	**Ground for co-operation, experience oriented applications, difficult to combine with problem solving**
	User centred design method	**Design method focussing on the participant(s) experience**		**Focus on end-user/participant**

(fig. 20. overview 'Kurort' methods (Bold))

3.2. Case studies: seminars, symposia and panel discussions

Literature studies (chapter 2) and practice (3.1.) illustrate the lack of communication and knowledge exchange among the disciplines, particularly among the disciplines involved in interdisciplinary collaboration. Working in an interdisciplinary field brings along a complexity of theory and practice with which to familiarise oneself. The amount and diversity of information often prevents one from studying other knowledge domains. The observed ignorance (Wilson 2.2.1.) makes it even more relevant to encourage dialogue. This was the main motivation to organise a series of seminars, symposia and panel discussions where representatives from different knowledge domains engage in moderated discussion and publications for a mixed audience. In the context of this research, the seminars, symposia and panel discussion served merely as a reality check for the proposed methods for the research and development of electronic art , especially in terms of the match between method or approach and aim or objective.

3.2.1. Case study *Anarchives: Connection-machines*[246]

The *Anarchives: Connection Machines* symposium was organised by V2_ on July 5th 2002, (led by Anne Nigten) and moderated by Michel Punt and Anne Nigten.

The event *Anarchives: Connection Machines*, organised by V2_ in July 2002, dealt with the opening up and ordering of archives as a time-honoured way of reflecting on the social and cultural cohesion of groups of people and communities, and the role of the individual therein. The presentations of artists and computer scientists provided useful statements and insights to compare, in a very general sense, the motivation and work method from scientific and artistic practice. The presented cases will be analysed for the working methods, the motivations and objectives of the makers.

The problem caused by the complexity of the research on image description, indexing and retrieval methods for multimedia archives provides a clear example of this complexity. Arnold Smeulders [247], a specialist who participated in *'Anarchives: Connection Machines'*, affirmed this. How does Smeulders (and many other researchers) deal with this and comparable complex issues? What methods are used to get a grip on these large issues? In his paper, he is mainly occupied with the technical solution to the problem. The technological solution he is working on is based on the notion that a small group of scientific disciplines (computer vision, databases, and information retrieval) need to design a technical solution that replaces or imitates human perception. This approach is related to the idea known in artificial intelligence and artificial life as the symbolic approach; programmed or explicitly encoded intelligence is the main factor in machine learning.

During the same event, Ben Schouten presented *"PARISS"* (Panoramic, Adaptive and Reconfigurable Interface for Similarity Search), an interface research project that allows the user to search images from a database in an iterative way by manually rearranging or classifying images. Schouten refers in his paper[248] to visual perception and the presumed iterative actions of the users:

> *'Colour is one of the most powerful features to describe an image with. The presence and distribution of colours induce sensations and convey meanings to the observer. In the Bauhaus period artist and designers like Itten developed colour schemes from a perceptual point of view.'* [249]

Although the artistic *processpatching* method and participatory design approach would be well-suited to the demonstration of the *'PARISS'* project, a reductive approach was used; the application domain was strictly limited to technical research objectives. The features implemented are based on mathematically pre-defined symbols, extracting and comparing contrast, coarseness, direction, line similarity, regularity and roughness. The content consisted of digitised pieces of patterned cloth (tartan). For Schouten's scientific purposes, the background or cultural 'meaning' of the pieces of cloth and the cross-domain interests of the users were not taken into account. Here the domain where the mathematical research is applied is narrowed drastically; the noise surrounding the research objective is filtered out. When the noise is filtered out the larger context is also left out.

Smeulders brings in some interesting nuances that refer to the awareness of users:

> *'In general, I would formulate as the challenge for image search engines: to tailor the engine to the narrow domain the user has in mind, via query specification, via learning from past, and via current interaction.'*

Smeulders includes interaction as an option for machine learning, however users are only hypothetical figures in his text, and other specialists, e.g. from cognitive science were not mentioned in the realm of his future research. In Smeulders' approach, the interdisciplinary research and development component exclusively involves scientific disciplines. As a side effect, this reductive research leaves no space for an extended or wider context, and therefore reduces the options for collaboration with other (non-scientific) disciplines.

The problem solving or solution led methods as presented by Smeulders and Schouten are included in the aRt&D matrix as a reductive method. The solution-led approach is mostly used in applied situations and is most appropriate for solving problems on a practical level. The experienced difficulties in, as mentioned by Smeulders, interdisciplinary collaborations bring forward the notion that this method is mostly suitable in single or multidisciplinary collaborations.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)	Type of aRt&D, type of collaboration, application domain
Problem solving	***Reductive method***	**Single or limited disciplinary problem solving approach, applied research, practical method**	Technicians as facilitators, artists as **engineer in single / limited disciplinairy situation**, no improvisation	**Sharp goal, clear aim**, useful for tool development, **no-divergence, lineair**, predictable, assistance or facilitations rather than co-operation	**Traditional methods in art**, engineering, design, **science and technology**	Empiric approach, applied R&D, **relevant in single- and multi- disciplinary teams, techno science**, artistic innovations

(fig.21. aRt&D matrix with methods from presentation by Smeulders)

During *Anarchives: Connection Machines* there were several art projects presented that were developed in an interdisciplinary context: '*Polar*'[250], by Marco Pelhan[251] and Carsten Nicolai, and '*whisper*'[252], by the '*whisper*' team led by Thecla Schiphorst and Susan Kozel.[253] In the following sections, the artists provide information about their goals, research and development processes.

On '*Polar*', Marco Pelhan and Carsten Nicolai state:

> *'One main question was posed in this process: How do we construct a cognitive and tactile experience of the seamless and near-abstract matrix with the analysis / construction / transformation of it included in the process?'*

The driving force in the design of '*Polar*' was to provide the audience with a cognitive and tactile experience. The visitor, supplied with a tactile interface device, could navigate and co-influence the software matrix, the sound and the visuals of the '*Polar*'-room. The technology used in '*Polar*' was designed to meet the requirements derived from the experiential concept. Several researchers with different backgrounds from Canon Art Lab[254] were involved in the design of the software architecture and implementation, and the project brought together a range of research fields and art practices bundled to create what was needed: the participatory '*Polar*' installation. The '*whisper*' team takes the audience participation even further into account, stating:

> *'Instead of situating the participants within the flow of a pre-scripted event, they will be involved in a conceptual, physical, aural and visual journey that unfolds according to their participation as a body, as a*

system. Their responses will drive the experience, and encourage the development of other senses within our synaesthetic matrix of sensory perception and proprioception.' (T. Schiphorst) [255]

To realise this participatory concept, several workshops were organised during the development process to explore concepts for physical intimacy. The mixed research, as illustrated by the *'Polar'* and *'whisper'* teams, represents an unintended collision with the reductive approach.

The interdisciplinary undertaken in both projects can be seen to offer an adhesive quality or function to the pieces or fragments of mixed expertise reflecting all disciplines involved. Electronic art practice, in many instances, seems to dissociate itself from single discipline art terminology and traditional art critique. The vocabulary used is a web of terms and notions from network theory, cultural studies, film and media theory, social sciences, etc. The jargon and references used by interdisciplinary practitioners reflects their position, and the critical discourse related to the digital dialectic. The references, the critique and the artistic research as a whole is described as a glued jargon from science fiction and cultural discourse, mixed with terminology from different relevant specialised fields. The interdisciplinary practice from an artistic perspective connects different specialists and fields together. Aside from proposing new forms of artworks, these artists bring in a valuable asset for science by extending the research networks and reshuffling equations aiming to raise awareness or to create mental / artistic experiments relevant for the social aspects of innovation and inventions. In these artistic experiments, the practice and the principles known from scientific practice are mixed up, and the acknowledged barrier between specialists and the users (laypersons) are not respected, as the participant becomes part of the temporal experience of the design process. The users were given a prominent role and they became participants who (co-) created and tested the interactive experiences.

Processpatching methods were used for the innovative art projects *'Polar'* and *'whisper'*, where methods and approaches from a range of disciplines were combined. *'whisper'* draws from methods known in cultural studies, improvisation theatre and somatics (see 3.1.2.). *'Polar'* and *'whisper'* both use an iterative participatory design approach, focused on Human Machine Interaction. Both teams represent a variety of disciplines. The Matrix below shows the methods and approaches as presented by Marco Pelhan (for the *'whisper'* Matrix see 3.1.2.).

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	**Parallel and intersecting methods and approaches, from involved disciplines**	**Freedom to change methods re-** contextualisation, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,
	Participatory method	**Itterative process, design method thought from the end-user / participant's perspective**	Complicated to combine with problem solving, interdisciplinary cooperation, 3-th space	Ground for co-operation, experience oriented applications, difficult to combine with problem solving	Post-Marxism, design theory, improvisation theatre / various design approaches e.g. human centred HCI, ethnography, social sciences, communication design,
	User centred design method	**Design method focussing on the participant(s) experience**		**Focus on end-user/participant**	communication studies , cultural studies

(fig. 22. aRt&D matrix with methods from presentation by Marco Pelhan (bold))

Collage 7.
Impressions of Anarchives-Connection Machines, 2002
Documentation photos by Jan Sprij © for V2_

Collage 8.
Impressions of DataPerception, DEAF2003
Documentation photos by Jan Sprij © for V2_,
and visuals from demonstrations by participants

In data perception, the principal duality we encounter is that of the immediacy of the image. Specifically,

3.2.2 Case study: *Data Perception*

The interdisciplinary workshop with an audience, *Data Perception*, is the next case study. *Data Perception* was a one day workshop organised by V2_ [256] March 1^{st}, 2003, moderated by Julie Tolmie and Anne Nigten. Based on the available knowledge and information about the presented projects and research, a decision has been made to elaborate on some of the projects more than others.

The *Data Perception* workshop tried to grasp notational shifts and visualisation techniques used for dynamic information and digital processes that are not compatible with, or describable in, natural languages. The presentations dealt with creative solutions to overcome the obstacles of not fully developed visual languages. The text below, written in close collaboration with the *Data Perception* team, describes the workshop.

The online and digital environments, in all their diversity, represented the context for this workshop. How do we experience and visualise these environments? As we become more immersed in our digital environment, it becomes more significant that data cannot be seen as neutral entities. A cultural, physical, intellectual, scientific evolution has been set in motion, changing our (digital) perception drastically. This perceptive change is perhaps one of the subtlest yet central questions confronting us today, reflecting our immersed behaviour in abstract and distributed spaces. A small subset of modalities crucial to our experiences is related to navigation, retrieval and perception. The future mastery (navigation /

retrieval / perception) and knitting together of these modalities or qualities into a single experience, is likely to irrevocably change our 'data perception', in the larger sense of the word. *Data Perception* tried to get a grip on the impact of this perception shift in 2, 2.5, 3 dimensional environments, dynamic or static information, familiar geometries or abstract topologies, mapping data spaces or assigning metadata. Together, this generated a pressing need to exchange ideas and be cognisant of the role of the artist in questioning and shifting paradigms, and leading the way towards new representations and their readings.

Data Perception directly addressed these issues by bringing together diverse speakers working with data visualisation in a participatory workshop. Speakers presented and demonstrated their own project-specific requirements and solutions. These solutions had, more often than not, been driven by the nature of the data itself. The participatory nature of the workshop was established early in the day by giving (non-technical) overviews of current scientific and artistic activity in the field. This workshop aimed to foster discussion and exchange among specialists from different disciplines and backgrounds.

The *Data Perception* workshop included presentations by Sheelagh Carpendale, a computer scientist and traditional artist; Ben Schouten, a computer scientist and traditional artist; Márton Fernezelyi and Zoltán Szegedy-Maszák media artists, software engineer / social scientist; Julie Tolmie a computer scientist with a mathematics background; Brigit Lichtenegger, a software engineer and video artist.

In this workshop, the invited speakers all had a dual or multiple backgrounds, partly in the arts and partly in either computer science or engineering. In previously organised seminars and workshops, the polarity between art and science, or art and engineering, aborted interesting discussions as the participants did not understand each other's terminology and were not informed about each other's work methods or work approaches. In this workshop, the moderators represented the arts, engineering and computer science, trusting that the different angles or perspectives would come to the surface naturally.

Of the presentations given during this workshop, a small selection is highlighted here. Most presentations showed the multiple backgrounds of the presenters.

Sheelagh Carpendale, for example, investigated the improvement of presentation spaces independent of specific representations or types of data. She took the limitations of a 2-D computer screen as a given fact. In order to zoom-in on visualised information or to enlarge certain parts of the displayed information on the screen, she developed the *'Elastic Presentation Space'* (*'EPS'*). *'EPS'* offers different lenses to view 'hidden' information. These lenses are easy to use algorithms that display the visual information underneath more clearly, like a magnifying glass. Carpendale's approach does not aim for a mathematical correct or precise representation of the visualised information, but rather a conceptual approach for a user-friendly system, working with optical illusions taken from traditional arts practice and metaphors. Carpendale's presentation focused on the visual and optical effect, the algorithm was not revealed.

Carpendale's *'EPS'* system demonstrates a user-oriented approach for screen-based information visualisation. The elegance of her approach is an aesthetic application based on a metaphor. This could stem from her partly artistic background. The graphical user interface, its ease of use and ease in understanding its functionality, was the main object of study and investigation, not the equations or math behind it. Carpendale worked on an experiential concept rather than on hardcore technical research and development.

> *'Since the advent of video display terminals as the primary interface to the computer, how to make the best use of the available screen space has been a fundamental issue in user interface design. The necessity for effective solutions to this problem is intensifying as the ability to produce visual data in greater volumes continues to outstrip the rate at which display technology is developing.'* (Sheelagh Carpendale)[257]

Carpendale also seems to fulfil this self-supporting artist-inventor role, as an artist who tries to find solutions to circumvent the limitations of the small 2-D screens used currently in daily computational environments (see also Problem solving in chapter 2, 'aRt&D and related methods' 2.2.1.). Moreover, it was observed that Carpendale and Schouten, both from a traditional art background, seem very well able to combine the artistic instrumental approach of technology with a reductive, problem solving approach. Carpendale's work covers parts of two categories in the aRt&D matrix, reflecting an attitude seen in traditional art productions, and her scientific work follows a solution lead path. From her presentation, it was understood that the team was limited and no large interdisciplinary collaboration can be traced. The migration of artists, such as Carpendale and Schouten, to the scientific field shows another way of self-supporting the development of their ideas. The work of Carpendale and Schouten was presented as scientific; no direct references to their current art practice were given in their presentations.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)
Problem solving	***Reductive method***	**Single or limited disciplinary problem solving approach, applied research, practical method**	Technicians as facilitators, artists as **engineer in single / limited disciplinairy situation**, no improvisation	**Sharp goal, clear aim**, useful for tool development, no-**divergence, linealr**, predictable, assistance or facilitations rather than co-operation	**Traditional methods in art, engineering, design, science and technology**
Selfsufficient, selfsupporting	***DIY and hacker methods***	Mis-interpretation / re-interpretation protest / activism via alternative methods, **mostly small scale**	artist as enfant terrible, **catalyst for creative thinking**, innovation of artistic oeuvre (the latter relates to DIY)	**Surprises, new perspectives challenges**, critical view, new insights, reflection, awareness, Critique, confusion, shaking up the teams, intuitive, **steep learning curve to become self-sufficient**	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, **relevant in multi disciplinary collaborations often autodidact** multi-tasker, exchange with other independent operators, FLOSS development

(Fig.23. aRt&D Matrix with methods from presentation by Carpendale (bold))

Brigit Lichtenegger (NL) presented the *'DataCloud'* projects developed by V2_ in collaboration with Archined (NL). *'DataClouds'* are highly interactive online platforms for exchange and debate, focussing on audiovisual information and text. The strength of the projects is the possibility to create relations between different media objects, and by doing this, new meaning and new associations are created. In the *'DataCloud'* projects, the user is the co-author and the information visualisation is tailored to the unpredictable and dynamic input and generation of information.

Lichtenegger showed some typically artistic approaches, where the audience becomes the co-author of the online *'DataCloud'* applications. The effort and investment in achieving an extremely flexible system that ought to be prepared for the unpredictable, to enable the participant to make new objects and to generate new meaning, is almost the opposite of the reductive approach. Lichtenegger's mixed background as artist and engineer represents the mediation aspect of her role in the team. Although Lichteneger highlighted some technical aspects, her artistic background and the art environment she works in are reflected in the *'DataClouds'* typical artistic approaches. For example, I notice a strong focus on making new connections, almost in a *processpatching* kind of way, and special interest in 'openness' and self-organising systems is an attitude I often observe in art projects. The summery of the *'DataCloud'* approach as outlined by Lichtenegger can be found in the aRt&D matrix below.

Problem solving	***Reductive method***	**Single or limited disciplinary problem solving approach, applied research, practical method**	Technicians as facilitators, artists as **engineer in single / limited disciplinairy situation**, no improvisation	**Sharp goal, clear aim,** useful for tool development, **no-divergence, lineair,** predictable, assistance or facilitations rather than co-operation	**Traditional methods in art , engineering, design, science and technology**
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	**Parallel and intersecting methods and approaches, from involved disciplines**	**Freedom to change methods** re contextualisation, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,
	Participatory method	**Itterative process, design method thought from the end-user / participant's perspective**	Complicated to combine with problem solving, interdisciplinary cooperation, 3-th space	Ground for co-operation, experience oriented applications, difficult to combine with problem solving	Post-Marxism, design theory, improvisation theatre / **various design approaches e.g. human centred HCI**, ethnography, social sciences, communication design,

(fig. 24. aRt&D Matrix with methods from presentation by Lichtenegger (bold))

Márton Fernelezelyi and Zoltán Szegedy-Maszák from C3 in Budapest, showed their *'Demedusator'* and *'Promenade'* projects. In both projects, they worked on experimental interfaces for mixed reality environments. In the physical version of their work, they used stereoscopic projection to visualise the data space. Their work fits into the artistic interest field of tactile and multimodal interfaces. In both projects, the interface turned out to be problematic for inexperienced users. Based on these earlier attempts, they decided to work with a neuroscientist for their next piece dealing with augmented reality. Fernelezelyi and Szegedy-Maszák underline the interest in interface design as a main ingredient of art and cultural research and development.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	**Parallel and intersecting methods and approaches, from involved disciplines**	Freedom to change methods re-contextualisation, space for cooperation, **ground for new discoveries and innovation,**	Post- Modernism critical theory, Fluxus, includes **humanities, computer science, arts,**

(Fig.25. methods from presentation by Fernelezelyi and Maszák (bold))

> *'In order to explore visual information by visual means, you first need to develop a system in which recognition has its place, according to Schouten. Image recognition is based on having seen something before. It relates an emotion, experience or visual input to an earlier event. Instead of using keywords to extract the meaning of an image, a more intelligent way of looking for similarities is required, based on visual features and concepts. To bridge the so-called "semantic gap", we could use new, interdisciplinary approaches.'*
> *(Rens Frommé)* [258]

Ben Schouten (NL) showed his image retrieval work, which was rather similar to the previously discussed *'PARISS'* project, presented during the *Anarchives: Connection Machines* conference. (see also 3.2.1.) The work of Ben Schouten emphasises, again, the problems experienced in image recognition by computer scientists. They find themselves confronted with the so-called semantic gap. This is the continuum that appears between computer-understandable languages, and the informal and not easily translatable aspects of (in this case visual) information. As observed earlier in the *Anarchives: Connection Machines* presentations, Schouten argued that an interdisciplinary approach could influence this research area in a positive way, by bringing in other concepts of meaning to make up for the limitations of current machine languages. The suggested reductive method is a difficult one to use in interdisciplinary collaboration. However, when applied in a multi- disciplinary setting, the problem solving approach for pressing questions in computer science, as brought forward by Schouten, could work very well.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)
Problem solving	***Reductive method***	**Single or limited disciplinary problem solving approach, applied research, practical method**	Technicians as facilitators, artists as **engineer in single / limited disciplinairy situation**, no improvisation	**Sharp goal, clear aim**, useful for tool development, **no-divergence, linealr,** predictable, assistance or facilitations rather than co-operation	**Traditional methods in art , engineering, design, science and technology**
Selfsufficient, selfsupporting	***DIY and hacker methods***	Mis-interpretation / re-interpretation protest / activism via alternative methods, **mostly small scale**	artist as enfant terrible, **catalyst for creative thinking**, innovation of artistic oeuvre (the latter relates to DIY)	**Surprises, new perspectives challenges**, critical view, new insights, reflection, awareness, Critique, confusion, shaking up the teams, intuitive, **steep learning curve to become self-sufficient**	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, **relevant in multi disciplinary collaborations often autodidact** multi-tasker, exchange with other independent operators, FLOSS development

(fig.26. aRt&D Matrix with methods from presentation Schouten (bold))

Julie Tolmie showed a large part of her PhD work on visual notation in mathematics, which was later extended into interactive virtual worlds. She developed a particle system that visualises data, based on a broader body of her work in developing a mathematical approach for the visualisation of abstract concepts. Tolmie often works together with artists from different disciplines (see also *'whisper'* 3.1.2.). The work she showed evolved from collaboration with mathematicians, visual artists, performers, engineers and scientists. These trips out of the science domain are a way to question and challenge her discipline and its methodology:

> *'How much of the mathematics does the individual want to know? Are they prepared to engage with the conceptual model, the algorithmic details, or the shortcomings of its projected 2D or 3D representations? And how much is the scientist / mathematician prepared to let go of what they think they are seeing (or should be seeing) and 'feel' their way, immersed in the information object which is created?' (Julie Tolmie)* [259]

Julie Tolmie also brought up the opportunities in interdisciplinary collaborations among artists and scientists, as artists could bring in new concepts that come closer to a visual language that could bridge the semantic gap or overcome obstacles and limitations of computer-understandable languages. Here Tolmie also refers to the artist in the role of inventor to solve problems or circumvent limitations in current software and hardware approaches. She appeals for *processpatching* or connected concepts, or non technological approaches, which could be brought in by artists through their collaboration, and which point toward the *processpatching* approach without further details about the preferred methods or approaches. According to Tolmie, interdisciplinary collaboration provides fertile ground for innovation and further development of not-fully-developed techniques. Further investigation into the appropriate methods is recommended as this approach includes a complexity of goals, used terminologies, methodologies and approaches that could cause friction and misunderstandings.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualisation, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,

(fig.27. Methods from presentation by Tolmie (bold))

3.2.3 Case study: *Wearable Turbulence*

This case study refers to the artistic attitude, theoretical background and the methods as are brought forward in the *Wearable Turbulence* [260] seminar. The seminar was held in the context of the Dutch Electronic Arts Festival 2004, with the theme *Affective Turbulence: The Art of Open Systems*. The *Wearable Turbulence* seminar was moderated by Sha Xin Wei (US).[261] Below the seminar and the festival is briefly described:

The theme of DEAF04 focused on the instability of open systems and feelings as the essence of actions that affect and influence these systems. The seminar focused on a subset of the theme, dealing with technology worn on the body or that becomes part of the body from a 'user's' perspective. We questioned the effects of this technological infiltration in our daily lives, evidenced in current scientific research, on runways, and in the industry's undeniable obsession with mobility, as we, the users, try to catch up with the hype. Is this new smart-wear empowering us, facilitating our daily tasks and helping us to improve our social communication skills? Or, are we becoming more vulnerable and arguably more disembodied, as our insides are thrust onto the outside, and constant connectivity becomes the norm? What are the implications of translating, transmitting and accessing sensory data, emotions and instinct through wearable, technological intermediaries?

This seminar examined the underlying struggle between the public and the private in the field of wearable computing, showing a variety of cutting-edge approaches to human-centred computing, and highlighting recent applications in context-aware computing and networked relationships. The seminar also invited reflections on the reasons for and benefits of wearable technologies, and expectations for the near and far future.

The following artists and researchers presented their work and participated in the panel discussion afterwards: Dr. Bradley Rhodes [262], a research scientist at Ricoh Innovations in California; Christa Sommerer [263], internationally-renowned media artists: Kristina Andersen, interaction designer and designer of experiences, and former research fellow at the Interaction Design Institute Ivrea.

The speakers were invited as representatives of opposing visions and attitudes towards (wearable) technology and its relation with the user or the body. This opposition comes from the field of knowledge representation, where I can (in retrospect) trace an evolution from the old school, machine-oriented, artificial intelligence visions to, more recently, human-centred approaches. The old school vision, promoting the super-computer brain, and modelled after the human brain with the intention to replace it, has been increasingly criticised over the last decades.

The speakers thus represented, with nuance, different perspectives on the machine-oriented and the user-centred approaches. Rhodes is specialised in intelligence augmentation, wearable & ubiquitous computing, software agents and "other things that make people smarter." He received his PhD in 2000 from the Software Agents group at the MIT Media Lab. From 1996 to 2000 Rhodes lived the life of a cyborg, integrating wearable computers into his daily life as a part of MIT's wearable computing "living experiment." Rhodes wore his cyborg-wearable spectacles with a built-in miniature camera / display during the seminar. Rhodes worked in the wearable group in the MIT medialab (USA) This group showed a mix of artistic and scientific research from MIT. An other well known artist who was a 'living experiment' from that group is Steve Mann[264] (see also chapter 2.2.7. Relevant Research Themes for Artistic Research and Development). Sommerer commented on this utopian view of prosthesis. She criticised the machine-oriented approach and the unwanted sharing of personal information. In disagreement with Rhodes, Sommerer pleaded for an option to switch technology off in order to stay aware of the presence of technology and thus its power to control and localise. The work of Sommerer, and her collaborator Mignonneau, is often designed from a useless point of view, with a strong poetic aesthetics and working with very sophisticated software and hardware. The artists wrote the following about the project presented during DEAF04, *Wearable Turbulence*:

> *'Mobile Feelings is an artistic project that explores the ambivalence of sharing personal information with an anonymous audience. Instead of communication via voice or images to people we know, "Mobile Feelings" lets people communicate with strangers through virtual touch and body sensations including smell and sweat using specially designed mobile phones.*
> *Mobile Feelings aims to create unusual and unsettling sensations of sharing private body sensations with complete strangers over a mobile phone network.' (C. Sommerere, L. Mignonneau)*

The last speaker of the seminar was Kristina Andersen, whose work is oriented on notions of tangibility versus intangibility, and the parallel universes of the real and fiction. Andersen spoke about critical design issues in social interaction, and how to investigate these with little or no technology. Andersen works with games or game play as an improvisation method to engage users in an early stage of the interaction design process. In her work, she frequently plays with 'the willing suspension of disbelief'. For this, she brings in non-technological props and placebos replaces complex technologies to give way to playful experiences. Andersen's work focuses on experience design that is mostly not task-oriented or meant for practical purposes. This again contrasts with Rhodes' who acts as a constant beta-tester of his new inventions, which are

'.. things that make people smarter.' (B. Rhodes) [265]

The final discussion circled around privacy issues and free will. Sommerer clearly opposed the trend towards transparent technology as this would camouflage the technology and dim the user's awareness of its implications, such as control and surveillance. Rhodes promoted the idea of 'living the experiment', that is the technological experiment. Rhodes approaches technology from an instrumental point of view, to 'improve' his live. This in turn provoked more discussion, as this so called improvement is controlled by 'invisible' powers, or the designers or makers of the technology. This refers back to the origins of most technology the military apparatus, which again loops back into the discussion of control, surveillance and privacy issues.

The different approaches and visions represented in this seminar and the final discussion seem to reflect, in particular, the very different aims and connected approaches of the participants. Sommerer, as artist, questions the social aspects of current technological approaches and communication protocols. She expresses herself in an aesthetic, artistic way by designing new devices and proposing another way of communication based on biofeedback. The researcher Rhodes lives the (part-time) technological dream of the cyborg, and deals with technology as the main instrument to make life easier. He thus takes it for granted that one adjusts one's physical condition, and social patterns to the (current) constraints of technology. Finally, Kristina Andersen showed game playing as a method to reach a level of engagement and intimacy for participatory design, which is hard to reach via mediated methods. Like Sommerer and Mignonneau, she works according to a human-centred approach. And although Rhodes is living a life as a beta tester, his thinking and concepts originate in the technological and instrumental realm, or the machine perspective.

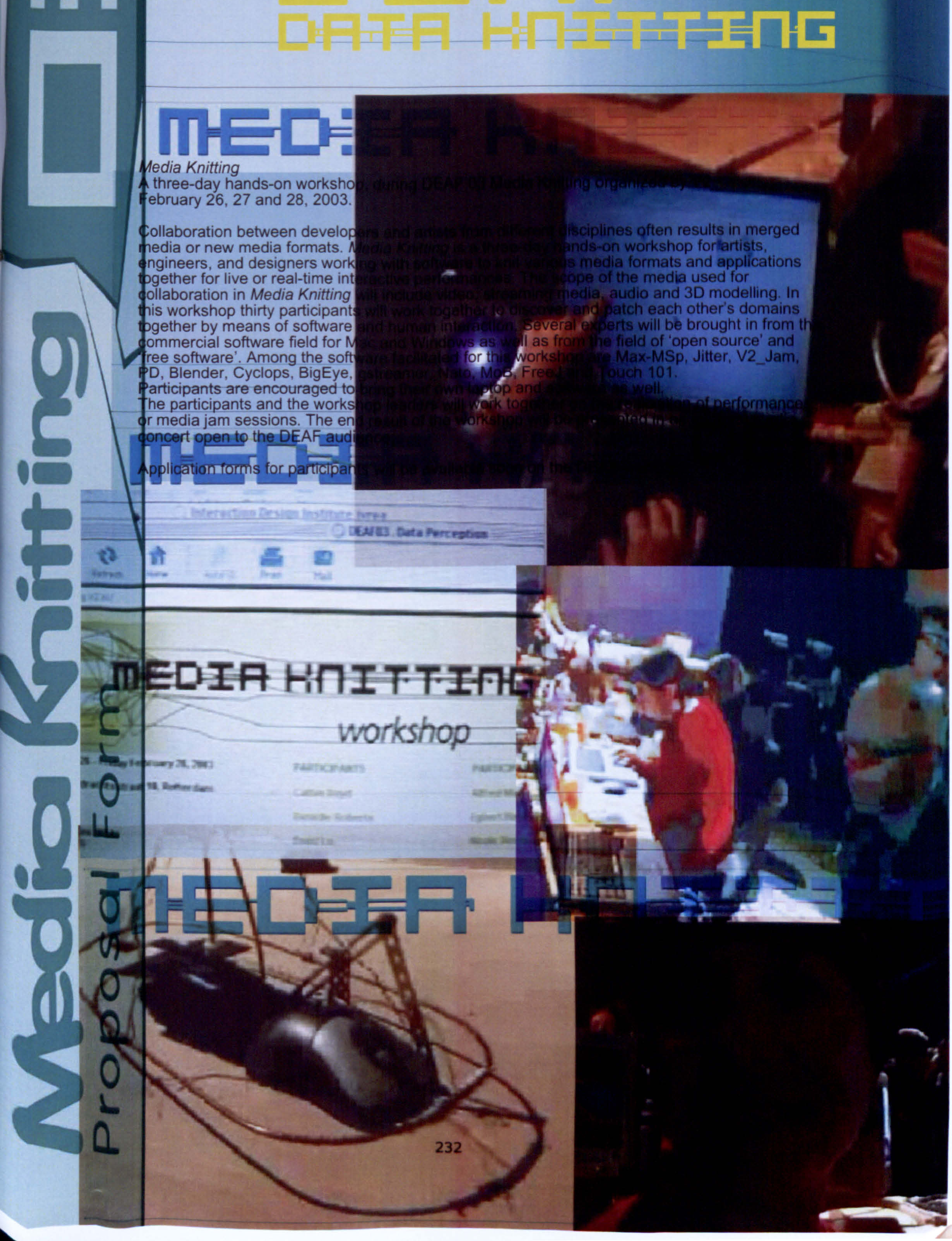
Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)	Type of aRt&D, type of collaboration, application domain
Problem solving	***Reductive method***	**Single or limited disciplinary problem solving approach, applied research, practical method**	Technicians as facilitators, artists as **engineer in single / limited disciplinairy situation, no** improvisation	Sharp goal, clear aim, useful for tool development, no-divergence, lineair, predictable, assistance or facilitations rather than co-operation	**Traditional methods in art, engineering, design, science and technology**	**Empiric approach, applied R&D, relevant in single- and multi-disciplinary teams, techno science, artistic innovations**
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualisation, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	Participatory method	**Itterative process, design method thought from the end-user / participant's perspective**	Complicated to combine with problem solving, interdisciplinary cooperation, 3-th space	Ground for co-operation, experience oriented applications, difficult to combine with problem solving	Post-Marxism, design theory, improvisation theatre / **various design approaches e.g. human centred HCI**, ethnography, social sciences, communication design,	**Heuristic research, experience design**
	User centred design method	**Design method focussing on the participant(s) experience**		Focus on end-user/participant	communication studies , cultural studies	
	re-engineering, reverse engineering	**re-purposing technology**			related to DIY and hacker approaches	

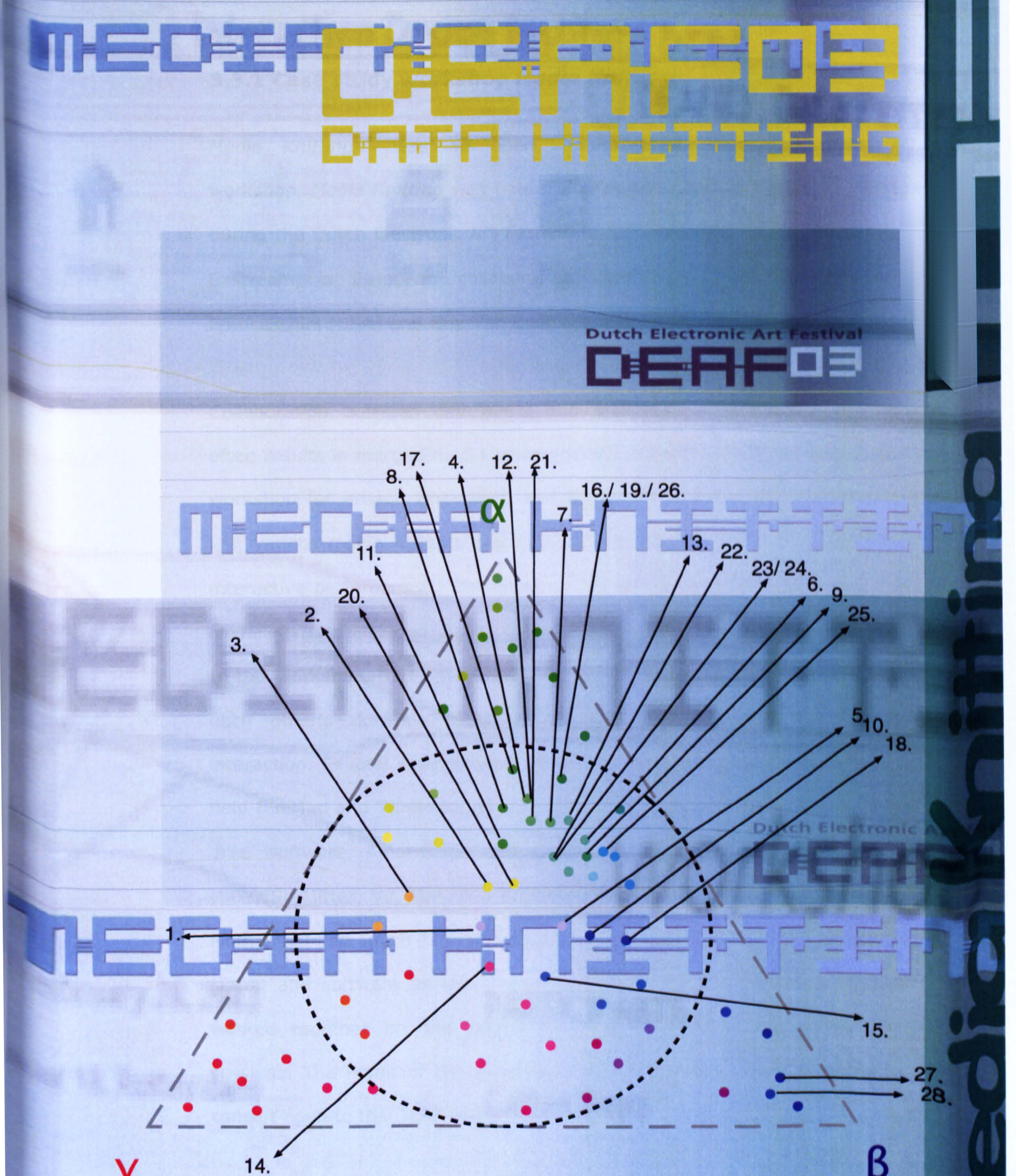
(fig.28. aRt&D Matrix with methods from Wearable Turbulence presentations)

3.3. Case studies workshops

The hands-on workshops are used to complement the observations found in 'the artworks' case studies in 3.1 and onwards, and vice versa. In the workshops, the participants worked on short term collaboration projects. Different workshop leaders worked with various models to improve the models for collaboration over a period of approximately five years.

collage 9.
Impressions of Media Knitting, workshop during DEAF03





aRt&D team map Media Knitting

3.3.1 Case study workshop *Media Knitting*

Media Knitting[266] was an open, non-directive, three-day hands-on workshop. *Media Knitting* was held from February 26th to March 1st ,2003, during the Dutch Electronic Art Festival in Rotterdam, in collaboration with Exstream, a European collaboration consortium, and led by Amy Franceschini (USA) and Guy Van Belle (B).

Collaboration between developers and artists from different disciplines often results in merged media or new media formats. *Media Knitting* was a workshop for artists, engineers, and designers working with software to knit various media formats and applications together for live or real-time interactive performances. The scope of the media used for collaboration in *Media Knitting* included video, streaming media, audio and 3D modelling. In this workshop, thirty participants worked together to discover and patch each other's domains together by means of software and human interaction. Several experts were brought in from the commercial software field for Mac and Windows, as well as from the field of 'open source' and 'free' software. Among the software facilitated for this workshop were Max/MSp, Jitter, V2_Jam, PD, Blender, Cyclops, BigEye, gstreamer, Nato, MoB, FreeJ and Touch 101. Participants were encouraged to bring their own laptop and software as well. The participants and the workshop leaders worked together on the realisation of performances and media jam sessions. The result of the workshop was an informal, improvised media concert open to the DEAF audience.

3.3.1.1. Method and approaches

Several models for workshops were discussed with the workshop leaders, to find the most suitable model for encouraging people to work together. The model applied to *Media Knitting* was inspired by the Bauhaus model for collaboration. The Bauhaus' master and pupil apprenticeship model and learning through mastering the technique, were the main elements van Belle planned to build upon. Note that the Bauhaus concept served mainly as a reference for the workshop leader, as the process of knowledge gathering and knowledge transfer, which is essential in the Bauhaus model, takes years, and this workshop covered a time span of 4 days. The workshop leaders also included some non-Bauhaus approaches as they intended to let the collaborations among the participants come into existence organically, while encouraging people to reconsider their personal methods and habits in order to explore new ways of working. There was no force put upon people to work together, and the workshop leaders were not instructed to pay special attention to certain workshop participants. The goal of this workshop was to explore new territory, both in a technical as well as in a disciplinary way. Van Belle's loose and not clearly communicated workshop approach did not acknowledge the diversity of backgrounds and knowledge represented in the group of participants. The final presentation was a media jam, an informal presentation.

3.3.1.2. Disciplinary background of the workshop participants

Preceding the workshop, several meetings were held with van Belle and online exchange with Franceschini. The proposals for participation were reviewed in two rounds. One round focused on the quality of the work (knowledge and ideas) and motivation for collaboration (expectations and intentions for the workshop), while the other focused on the workshop constellation to guarantee the diversity of disciplines and gender. The participants thus represented a broad range of disciplines, from visual arts, theatre, interaction design, audio art, software and hardware engineering, architecture, computer science etc. as visualised in the art&D Triangle in collage 10. Many of them had a mixed background. The applications inform us about the following information from the participants. Adam Hyde who has a background in philosophy, software engineering, art (1. collage 10); Alejandro Duque, who has a background in art , media and communications (2. collage 10); Cathie Boyd, who has a background drama, theatre (3. collage 10) ; Danielle Roberts, who has a background in sculpture, new media art (4. collage 10); David Lu, who ahs a background in computer science, economics, psychology, interaction design (5. collage 10); Dessislava Karushkova (no info), Gp Cribari, who has a background in music, digital arts (6. collage 10); Kalliwoda Majoor (artist duo): who have a background in interactive art (7. collage 10), photography, performing arts (8. collage 10); Karmen Franinovic who has a background in architecture, audiovisual arts (9. collage 10); Keith Armstrong, who ahs a background in visual arts, electronic engineering, information technology(10. collage 10); Kelli Dipple, who has a background in theatre, choreography, audiovisual arts (11. collage 10); Luther Thie, who has a background in visual arts, performance art, interaction design (12. collage 10); Marjolein Kassenaar who has a background in interaction design and audiovisual arts (13. collage 10); Marseille & Bleyenburg (artist duo) Alfred Marseillewho has a background in philosophy, graphic design (14. collage 10), Egbert Bleyenburg who has a background in theoretical physics, visual arts, writing, theatre, software engineering (15. collage 10); Nicole Biermaier who has a background in art and design (16. collage 10), Nina Czegledy who has a background in media arts, curating and writing (17. collage 10), Onno Ernst who has a background in software engineering, digital arts (18. collage 10); Petko Dourmana who has a background in media arts (19. collage 10); Pieter Verhees who has a background in drama, technology, sculpture (20. collage 10); Piotr Pajchel who has a background in fine arts (20. collage 10); Rosanne van Klaveren who has a background in fine arts and photography (21. collage 10), Sara Nuytemans who has a background in digital arts, industrial design engineering(22 collage 10); Schiffeleers & Leper (artist duo) who have their background in photography (23/ 24 in collage 10); Sonia Cillari who has a background in digital arts, architecture (25. collage 10); Vesna Stefanovska who has a background in audiovisual arts (26. collage 10), Stefano Bocconi who has a background in software engineering and computer science (27. collage 10); Joost Geurts who has a background in software engineering and computer science (28. collage 10). [267]

3.3.1.3. Outcome and interviews

The following workshop outcomes are based on interviews with several participants and one of the workshop leaders. Interviews were held to gain insight into the process and experience of the participants and the effect of the selected method as a tool to facilitate interdisciplinary collaboration. The interviews were held after the workshop, so as not to influence the workflow and concentration during the workshop. In the evaluations, one of the participating computer engineers mentioned that he had

> *'.. expected to meet artists; people that were mainly concerned with art and less occupied with technology ' He expected more people with ideas who were looking for help with the implementation or realization of their artwork. He 'missed their commitment to Art as he would expect from artists.'*

As the conversation continued, it was clear he had hoped to meet the contemporary version of the 'romantic' artist, who he could have rescued from some tedious technical problems. The chosen workshop approach was another complicated aspect that was highlighted in two interviews with computer scientists. As they were expecting a structured class or work environment, and the Bauhaus master-students collaboration model was unfamiliar to them, it took a long time before any interaction with the other participants was established. One of the workshop leaders mentioned that the artists, on the other hand, acted more self-sufficiently and invaded the space and tagged together different parts of software and hardware in unexpected ways. When the participants shared software or hardware knowledge, this worked as a magnet to pull the involved participants together and concentrate on their artistic concepts, without the distraction of steep learning curves, as is stated by one of the participants:

> *'At a three-day-workshop where you have to collaborate with people who use different media (mediaknitting) Teleo proved to be very effective. fast setup, easy way of getting reliable data into the computers system, possibility of connecting different kind of media ... perfect marriage.' (Stijn Schiffeleers)* [268]

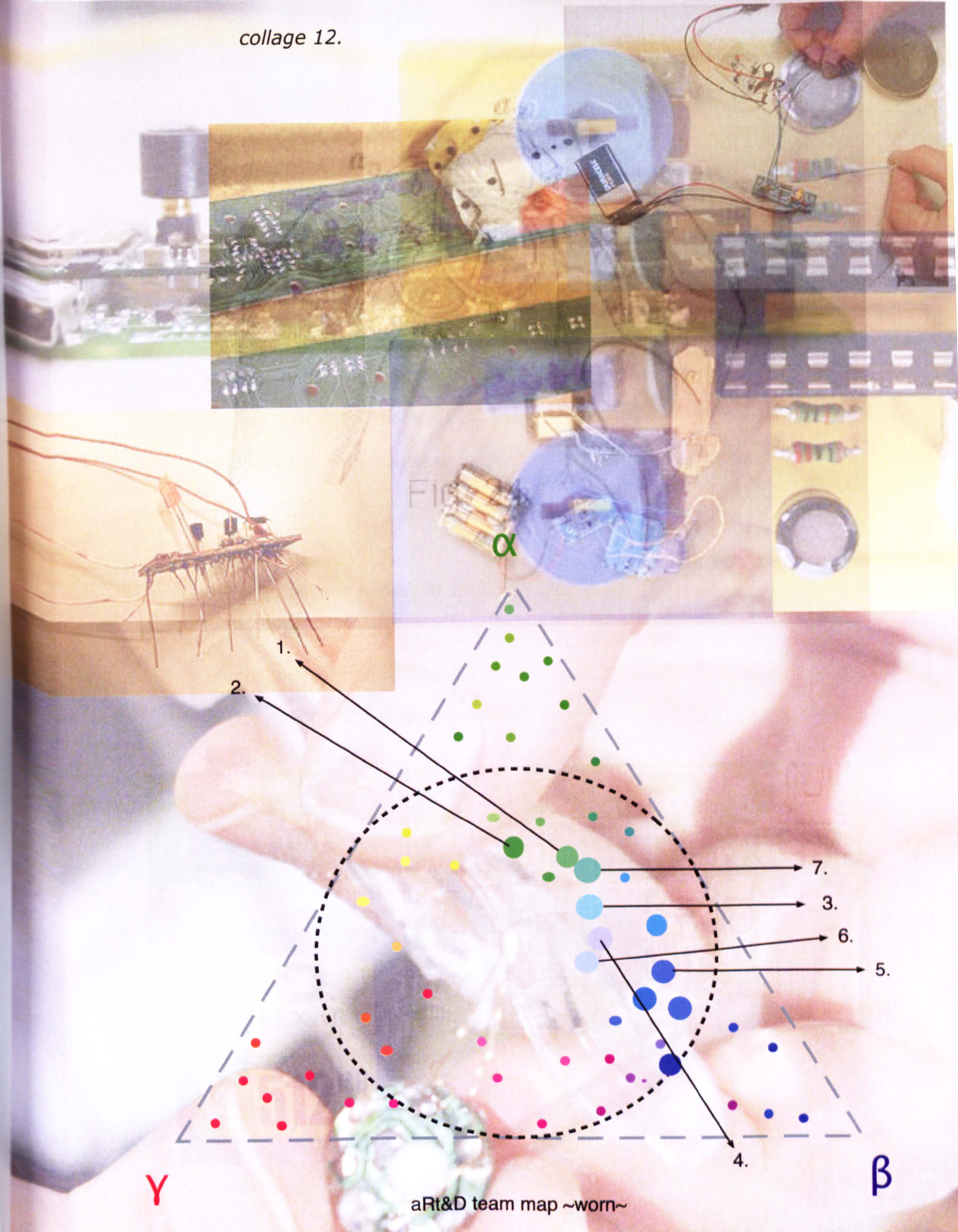
All together, this made the workshop less successful for those who did not have a mixed background and neither shared experiences and software nor hardware knowledge with others. In this workshop, the DIY method was most suitable for the multi-professionals and was used for independent, critical or ironic artistic works.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)	Type of aRt&D, type of collaboration, application domain
Selfsufficient, selfsupporting	***DIY and hacker methods***	Mis-interpretation / re-interpretation protest / activism via alternative methods, **mostly small scale**	**artist as enfant terrible, catalyst for creative thinking, innovation of artistic oeuvre (the latter relates to DIY)**	Surprises, new perspectives challenges, critical view, new insights, reflection, awareness, Critique, confusion, shaking up the teams, intuitive, steep learning curve to become self-sufficient	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, **relevant in multi disciplinary collaborations often autodidact multi-tasker, exchange with other independent operators, FLOSS development**	Thinktank or brain storm approach, engagement, Critiquing, awareness, empiric or practical approach, single person multi tasking, artist-commentator, **engineering, hackers**

(fig. 29. aRt&D Matrix with methods from workshop Media Knitting)

Collage 11.
Impressions of ~worn~ workshop, visuals from reader and by workshop participants

collage 12.



aRt&D team map ~worn~

3.3.2. Case study: ~worn~

The workshop '*~worn~*' was initiated in close collaboration with Matthew Fuller from the Media Design department of the Piet Zwart Institute, Willem de Kooning Academy Rotterdam and V2_Lab in the context of the MultimediaN research project. The workshop was led and coordinated by Kristina Andersen, and assisted by Simon de Bakker, Stock and Antoine van de Ven from the V2_Lab team. The text below is partly written in collaboration with Matthew Fuller and Kristina Andersen as part of the collaboration.

'*~worn~*' was a hands-on investigation into cross-disciplinary design and the development of wearable objects of desire. It was recently run as a 3-month thematic project for 4 first year M.A. students. It investigated which boundary objects or shared methods could facilitate a third (or hybrid) space for collaboration, play and circuitry.

The workshop aimed to promote a different creative use of wearable technology compared to what we experience in our daily life, by scrutinising its origins, playing with its anomalies and cultural qualities and modifying its applications in life and expression. However, repurposing technology often introduces problems and misunderstandings among collaborators who understand and codify the technologies differently. '*~worn~*' explores ways to translate the designer's 'object of desire' into design methods or approaches understood by all involved areas of knowledge; from the generous or over-stretched technician and the alien artist to the practical designer. Simply hooking the parts together does not guarantee results. Knowing where they might be found, learning ways to trick them into receptiveness conjoins many kinds of skill. Knowing how and where to make such marks, so that others can pick up the work and progress with it to the next stage, is key to effective work. Starting the project from the basis of desire, from non-knowledge to collaborative execution of the work, allowed students to recognise the various marking points, the moments of transition from one kind of work, or one kind of technological embodiment to the next.

3.3.2.1. Disciplinary background of the participants

The students represented different fields of design (sometimes combined with other backgrounds). All students were doing their first year of their Masters program at the Piet Zwart Institute Rotterdam, in the department of media design. In collage 12, the participants of the workshop are represented in the aRt&D Trangle. Sasson Kung (1. collage 12) has a background in graphic design and installation art. Cheryl Gallaway (2. collage 12) has a background as fashion and media designer. Dragana Antic (3. collage 12) has a university background in architecture design. Tsila Hassine (4. collage 12) has a background in mathematics and computer science / media design. Stock (5. collage 12) has an electro-technical, sound and music background. Simon de Bakker (6. collage 12) has a background in art and technology. Kristina Andersen (7. collage 12) has a background in media art and interaction design. The workshop leaders reflected the disciplines engaged in the interdisciplinary collaboration in a general sense; design, art and technology were represented in different variations, while the whole project was supervised by an educator and lab manager, the latter were not included in the aRt&D Triangle as they did not engage in the collaboration.

3.3.2.2. Method and approach

The participants worked according to a rather traditional master and student model, although as the workshop was focused on the students' design process and the realisation of their concepts, it was sometimes hard to identify who was the instructor and who was the student, as these processes still reveal new areas of learning for all involved. The *'~worn~'* project was intended to develop new conjunctions of technologies and not to develop new technology per se. These conjunctions and the finding of new means to motivate and evaluate them drove the project. *'~worn~'* was conducted as a series of workshops and hands-on sessions aimed at experimenting with various boundary objects as the participants were asked to move through a design exploration, from artistic desire through to technologically sophisticated development and realisation. The methods of exploration varied from hacking and re-appropriating existing technological objects to quick and dirty prototyping, and formal writing and drawing. They employed ready-mades and low-tech devices as tools for improvisation and easy collaboration among participants and technologists with very different backgrounds. From a teaching point of view, '~*worn*~' was designed as an immersive experience inspired by performance and gaming.

3.3.2.3. Artistic methodology

The research and development approach of '~*worn*~' was an interplay between electronic art , design and technology approaches, where the ball bounced between improvisation, hacking or re-appropriating technology, and problem solving. The general methodology is a *processpatch* of imagined and practical approaches. *Processpatching* in this respect shouldn't interpreted as a vague concept, applied to circumvent statements about methods, but rather a way of working rooted in art movements built on concrete, non-random conjunctions. In this case, the aesthetics of conjunction (which can also be found in montage or collage) is not necessarily reflected in the output; for instance in sound files, but is embedded in the underlying hardware and software design that is tagged together in order to establish (or to come as close as possible) to the concepts of the students' dreams or the desires.

The hacking or re-appropriation approach was chosen as it provides space for all involved disciplines to meet on a potentially neutral ground, or what in participatory design might be called a Third space. One possibly unexpected example is where the hobbyist electronics kits that were provided opened up technology for the students on a basic level. Normally, professional technologists are removed from such simple consumer electronics / tools and found them refreshingly fun to work on. In this case, a Third space was created by using a boundary object; something to collaborate on which neither party can claim an inability to work on, yet which neither can claim to totally 'own'.

3.3.2.4. Outcomes

The success and the impressive outcome of the '*~worn~*' workshop is based on the respect of the collaborators, and the balanced interplay between playful exploration and an open approach towards the technology. The technology was introduced to the students in a human-centred approach. Through the introduction of consumer electronics, the technology entered the arena as a soft component, allowing for hands-on soldering, hacking, re-engineering and repurposing. The role of the workshop leader was of crucial importance as she acted as a mediator between the students' art and design concepts and the hardware developers. She facilitated the Third space or neutral ground for the students and the developers to meet, collaborate, create and learn. This Third space worked well as it provided a workable model without too much waiting time, or need for expert knowledge (either from the technological or the artistic / design side). The low-tech consumer hardware kits worked well as boundary objects, and enabled the artists, designers and technicians to meet in a semi-neutral space.

A key indication of the workshop's success is that several students are planning the next version or steps in product development from the prototypes developed in the '*~worn~*' workshop. A paper about the process and methodology of the workshop was presented during Wearable Futures[269], a conference at the University of Wales (UK). Currently V2_ is negotiating the options for showing the students' works in a scientific and multimedia research context, as the work was perceived as user-centred innovative design by the MultimediaN consortium.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / Disadvantages	Theoretical context / Matching approach(es)	Type of aRt&D, type of collaboration, application domain
Selfsufficient, selfsupporting	***DIY and hacker methods***	Mis-interpretation / re-interpretation protest / activism via alternative methods, **mostly small scale**	artist as enfant terrible, **catalyst for creative thinking, innovation of artistic oeuvre (the latter relates to DIY)**	Surprises, **new perspectives challenges, critical view,** new insights, reflection, awareness, Critique, confusion, shaking up the teams, intuitive, steep learning curve to become self-sufficient	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, **relevant in multi disciplinary collaborations often autodidact multi-tasker, exchange with other independent operators, FLOSS development**	Thinktank or brain storm approach, engagement, Critiquing, awareness, empiric or practical approach, single person multi tasking, artist-commentator, **engineering, hackers**
Innovating arts, re-contextualising technology, creating new connections	***Process patching***	**(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale**	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualisation, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxus, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	Participatory method	**Itterative process, design method thought from the end-user / participant's perspective**	Complicated to combine with problem solving, interdisciplinary cooperation, **3-th space**	Ground for co-operation, experience oriented applications, difficult to combine with problem solving	Post-Marxism, design theory, improvisation theatre / **various design approaches e.g. human centred HCI,** ethnography, social sciences, communication design,	**Heuristic research, experience design**
	User centred design method	**Design method focussing on the participant(s) experience**		Focus on end-user/participant	communication studies, cultural studies	
	re-engineering, reverse engineering	**re-purposing technology**			related to DIY and hacker approaches	

(fig.30. Methods from '~worn~' (bold))

3.4. Conclusion case studies

The conclusion of this case study chapter deals with different aspects of the observed and analysed projects. Firstly, some of the case studies included references to the stereotypes from literature, as listed in chapter 2. The stereotypes that had an effect on the collaboration will be highlighted as indicators for attention and improvement. Secondly, the case studies provided an important realty check for the proposed methods and their related objectives in the aRt&D Matrix. The conclusion continues with the outcome of the compared aRt&D Triangles, and each project's Matrix information. The information from the aRt&D Triangles with the Matrix will in turn be compared and combined which results in a set of additional references and conditions for collaborators. The conclusion of this chapter ends with a short résumé of the most significant instruments for collaboration that were used successfully in the case studies.

3.4.1. Stereotypes

The case studies above bring forward some of the earlier discussed stereotypes or assumptions (chapter 2.) about the roles, approaches and linguistic obstacles in collaborations. In the *Media Knitting* workshop, the image of the stereotyped artist and scientist was re-confirmed. The evaluating interviews brought the ignorance about the other's discipline to the surface (of both the electronic artists and the software engineers). The image of the Romantic artist still seems persistent with engineers from a computer science environment. From the art side, the assumption about some artistic approaches also caused confusion and obstruction of the intended collaboration among the participants. In some of the reported events, linguistic confusion arose, and it was most significantly articulated by Smeulders (3.2.1) who is a representative of computer science. Whereas the artists in most case studies refer to 'interdisciplinary' as an indicator for a range of different backgrounds and different disciplines, Smeulders used the term to refer to other disciplines within computer science as interdisciplinary collaborators. In the field of linguistic confusion and terminological obstacles, it was confirmed that the innovative artists, such as from *'whisper'* and *'Polar'* (3.2.1), glue together terminologies and expressions from different types of disciplines and expert-fields to describe their work. They draw from network theory, cultural studies, film and media theory, performing arts, social sciences and so on. Smeulders and Schouten (3.2.1., 3.2.2.) also emphasised that the audience is a hypothetical actor in their computer scientific research and development work, in contrast to the artworks such as *'M.U.S.H.'*, *'whisper'*, *'Kurort'* (3.2.1.), *'Polar'*, *'Mobile Feelings'* (3.2.3) and the projects developed in *'~worn~'* (3.3.2.), where the user or participant plays a central role.

The potential benefit for science to collaborate with (electronic) art, is that the semantic gap can be bridged via informal (emotional or intuitive) approaches. This was brought forward by Tolmie (3.2.2.) and Smeulders (3.2.1.).

3.4.2. Outcome of the aRt&D Triangles

The collaboration process of most case studies was analysed and graphically represented in the aRt&D Triangle. On a general note, it is important to bear in mind that most of the studied electronic artworks were developed by team members from a range of disciplines with different backgrounds (3.1.1, 3.1.2., 3.1.3., 3.2.1.). and the presented scientific projects were developed by team members from limited scientific disciplines (3.2.1., 3.2.2.). In the conclusion of this chapter, I compare the case studies and draw some significant conclusions. The compared aRt&D Triangles (Collage 2., 4., 6., 10.,12) show:

- That successful collaboration is mostly achieved by the collaborators whose backgrounds are closely positioned in-between the disciplines (3.1.1, 3.1.2., 3.1.3., 3.2.1.).
- That the artists who engage in successful collaboration with software and hardware engineers or technological science have technical know-how and experiences or design backgrounds (3.1.1, 3.1.2., 3.1.3., 3.3.1.).
- That artists from electronic music often share technical knowledge with the software or hardware engineers (3.1.1, 3.1.2.).

This affirms the effectiveness of shared knowledge, which acts as a boundary object (see 2.2.6.6. Henderson). It underlines the practical aspect of multi-professionalism, ('whisper' 3.1.2.2., '~worn~' 3.3.2.) in that it also confirms the bridge function of the artist as mediator between the audience, non-technologists and the technical team members.

- The projects that were developed by a team representing a few different backgrounds worked in a problem solving or reductive way (3.1.1., 3.2.2.).

The studied projects with a clear objective (overview and focus) for technical development used an instrumental approach to the technician, and the technician fulfills the role as facilitator in a multi-disciplinary way. (see 2.2.3.4.)

- That multifaceted electronic art research starts with a larger amount of collaborators from very different disciplines (3.1.2, 3.1.3.).
- That interactive experience projects with a larger number of collaborators began in the very first instance with a *processpatching* method (3.1.2., 3.1.3., 3.2.1., 3.3.2.) but changed the overall approach in the course of the project into various different research and development methods in order to meet the preferred work approach of the team members with different backgrounds.

This highlights an important addition to the definition of *processpatching* as the assumed method for research and development in the electronic arts. These case studies demonstrated that it can be useful to embed DIY and problem solving, as well as other artistic methods in a larger context of the *processpatching* method.

3.4.3.Outcome of the aRt&D Matrix

The aRt&D Matrix has been implemented as an instrument of reference in this case study chapter. The aRt&D matrix lists and compares the proposed artistic methods (chapter 2) with the practice from the case studies in this chapter. Based on the case studies, several crucial points underlined and additional aspects are taken into consideration for fine-tuning and explanation of the listed electronic art approaches and methods. The case studies in the aRt&D Matrix shows us:

- That in the techno-scientific work presented here, the reductive approach was most used as a method for solving technical problems, and to achieve technical innovation (Smeulders 3.2.1., Carpendale 3.2.2., Rhodes 3.2.3.).
- The techno-scientific cases reflect an instrumental approach to technology (Smeulders and Schouten 3.2.1., interviewed computer scientists / engineers 3.3.1. , Rhodes 3.2.3.).

- That problem solving proved to be fruitful ground for innovation in the electronic arts and technology (*'M.U.S.H.'* 3.1.1., *'EPS'* 3.2.2.)
- In the process of creating participatory interactive artworks, an iterative participatory design approach can be observed (*'whisper'* 3.1.2., *'Kurort'* 3.1.3., *'Polar'* 3.2.1., *'DataCloud'* 3.2.2, Andersen 3.2.3., *'~worn~'* 3.3.2.).
- That the presented interactive electronic artworks are focused on the participant's experience (*'M.U.S.H.'* 3.1.1., *'whisper'* 3.1.2., *'Kurort'* 3.1.3., *'Polar'* 3.2.1., *'DataCloud'* 3.2.2.).
- That the scientists, who have a mixed background in traditional art and science, feel most at ease as autonomous scientific researcher with a reductive or problem solving approach (Carpendale, Schouten 3.2.2.)
- That persons with a mixed background in technical science and art (in general) represent two types of roles in the team working process, which is of crucial importance when considering collaboration: the self-sufficient person (no collaboration required): Kerne, (3.1.2.) Carpendale, Schouten (3.2.2.) or the mediator (a key person in a team with members from diverse backgrounds): Lovell, (3.1.2.) Verouden, (3.1.3.) Lichtenegger, (3.2.2.) Andersen (3.3.2.).

- Persons with a technical background often tend to find their most suitable collaborators in the problem solving field (3.1.1., 3.1.2., 3.1.3.)
- That re-purposing existing technology is a recurring aspect of several approaches of artistic research (*'M.U.S.H.'* 3.1.1., *'Kurort'* 3.1.2.), but might be a difficult issue in *processpatching* approaches, as it might conflict with other, individual, objectives of the involved collaborators (*'whisper'* 3.1.2.)
- That *processpatching* is difficult to apply for hardware and software development (*'M.U.S.H.'* 3.1.1., *'whisper'* 3.1.2., *'Kurort'* 3.1.3., interviews *Media Knitting* 3.3.1.)
- The participatory process (*'whisper'* 3.1.2., *'Kurort'* 3.1.3.) caused difficulties for the technical research and development process as these were simultaneous cycles. Trouble occurred when the interaction was tested with not fully developed technology and vice versa.
- The iterative method of research and development as applied by artists as part of *processpatching* might collide with the differently planned development approaches and aims of a computer scientist (*'whisper'* 3.1.2.)
- That technical and non-technical approaches (e.g. drama, mock-ups, props or stage design) are often combined in

the *processpatching* approach (*'whisper'* 3.1.2., *'Kurort'* 3.1.3., Andersen 3.2.3. , *'~worn~'* 3.3.2.). This brings forth another reference to rapid prototyping as known in e.g. design practice.

- Interactive art pieces, with a strong emphasis on the pro active role of the participants, often use a *processpatching* approach. In the design process of these highly interactive pieces, methods from performing arts and experience design were most observed (*'whisper'* 3.1.2. , *'Kurort'* 3.1.3. , *'Polar'* 3.2.1., *'DataCloud'* 3.2.2.).
- Regarding the theoretical context and related approaches, the reductive method has the most references to single and multidisciplinary engineering and science practice (*'M.U.S.H.'* 3.1.1., *'whisper'* 3.1.2., *'Kurort'* 3.1.3., *Anarchives: Connection Machines* 3.2.1., *'~worn~'* 3.3.2.).
- Participatory design, as a subcategory of *processpatching*, is related to experience design and uses a heuristic research approach, which is influenced by various methods from social sciences (*'whisper'* 3.1.2., *'Kurort'* 3.1.3., *'whisper'* and *'Polar'* 3.2.1., , *Wearable Turbulence* 3.2.3., *'~worn~'* 3.3.2.).
- *'whisper'* 3.1.2. and *'Kurort'* 3.1.3. showed us that it is useful to consider DIY and problem solving methods and

their related teamworking models for specific trajectories in a larger processpatching method.

- *'M.U.S.H.'* 3.1.1., *'Kurort'* 3.1.3., *'~worn~' 3.3.2.,* bring forward the effective use of hacking or DIY methods for rapid prototyping for testing and participatory design purposes.
- All described artworks bring forward several streams in theory. These are patched together as a part of the research and development process. The patched discourse comes from branches such as critical theory, communication studies, phenomenology, theatre, philosophy, cybernetics and visualisation.

3.4.4. Co-relation aRt&D Triangles and Matrix

The data from the compared aRt&D Triangles provides important information about the conditions and constraints that should be taken into account before or during the collaboration process. In addition to the previously mentioned observations, the correlation between the aRt&D Triangles and the Matrix also show us:

- That complex projects, or projects with a varied conceptual background, demand a mix of various methods and this also demands a mix of collaboration models, as was illustrated in *'whisper'* and *'Kurort'*, where the hardware and software engineering worked much better according to a problem solving approach or DIY method (multi-disciplinary collaboration model) whereas the performative aspects or the participatory aspects benefit from improvisation and iteration (both interdisciplinary and multidisciplinary models).

- The focus of the work or the aimed outcome is of crucial importance when choosing a suitable method; for technological innovation, a reductive method is most commonly used, and in the experimental, experience-oriented art, the *processpatching* method is a favourite, as was reaffirmed in several cases. This affirms that problem solving or a reductive method is mostly used in multidisciplinary collaborations.
- The team members whose representation in the graphical aRt&D Triangle were remote from each other had trouble in understanding each other's methods. In the analysed case studies, some parts of the research and development process had to be changed from *processpatching* to a reductive method during the process (3.1.2., 3.1.3.). Taking into account that DIY and problem solving refer mostly to a multidisciplinary collaboration, this affirms that a multidisciplinary approach is often more successful for collaborators with little or no shared knowledge.

The approach towards hardware and software raises another important issue. Successful collaboration, as discussed earlier, often depends upon shared knowledge. For artists and technicians, this knowledge is partly facilitated by software and hardware instruments. In the case studies of *'M.U.S.H.'* (3.1.1), *'whisper'* (3.1.2.), *'Kurort'* (3.1.3.), and in the *Media Knitting* workshop (3.3.1.), it was confirmed that the artists and software and hardware engineers shared a certain level of knowledge of the same software program(s). The software and hardware engineers were experts in these fields, but never-the-less, the software was common ground or a true collaboration platform. The concept of master and student enabled collaboration where the different participants could contribute their specific knowledge and expertise. This was further explored for hardware and software purposes in the *'~worn~'* workshop (3.3.2.), where the common space for collaboration was especially designed to create a more 'neutral' or Third space. This Third space, with its boundary objects, functioned well to bridge some of the disciplinary knowledge gaps. The ~ worn ~ workshop could serve as a good practice example where simple DIY technology kits worked well as boundary objects to be used in the Third space where technicians and designers / electronic artists can meet and work together, led by a mediator or workshop facilitator who understands both fields.

Finally, the role of the mediator is important to mention, as this is often a team member, something that is different from most technical R&D development trajectories. This chapter presented two different ways to deal with the space in between the disciplines. The self-sufficient artists, who work independently, demonstrated in several case studies his/her capability to define a problem and solve it without the required involvement of others. These artists embody multiple professions in one single person. The other option is the mediator, the mixed discipline based person who knits the disciplines together. The latter is often aiming for the joint creation of something new, without a pre-defined single disciplinary tradition. The difference between the two approaches observed so far, is that the first self-sufficient approach reflects the homo-universalis or independent artist, while the second mediation approach takes into account a larger goal, disciplinary shifts and objectives, and has a strong focus on disciplinary exchange and collaboration. This case studies chapter thus provides us with sharper definitions of the three main categories used for electronic art research and development:

- Problem solving, or the reductive method, is widely used by technicians, and in applied science, art and design practices to solve a technical problem. This technical problem might represent a particular aspect of an electronic artwork or a reccurring or generic technical problem. For this method, the multidisciplinary model is mostly observed in collaborating teams. Problem solving, or the reductive method, refers to traditional methods in art, engineering, design, computer science and technology.
- DIY, hacking or the self-sufficient method is widely used by independent artists, technicians and (cultural) activists. It spans a range of objectives, which comprise re-purposing and re-interpretation of technology and/or socio-political themes. In a more practical sense it is also used for rapid prototyping and testing purposes. It works mostly according to an autonomous or multidisciplinary collaboration model. In a

cultural theoretical context, it links to avant-garde and critical thinking (activism and autonomy) and to post-modernism (deconstruction).

- Processpatching is the assumed overarching method for electronic art research and development of process oriented artworks. Processpatching is the method to connect, mix and repurpose different materials, knowledge fields and methods for the realisation of interactive electronic artworks. Processpatching strongly emphasises ethics, aesthetics and participant (user) experience. To accomplish this, artists often draw from participatory design and user-centred design. Processpatching is frequently used by artists in complex projects that comprise a range of methods and approaches (both formal and informal) from other disciplines and knowledge fields. Human Computer Interaction design, communication studies, ethnography, performing arts, social sciences, and computer sciences are among the most frequently referenced fields in processpatching. The above-mentioned problem solving and DIY approaches for electronic art research and development are also frequently included in the overarching processpatching method. In the processpatching process the remote fields are often connected by using boundary objects and the concept of Third Space. Furthermore, processpatching builds on post-modernism and critical theory, phenomenology, and a range of art and design theories.

This chapter concludes with an overview of the adjusted aRt&D Matrix. In this phase, all information from the case studies has been included, the related methods from other disciplines are checked and in the final conclusion, the matching types of aRt&D (or application domain) are discussed as the last iteration of the aRt&D Matrix.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / disadvantages	Theoretical context / matching approaches	Type of aRt&D, type of collaboration, application domain
Problem solving	***Reductive method***	Single or limited disciplinary problem solving approach, applied research, practical method	Technicians as facilitators, artists as engineer in single / limited disciplinary situation, no improvisation	Sharp goal, clear aim, useful for tool development, no-divergence, linear, predictable, assistance or facilitations rather than co-operation	Traditional methods in art, engineering, design, science and technology	Empiric approach, applied R&D, relevant in single- and multi- disciplinary teams, techno science, artistic innovations
Self-sufficient, self-supporting, rapid prototyping	***DIY and hacker method, Re-engineering, reverse engineering***	Mis-interpretation and re-interpretation, re-purposing technology, protest / activism via alternative methods, mostly small scale	Artist as enfant terrible, catalyst for creative thinking, innovation of artistic oeuvre (the latter relates to DIY)	Surprises, critical view, steep learning curve to become self-sufficient, suitable for rapid prototyping and user testing	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, relevant in multi disciplinary collaborations often autodidact multi-tasker, exchange with other independent operators, FLOSS development	Think-tank or brain storm approach, engagement, Critiquing, awareness, empiric or practical approach, single person multi tasking, artist-commentator, engineering, hackers
Innovating arts, re-contextualizing technology, creating new connections	***Process - patching***	(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualization, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxes, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	_Participatory method	experience design concepts, interaction desgin experiments	Often used tools for interdisciplinary collaboration: Third space, boundary objects	Ground for co-operation, experience oriented applications, difficult to combine with problem solving, improvisation	Post-Marxism, design theory, human centered H.C.I., ethnography, social sciences, communication design, computer sciences especially A.I., A.L.	Heuristic research, experience design
	_Art and design techiques and methods	focus on process and ittertive approach, thought from the end-user / participant's perspective	mixed teams, parallel trajectories in one project	Focus on end-user/participant experience, ethics and aesthetics	industrial design, interaction design theory, H.C.I., theatre	product design, game design
	_Combination of all above and informal approaches	mixing, re-purposing and parallel approaches in one project	all of the above in new variations	knowledge needed from all included methods, appraoches and backgrounds	potentially all of the above	re-mix culture, interactive electronic artworks

(fig. 31. Adjusted aRt&D Matrix overview)

Chapter 4. Overall conclusion

This chapter brings together information and analyses gleaned from the literature reviews and case studies, and applies them to the new methodology and matrix in development in this thesis. Conclusions drawn from the case studies (3.4) are applied to and compared with the conclusions drawn from the literature studies (2.8). The outcome of both of these conclusions provides the material for the last iteration of electronic art research and development (aRt&D) methods, and the last details for the aRt&D Matrix. The overall conclusion provides an overview of the most significant outcomes from the theoretical and practical investigation.

This overall conclusion provides a final vision of the stereotypes, expectations and motivations in interdisciplinary collaboration among electronic artists, technicians and (mainly computer) scientists. (4.1.) These concluding stereotypes are based on the literature studies in chapter 2, and these are compared and informed by the case studies in chapter 3. This overall conclusion continues with the summary of the aRt&D methods. In 4.2.1., 4.2.2., 4.2.3. I provide an overview of the three main categories of electronic art research and development methods, including their subcategories. The literature studies (2.2.1., 2.2.2. Wilson, Century, Weibel) provide the basis for the proposed aRt&D methods. These were completed via field research and a range of case studies from chapter 3, and these final iterations of the aRt&D Methods are presented in 4.2.1., 4.2.2., 4.2.3.. In the descriptions of each aRt&D method, the theoretical and/or practical background, aims and applications are highlighted to inform the reader about their relevance for each application domain. Each aRt&D method's description ends with the key information about its suitable collaboration model and most frequently observed application domain(s).

In this overall conclusion, the last iteration of the aRt&D Matrix will be presented (4.3.). The last iteration gives an overview of the relationship between objectives and methods. It lists the characteristics of each aRt&D method and the links with the observed group dynamics or team composition. The crucial advantages or disadvantages are also included according to their relevance for the collaboration process. The aRt&D Matrix also suggests the best matches with comparable or complementary methods from other disciplines. Finally, the advantages and disadvantages of each method are brought forward. In 4.3. I connect the analysed models for collaboration with certain types of artworks and Information Technology research themes. In 4.3.1., the supporting tools and instruments for *processpatching*, as suggested in chapter 2 and used for the case studies in chapter 3, are discussed as one of the additional outcomes of this study. The aRt&D Triangle (4.3.1.), the diagrammatic instrument for analysing the team constellation, serves as a basis for the collaboration model. The conclusion ends with a set of recommendations for future work (4.4.) and recommendations for professional artists, educators, future collaborators and policymakers to improve artistic practice in interdisciplinary collaboration (4.4.1.).

4.1. Stereotypes

The conclusions drawn from the findings of literature on stereotypes and expectations underline the need for clearly defined electronic art methods. This is in part related to another issue that was brought forward by several authors: ignorance about each other's practices. The investigation into stereotypes confirmed assumed misconceptions and provided useful perspectives for analysing multi- and interdisciplinary collaborations. The insights provided through those stereotypes and the case studies are the clues that form the basis for identifying three categories of electronic art methods and approaches: reductive (problem solving), DIY (self-sufficient) and *processpatching* (connecting). The reductive method and the problem solving approach are useful for specific parts of an art project and technological invention emerging from shortcomings identified in existing software and hardware. However, the reductive approach for problem solving is often regarded as an obstacle in electronic art practice. Problem solving roles also provide valuable clues for innovation. Here the first type of electronic art innovation was identified: artists as inventors of technology. Technological innovation by artists is directly linked to the instrumental problem solving approach (2.2.3.1.1.).

4.1.1. Artists as problem solvers

The outlined stereotypes exposed the call from scientists, policymakers and urban developers, for artists as problem solvers of communication problems and social issues from science, technology and design fields (2.1.1.1., 2.1.1.2.).

4.1.2. DIY artists

In today's electronic art practice there is a growing interest in socially engaged interactive art. However, the approach of the cultural activist dissociates itself from the role of social worker. The cultural activist in electronic art refers also to the independent or self-sufficient artist and mostly uses the DIY method (2.2.4.).

4.1.3. Artists as *Processpatchers*

The second type of artistic inventor has been identified as innovator in the arts. Innovation in the arts is more explorative and less practically oriented than technological innovation (see problem solving above), and refers in that sense directly to the artistic tradition of material research, and is motivated by a renewal of the artistic oeuvre and the exploration of new aesthetics or expressions (2.2.5.1.1.). Artists in the role of art innovator was further investigated in the case studies, with special focus on the implications and reconsiderations of disciplinary borders. This led us to the details of the *processpatching* method, which is used in the zone of *transvergence* (2.2.5.2 Novak). This zone is located between the disciplines, where a new practice comes into existence. *Processpatching* is the key method for stitching all different methods together and bridging the disciplinary, methodological differences in this zone. The most frequently identified electronic art method in the case studies is the *processpatching* method, which is the main placeholder for artistic approaches. *Processpatching* is in the first place a poetic word with associations and references to the process as a series of actions, changes or functions bringing about a result, or a series of operations performed in the making or treatment of something. The term as such refers to the artistic iterative research and development process. Process refers in this context also to the (social) interaction process as part of the interactive electronic artwork, and has a strong association with experience design, rather than exclusively to 'product' design. The *processpatching* method is characterised as an informal, iterative and intuitive method. The *processpatching* artist connects things, knowledge, materials and methods and so on, as she/he considers something or someone to be related to something or someone else. *Processpatching* thus allows for improvisation and connects a range of digital and analogue 'things' (material and ephemeral, techniques, methods, processes). In *processpatching*, different approaches and methods from scientific and (non) technical disciplines are patched together with a personal or combined aesthetic. *Processpatching* includes re-purposing and remixing of expertise, material and the ephemeral with a user-centred emphasis. It often bears traces of various art fields, ethnography, cultural studies, critical theory, human-centred H.C.I., social sciences, and communication design. *Processpatching* is a highly explorative method that often leads to innovation in the arts (2.2.5.).

4.1.4. Mixed methods

The case studies demonstrated that complex projects benefit from a mix of the above-mentioned methods for different parts of the research and development process.

4.2. The artistic research and development methods

In this part of the overall conclusion, I provide the details of the examined methods used by practitioners who work on the edges of their disciplines and those who work in the space in-between the disciplines. Based on the conclusions from the literature studies and case studies, the following aRt&D methods are identified:

- Reductive method, mainly used for solving technical problems (4.2.1)
- DIY method, mainly used in activist, hacker and self-sufficient situations (4.2.2)

- *Processpatching,* mainly used for re-contextualising technology, mixing, blending and creating new connections (4.2.3)

4.2.1. Problem solving, reductive method

In problem solving, the expectations, which are projected to the 'other' discipline(s), represent an instrumental view. The situation outlined shows that one discipline looks for assistance from the other(s) to solve problems, which are hard to tackle with the expertise or methods available in their own discipline. This instrumental attitude matches a multidisciplinary approach, where collaborators are called in for their expertise without the intention of disciplinary blurring or merging of disciplines. This model for multidisciplinary collaboration has proven itself worth; however, it should not be confused with interdisciplinary or transdisciplinary collaboration, where the disciplinary borders may blur or (temporarily) disappear. As was shown in 2.1.3., the call for problem solvers is always formulated from a particular perspective and reflects a certain set of background concerns and need(s).

From the literature studies analysed in this thesis research, observable and reasonably distinct forms of research problems can be identified:

- Most significant are the pleas for artists to solve the scientific communication problem. Here the scientific community searches for expert knowledge in communication from the arts (2.1.1.1.).
- Urban designers, historians of science and policymakers suggested making up for the shortcomings of technology driven innovation, and to restore social cohesion (2.1.1.2.).
- Solving technical problems is rooted in technical engineering and design practice. Here the electronic artist seeks expert assistance. Technological innovation by artists is among the outcomes of the technical problem solving approach. Here the electronic artist often works in multiple roles, as artist and engineer (2.1.1.3.).

The three distinct types of problems demonstrate that there is always a commissioning party and a party who carries out the task, and that the commissioning party approaches the other's work in an instrumental way. The knowledge gleaned about the respective domains or disciplines does not always match reality, but this is partly compensated by the widely known and simple format of the method. The most common way to manage problem solving is to apply a reductive approach while formulating the scale of the problem and its domain of application. Here all noise around a problem is eliminated and the complicating factors are wiped out.

This approach of problem solving shows a direct parallel with design and engineering practice (2.1.1.2., Gropius, 2.2.3.1.). A reductive method is also used in computer or technical science, which builds on existing knowledge (Kuhn, Popper 2.2.3.3, Smeulders 3.2.1., Schouten 3.2.1.). The case studies show that the art projects that were developed by a small team with little diversity in their disciplinary backgrounds, (3.1.1., 3.2.2.) and the scientific projects developed by people from limited scientific disciplines (3.2.1., 3.2.2.) worked according to a problem solving or reductive approach. The case studies also reveal that the artists, with mixed backgrounds in traditional art and science, feel most at ease as autonomous scientific researchers with a reductive or problem solving approach (Carpendale, Schouten 3.2.2.).

4.2.1.1 Scientific problems

Several historians of science call for artistic interventions in science for the opening up of the scientific community. Snow argues for the reconsideration of the dominant social and political position of science and suggests a counterbalance through the arts (2.1.1.1.). Kuhn highlights the risk for the scientific community to lose contact with societal and social problems due to their highly specialised reductive approach (2.1.1.1., 2.2.3.3.). Latour continues with an invitation for inclusion of outsiders in the scientific fact building process (2.1.1.1., 2.2.3.3.). Ridley calls literally for artists to save the world from a scientific unity theory or what he calls 'scientism' (2.1.1.1.). In milder forms, several art-science and art-engineering initiatives are based on the concept of the artist as communicator or mediator to the rest of the society. This relates in part to communicating the abstract scientific matter to a broad audience via artistic impressions and visualisations (Bijvoet, Latour 2.2.3.2.). The expected positive influence of artists on the social status of engineering and science has been a main motivator of several programs (Elwes 2.1.1.1.). This suggests an applied approach to the artistic contributions, and is based on a multidisciplinary instrumental approach. The suggested model for collaboration is based on commissioners and facilitators. Weibel sees the artistic salvation role in the liberty or diversity of methods, which is in line with Feyerabend's 'Anything Goes theory' (2.2.3.2.). On a practical level, however, the salvation role of the artist to rescue science does not always match with the contemporary engaged artist who is often involved in hacker culture and cultural activism. Moreover, the artist as cultural activist values his/her autonomy as an independent criticaster. (2.2.4.1., 2.2.6.4., 2.2.8.) Feyerabend's suggestion is more in line with Elwes (2.1.1.1.), who brings forward a smaller scale approach to the 'rescue role' of artists. She states that artists, in the Welcome Trust program, often broaden the scientist's telescopic view through their critical perspective and context awareness. Elwes refers to this as being especially useful for brainstorming purposes at the start of an art-science collaboration project. These observable patterns lead to the conclusion that artists take the role of communicators for science: a role that is mainly motivated by poor functioning scientific models. Here we observe an implicit plea by scientists to renew and enliven debates in the sciences; a cal to use the process of multidisciplinary brainstorming for the regeneration of ideas in a more general sense.

4.2.1.2. Social problems

In addition to the scientific problem as outlined above, there is often a returning call for restoration of social cohesion or solutions for social problems. In particular, in cases caused by industrialisation and technological innovation, such as the digital revolution. Among the most striking examples of this suggested role of the artist as social worker is the Bauhaus approach and the social engineering approach in the former USSR (Gropius, 2.1.1.2., Filippov, 2.1.1.2.). The communication component in interactive art has recently engendered renewed attention to audience participation and social interaction (Laddaga, 2.1.1.2.). Although these works certainly contribute to social coherence, they are initially not designed as instruments for solving social issues. Art can definitely contribute to the process of raising awareness and social cohesion or art can act as a catalyst for brainstorming. However, the problem itself and the scale need to be clear and realistic. Interactive art projects are not usually initially created to solve social problems, although they might contribute to a certain feeling of social coherence or social interaction. The artist's intention in the role of communicator and catalyst for raising awareness is not necessarily to solve the problems, but rather to alert and draw attention to very specific ethical issues (*Wearable Turbulence* 3.2.3.). In line with the scientific problem, the social problem also calls for artists in facilitating roles and for art to be used in an instrumental or applied way. The problem solving approach usually brings along this reference to practicality. The most suitable model for collaboration in this case is the multidisciplinary approach.

4.2.1.3 Technical problems

In the context of solving technical problems, the artist (as inventor of new technology) fulfils the commissioning role while the technician is person who carries out the work. The technician as the problem solver is particularly relevant for those artists who are not interested in (or able to) acquiring technical or programming skills. The case studies showed that people with a technical background often find the most suitable collaboration in the problem solving approach (3.1.1., 3.1.2., 3.1.3.). Furthermore, the artist's communication skills are of crucial importance in explaining the problem to the technician, and usually this needs to be dealt with at once, without conceptual changes from the artist's side as this might interfere with the selected approach by the technician (Candy and Edmonds 2.2.3.3. '*whisper*' 3.1.2.). Artists with technological knowledge and skills often work in a different way in the context of problem solving. They develop (most of) their technology by themselves. The technically complex parts of the project are isolated and channelled to an engineer, accompanied by a clearly formulated problem. The artist and the engineer work together to integrate the different parts. The problem solving approach enables explanation or communication to the technician of specific tasks, without deep involvement by this person in the whole work. The problem solving approach often fosters technical innovation as in the case study *'M.U.S.H.'* (3.1.1.), where an innovative wireless interface device was developed.

Interactive works that accommodate unpredictable interaction patterns and extended options for the participant's input, show the limitations of the problem solving approach. When the project's characteristics lie in its openness, there is no clear problem and therefore the reduction method is not sufficient. The reduction method might even conflict with the project's intentions. Or to illustrate it more precisely; if one would filter out all the noise surrounding the problem in order to arrive at a clear, delineated problem to be solved, one also risks filtering out (all) options for unexpected interactions and contributions as it is impossible to predict where and when these surprises will take place. This difficulty of not being able to clearly define the problem is one of the most common obstacles in the reductive method (Candy and Edmonds 2.2.3.3.). In the case studies *'whisper'* (3.1.2.) and *'Kurort'* (3.1.3.), it was useful to apply the problem solving approach to small sections of the project. It is therefore, only recommended for application to parts of projects that can be completed independently from other parts of the whole.

Also in the case of solving technical problems, team members stay within their discipline and the motivation for collaboration is mainly instrumental and self-centred: the other party is invited to solve a problem. This is again a multidisciplinary collaboration model. None of the people involved is seriously considering migrating towards another discipline, nor working in a space between the disciplines. It is expected that the parties involved will choose to work in a facilitating mode.

The reductive method works according to a problem solving approach. This approach is suitable for clearly defined objectives or sharp goals and does not allow for much improvisation, 'open' scenarios, or unpredictable situations.

4.2.1.4 Artist as inventor of new technology

One exception to this situation, where the problem solving approach is related to the multi-disciplinary collaboration model, is the problem solving approach that leads to technological innovation. Problem solving turned out to be useful for specific parts of an art project and for artistic invention emerging from shortcomings in existing software and hardware (2.2.3.1.1.). The artist-engineer fulfils both roles as commissioning party and facilitator. In the art and media technology field, one notices a growing number of persons who have mastered multiple professions, e.g. artists who are also software and/or hardware engineers and/or scientists.

Most electronic artist-inventors are simultaneously entrepreneurial engineers who develop their own artworks from which their inventions stem. The 'problems', the experienced shortcomings or lack of existing software or hardware, are reflected in their own art practice. They solve the problems in their role as engineer, sometimes assisted by other engineers (Diamond 2.2.3.1.1.). The outcome of these software and hardware inventions varies from small downloadable plug-ins to commercially available software and hardware inventions. The significance of the outcome depends in part on the relevance of the formulated problem for a larger field (Century 2.2.3.1.1.). The case studies, showed the inventions of Carpendale who developed the highly innovative *'EPS'* system using a problem solving approach (3.2.2.), and 'Mobile Feelings' by Christa Sommerer and Laurent Mignonneau (3.2.3.). The artist as inventor of new technology is a special category in the problem solving approach, as artists work mostly self-sufficiently. Here the artist fulfils at least two professions and thus two roles, first as an artist in the role of the commissioning party who has a problem, and second as an engineer to solve the problem, which could lead to small or large scale marketable hardware or software innovations.

4.2.1.5 Problem solving: collaboration model and domain

The reductive method is most suitable for applied research and development and reflects a practical, empirical attitude. Based on the three types of problems (scientific 4.2.1., technical 4.2.2. and social 4.2.3.), problem solving is based on an instrumental attitude towards the remote discipline. The problem solving approach is useful for projects developed within a single discipline or in collaborations with a limited number of disciplines. It is particularly useful in situations where the artist has little or no technical knowledge, as well as in certain parts of interdisciplinary collaborations, where specific problematic (or technically complicated) parts of a project need to be solved through expert knowledge. The reductive method and the problem solving approach are solidly grounded in traditional arts and crafts, engineering, various branches of design and technical science. The collaboration model for the problem solving approach, either in the whole project or in those parts where isolated problems need to be solved, is a director-led model based on the commissioning and facilitating roles. This model has several parallels to audio-visual or movie productions. The input or contribution of the facilitators (who carry out the work) depends a great deal on the rigidity of the problem or the degree of freedom provided by the director. This director (artist)-led collaboration model can be found in several other art disciplines outside media practice and design (Grau 2.2.3.1). The facilitating role of the problem solvers brings us to a multi-disciplinary collaboration model, where all collaborators stay in their own field of expertise and work according to a reductive approach. Obviously, the artist-innovator who works mainly as a solitary multitasker falls outside the scope of the discussed collaboration model. Below is the final overview of the problem solving method and its implications on the roles and types of work, listed in its specific part of the aRt&D Matrix.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / disadvantages	Theoretical context / matching approaches	Type of aRt&D, type of collaboration, application domain
Problem solving	***Reductive method***	Single or limited disciplinary problem solving approach, applied research, practical method	Technicians as facilitators, artists as engineer in single / limited disciplinary situation, no improvisation	Sharp goal, clear aim, useful for tool development, no-divergence, linear, predictable, assistance or facilitations rather than co-operation	Traditional methods in art, engineering, design, science and technology	Empiric approach, applied R&D, relevant in single- and multi-disciplinary teams, techno science, artistic innovations

(fig.32. Reductive method)

4.2.2 Self-sufficient approach: DIY method

A large group of artists is engaged in questioning and raising awareness about technology and science's effects in a larger context, as a form of cultural activism. This does not always coincide with solving the problems, but the artists' attempts to raise awareness often result in intentional collisions with scientists, industry or technology developers. A considerable number of artists raise awareness through the process of intervention, or cultural activism (Arns, 2.2.4.1.). This critical attitude often questions the existing power structures, and has strong references to art movements of the 20st century such as the Situationists International and the Dadaist movement (Critical Art Ensemble 2.2.4.1.).

The space acquired by artists to question or critique technology and its effects on society is not always the most suitable ground for collaboration. Moreover, in collaborating teams, the artist's autonomy could be at risk (Critical Art Ensemble 2.2.4.1.). Intended collisions and cultural activism show parallels with the independent artist who chooses to acquire technical skills through self-education or through becoming part of the software and hacker culture. This engagement with technical communities is motivated by the search for ideological independence. Artists working with this approach often acquire technical skills themselves to secure their independence. In the latter case, this might refer to both ideological as well as financial independence. The like-minded independent activists from different backgrounds meet in the struggle against the existing power structures and political issues to build alternative organisation and collaboration forms that are often inspired by hacker culture. Here a growing group of media artists who work in multiple professions, combine their artistic skills with software development. These artists usually do not have the ambition to become a formally recognised engineer. In the cultural activist's practice, a total blur of disciplines is observed, as the majority of DIY artists undertake action to obtain programming or technical skills. For some parts of their work, they call in experts to solve a specific problem. Their work migrates into a disciplinary void where they work together with their peers from a range of backgrounds on subversive software to destabilise or cause collisions with traditional software and hardware engineering. In addition to artists who have morphed themselves into technicians there is a growing group of engineers who morph themselves into self-taught (or DIY) artists (*Media Knitting* 3.3.1.).

This attitude is different from problem solving in that it is mainly focussed on cultural activism, not so much on software development or technical innovation. An increasing number of multi-professionals, mostly engineers who also work as artist, follow the DIY approach as self-sufficient artists. Given that the DIY engineer-artist has acquired programming skills, it is a small step to the FLOSS (Free, Libre Open Source Software) philosophy where they can 'borrow' the software and adjust it according to one's own needs. This same attitude is observed with independent producers and activists as an act against the proprietary software mechanism. Moreover, several empowerment issues and critique towards the power structures are shared topics in this context of the FLOSS ideology and the cultural activist's mission.

Another type of intentional collision is caused by different objectives and attitudes towards technological innovation among technologists and artists. An important difference here between most formal scientific research and the DIY artists' approach is the artists' tendency to re-appropriate technology for very different purposes, or to engage in experiments dealing with technological anomalies (Naimark, Post and Mulder 2.2.4.1.). In this intentional collision approach, some similarity with 'Wild Thinking' or the unconventional artistic way of thinking is present. The intentional collision also refers to artistic practice in the 20th and 21st centuries, where electronic artists work as independent producers or cultural activists for radio, television and theatre. In these 'independent' practices, artists often have their own personal heuristic 'collision method' in place, without it being clearly defined (Feyerabend, Haring 2.2.4.2.). Intentional collisions are associated, as a method, to the critical practice as defined by Stephen Wilson (Wilson 2.2.1.). The intentional collisions are part of the confronting motives (2.2.4.), and these are rooted in art practice and currently mainly expressed in cultural activism and art-hacker practice. This approach dissociates itself from the standard approach or style that might be adopted by the domain of social science, or social work. Although its intention is socially engaged, it is usually channelled as cultural activism in independent (non-institutionalised) situations. The analytical deconstruction approach is common for this type of artwork, where artists become familiar with the technology, and use it for commenting on the technology and its related social factors (Wilson 2.2.1.). The intentional collisions work according to a heuristic artistic approach where technology is repurposed, and the investigation of the imperfection of technology indicates other uses or new areas for artistic and social technology.

4.2.2.1 Hacking and re-engineering

In the FLOSS field, I also observed these kind of 'free or open' concepts where developers can meet, share knowledge and collaborate. However, for active participation in the FLOSS arena, artists need to obtain programming skills (2.2.6.4.). Software and algorithmic design are important ingredients of DIY, and are positioned in the field of (im)material exploration in search of empowerment, cultural activism, and new artistic means of expression (Cramer 2.2.6.3.). Artistic hacks of game engines are among the most frequently used forms of the self-sufficient and hacker approaches, where the artist repurposes the technique while critiquing the political aspects or content of the games (2.2.4.1.).

From a pragmatic perspective, the case studies (*'M.U.S.H.'* 31.1., *'whisper' 3.1.2.*, *'Kurort'* 3.1.3., '~worn~' 3.3.2.) show us that hacking or repurposing of existing hardware provides a good approach for manufacturing rapid prototypes for testing purposes and try-outs. In a short time span, a rather stable (with limited features) device becomes available for user testing purposes without distracting the test-experience because of unstable technology. The case study '~*worn*~' also included re-purposing and hacking of consumer electronics as a shared approach with hardware engineering (3.3.2.).

4.2.2.2. Self-sufficient approach: collaboration model and domain

The DIY artist gathers his/her knowledge through reverse engineering, hacking and the deconstruction of existing consumer technology and, to an increasing degree, in multi-professional education. This is part of his/her search for independence. In electronic media, DIY artists obtain software and hardware engineering skills. Among like-minded, some collaboration is observed, or an exchange of ideas (or software patches or software parts) and work methods, and there is a growing exchange among DIY artists and the field of open source and free software. As briefly mentioned earlier, on an ideological level, this attitude fits well with DIY. The best known concept from the FLOSS community is the notion of sharing and making work freely available, and the possibility to build on each others' work. An increasing number of laboratories in the cultural sector support FLOSS and Creative Commons approaches as they see it as part of their culturally motivated contribution. These laboratories also sometimes act as a mediator between the artists and the FLOSS community (2.2.6.4.) The DIY, or hacker, method is rooted in the desire for independence. The self-educated technical skills also reflect this autonomous aspect. On a larger scale, the collaboration of DIY artists with established research centres and industry is, on some occasions, a sensitive issue as this can threaten the autonomous character of the cultural activist or independent producer's intentions. For think tank or brainstorming purposes, the creative and critical view is a useful catalyst for idea generation and different perspectives relevant for large research projects. Whether this type of collaboration is desired remains a question, as it has its consequences for the artist's ideological independence (*'Kurort'* 3.1.2., *Media Knitting* 3.3.1.). The strength of the self-sufficient and hacker approach lies in its critical independence.

The hacking or re-purposing approach in the case studies (*'M.U.S.H.'* 31.1., *'whisper' 3.1.2.* and *'Kurort'* 3.1.3. is based on a multi-disciplinary approach, while the hacked consumer hardware kits are used as boundary objects to facilitate interdisciplinary collaboration in '~worn~' (3.3.2.).

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / disadvantages	Theoretical context / matching approaches	Type of aRt&D, type of collaboration, application domain
Self-sufficient, self-supporting, rapid prototyping	***DIY and hacker method, Re-engineering, reverse engineering***	Mis-interpretation and re-interpretation, re-purposing technology, protest / activism via alternative methods, mostly small scale	Artist as enfant terrible, catalyst for creative thinking, innovation of artistic oeuvre (the latter relates to DIY)	Surprises, critical view, steep learning curve to become self-sufficient, suitable for rapid prototyping and user testing	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, relevant in multi disciplinary collaborations often autodidact multi-tasker, exchange with other independent operators, FLOSS development	Think-tank or brain storm approach, engagement, Critiquing, awareness, empiric or practical approach, single person multi tasking, artist-commentator, engineering, hackers

(fig. 33. aRt&D Matrix DIY method)

4.2.3 Connecting and re-contextualising, the *processpatching* method

Processpatching is the intrinsic electronic art method. I've choosen to use the term 'method', which refers to a particular way of doing something, and as a provocation in relation to the vagueness that surrounds the artistic research and development practice. The artist as *processpatcher* patches together expertise and methods from different disciplines and knowledge fields. *Processpatching* is in the first place a poetic word with associations and references to the process as a series of actions, changes or functions bringing about a result, or a series of operations performed in the making or treatment of something. The term as such refers to the artistic iterative research and development process. Process refers in this context also to the (social) interaction process as a crucial part of the interactive electronic artwork, and has a strong association with experience design, rather than exclusively to 'product' design. The term *processpatching* links to a range of meanings and associations, such as patches in software, patch cords, telephone patches, fixes for a software program and the process as a cycle of events, social interaction and actions. This practice of stitching and patching things together works according to a network topology, such as rhizomes. Deleuze and Guattari see a direct parallel between rhizomes and the associative artistic practice of connecting things, in a non-linear way, which contrasts the tree-like linear structure, the latter attributed by them to science research methodologies (2.2.5.).

Processpatching refers to combining and repurposing knowledge, methods, and materials with a strong emphasis on aesthetic innovation, knowledge generation and the renewal or development of mediated artistic expression. *Processpatching* stands for mixing and re-interpreting a plurality of methods into the artistic method. It builds on the Fluxus tradition (2.2.5.1., 2.2.6.1.), as well as on other artistic, technological and non-technical disciplines and traditions. The *processpatching* method shows parallels with Weibel's theory of art as method, where he uses the definition of method as being the experiment at large (Weibel 2.2.5.1.). Although reasoned from the opposite direction, Feyerabend's 'Anything Goes' credo comes close to the artistic blend of methods and techniques (Feyerabend 2.2.5.3.), although this might read as a contradiction, as Feyerabend argues against methodology. The proposed electronic art method and Feyerabend share the objective of breaking the disciplinary paradigm to achieve significant growth of knowledge, innovation and renewal. This research proposes processpatching as the artistic method to break with the prevailing romantic and mysterious paradigm of art making. On a conceptual level, the *'Anything Goes'* route and the *processpatching* route could intersect in a Third Space or the transvergence zone between the disciplines.

The artist as *processpatcher* between different disciplines is also referred to by authors from emerging fields, where the artist plays the role of bridge builder or associative mediator in the field of interactive storytelling and media art and technology (Vesna, Crawford, 2.2.6.6.). The artist as *processpatcher* refers to the role of bridge-builder, one who is working, with his/her collaborators in the space between disciplines, according to Marcos Novak's concept of *transvergence* (2.2.5.2.).

In practice, the case studies *'whisper'* (3.1.2.) and *'Kurort'* (3.1.3.) showed that the *processpatching* method brings forward a range of complications inherent to these re-mixed scenarios.

For the *processpatching* approach, a range of design and technical methods was studied, all of which are somehow related to Human Computer Interaction that was identified as the key research and development area. The aesthetics of *processpatching* relate to several movements and disciplines in 20th century art and design, such as collage (Dada 2.2.5.1.), improvisation (various branches of performing arts 2.2.6.2.), bricolage (structuralism 2.2.5.) and re-mixing (new media 2.2.6.2.). The *processpatching* approach (2.2.5.) captures a heterogeneous and changing composition of techniques and methods, which create a new dynamic aesthetics and the related discourse (Quinz 2.2.5.).

The combined technological and non-technological approaches in *processpatching* turn out to be relevant for obtaining more knowledge and ideas to solve the tension between computer understandable concepts and human intuition, or symbolic and natural communication.

In particular in knowledge representation practice, a correlation between the type of research and *processpatching is manifested. Processpatching* is often used to compensate for the shortcomings of today's machine languages. (2.2.7.2.) The *'whisper'* (3.1.2) and *'Kurort'* (3.1.3.) case studies, and the themes of the *Wearable Turbulence* seminar (3.2.3) showed that artist-led *processpatching* approaches include a variety of methods, techniques (digital and analogue) and technology approaches. *'Kurort'* (3.1.3.) by Oei and Vanouden used techniques from performing arts, visual arts, dramaturgy, stage design, cognitive science and experimental psychology. An overview of the methods in the *'whisper'* project listed by Schiphorst (3.1.2.) include performance methods, choreography, improvisation, first person methodologies, somatics, participatory design and many more. This non-linear improvised and collage-like approach is preferred for working around the limitations of the formal approach. Although, machine language and software design have also been identified as key techniques for *processpatching* (Cramer et all 2.2.6.3.) the inclusion of non-technological and informal aspects is also of major importance for the artistic method. Moreover, this approach introduces interesting new ideas for developing machine learning and overcoming the current limitations of computer languages. It is difficult to express typical human emotions or experiences with today's computers and machine languages. This is, in part, an ongoing research theme in Human Computer Interaction that stems from bi-directional interaction patterns between humans and machines. The shifting human-machine interaction pattern blurs the borderlines between human and machines and brings us to cybernetics and research into embodiment, experience design and new forms of intelligent design as an answer to first generation cybernetics (Nigten, Hayles, Sengers 2.2.7.2) Where artists bring in new research perspectives and techniques from somatics, performing arts and theatre. ('whisper' 3.1.2. , 'Kurort' 3.1.3.)

4.2.3.1. Relevant design disciplines

The rapidly growing field of interactive mediated experiences has accelerated the merge of artistic *processpatchers* with several bordering design disciplines, such as interaction design, experience design, participatory design and interface design. In particular participatory design and user-centred design. The Third space is highlighted as a concept for collaboration among participants from different disciplines (Muller 2.2.6.6.).

4.2.3.1.1. Participatory design

Processpatching borrows from participatory design approaches, (Schiphorst, Andersen et al 2.3.1.) where the audience becomes part of the design and development process, which turns out to be particularly relevant for interactive, user-centred design, where the audience becomes co-author. The focus on the audience and their early inclusion in the

iterative development process was manifested in several case studies (*'whisper'* 3.1.2., *'Kurort'* 3.1.3., *'Polar'* 3.2.1., *'DataCloud'* 3.2.2).
In addition, combinations of participatory design and participatory action methods are useful for experiments in the field of Human Computer Interaction (H.C.I.) and interface design (Candy and Edmonds, 2.2.6.1.).

4.2.3.1.2. User-centred design

The investigation into the *processpatching* method was furthered with a short enquiry about the themes and areas relevant for electronic art research and development, and for its potential value as shared expertise for the collaboration. For this purpose, two research themes were identified: user interface design and knowledge representation (2.2.7.). Both have a strong emphasis on the involvement of the user, a recurring characteristic of many interactive artworks. In the field of user interfaces, it was observed that artistic research and development particularly focuses on the fields of information visualisation and interaction processes, and less on static Graphical User Interfaces (*'M.U.S.H.'* 3.1.1, *'whisper'* 3.1.2, *'Kurort'* 3.1.3, *Anarchives: Connection Machines* 3.2.1., *Data Perception* 3.2.2.). The participant's role and the critical view on information flows are of major importance for this field of artistic research and development. Non-formal means of communication represents another area of user interface design. Knowledge representation is in particular relevant for critical artistic approaches as it touches the socio-political awareness and calls for a (theoretical) counterbalance of the prevalent trends in technology design as analysed by Hayles (2.2.7.2). The case studies underlined the artists' interests in dynamic interface design, social interaction and knowledge representation as closely related research themes. These themes offer space for artistic exploration due to their up to date and experimental or innovative states.

4.2.3.1.3. Third space and boundary object

FLOSS was briefly referred to as a concept or a 'space' for collaboration and interaction (2.2.6.4.). This relates to the concept of Third space, a term which is frequently used in design practice. On a conceptual level, the Third space works as a key area for collaboration, as a space for negotiation and where the disciplines can meet on neutral ground. The case study '*~worn~*' (3.3.2.) showed how people with very different backgrounds worked together in this 'neutral' zone in which none of the participants were specialised. Consumer electronics were used as boundary objects to facilitate collaboration among people with different backgrounds and methods. In this case study, problem solving, hacking and improvisation were among the methods used. In a more general sense, the concept of Third space is identified as a useful approach for combining different methods within *processpatching.* The Third space concept facilitates the zone of *transvergence* between the disciplines (2.2.6.6.). It allows for *processpatching* between the reductive, DIY and hacker methods, improvisation, and iterative participatory and user-centred design.

The middle space of the aRt&D Triangle (fig.36.) is circled to indicate the common ground among collaborators from different backgrounds. The boundary object, for example the consumer electronic kit in the '*~worn~*'

case study, the technical drawing (2.2.6.6.) or shared knowledge about software (*'M.U.S.H.'* case study, *'Kurort'* case study, *'Media Knitting'* case study) are supporting tools to create a shared zone or common ground. The case studies demonstrated that this is a practical instrument to connect the participants without shared knowledge or expertise (~worn~) or to offer a platform where participants with different levels of expertise can actually work together.

4.2.3.2. *Processpatching* collaboration models and domain

Based on the reports of the case studies, I conclude that a mix of methods in one single project is an interesting option to consider for projects where a range of different/remote disciplines are involved. Complex projects, or projects with a varied conceptual background, demand a mix of various methods, as observed in *'whisper'* (3.1.2.) and *'Kurort'* (3.1.3.). Here the hardware and software engineering worked much better according to a problem solving approach, while the performative aspects or the participatory aspects benefit from improvisations and iterations. These various methods also bring along their specific characteristic collaboration model. The *processpatching* method is thus not only a mix of methods but even uses parallel collaboration models.

As mentioned earlier, it was observed that people with a mixed background in technical science and electronic art (in general) represent two types of roles in the teamworking process, the self-sufficient person, (Kerne 3.1.2., Carpendale 3.2.2., Schouten 3.2.2.) as discussed in the DIY method, and the mediator (Lovell 3.1.2., Verouden 3.1.3., Lichtenegger 3.2.2., Andersen 3.3.2.). The mediator plays a crucial role in the *processpatching* approach. In particular, in complex projects, the multi professional mediator embodies the patch between the disciplines and diversity of methods (Schiphorst 3.1.2.).

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / disadvantages	Theoretical context / matching approaches	Type of aRt&D, type of collaboration, application domain
Innovating arts, re-contextualizing technology, creating new connections	***Process - patching***	(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualization, space for cooperation, ground for new discoveries and innovation,	Post- Modernism critical theory, Fluxes, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	_Participatory method	experience design concepts, interaction desgin experiments	Often used tools for interdisciplinary collaboration: Third space, boundary objects	Ground for co-operation, experience oriented applications, difficult to combine with problem solving, improvisation	Post-Marxism, design theory, human centered H.C.I., ethnography, social sciences, communication design, computer sciences especially A.I., A.L.	Heuristic research, experience design
	_Art and design techiques and methods	focus on process and ittertive approach, thought from the end-user / participant's perspective	mixed teams, parallel trajectories in one project	Focus on end-user/participant experience, ethics and aesthetics	industrial design, interaction design theory, H.C.I., theatre	product design, game design
	_Combination of all above and informal approaches	mixing, re-purposing and parallel approaches in one project	all of the above in new variations	knowledge needed from all included methods, appraoches and backgrounds	potentially all of the above	re-mix culture, interactive electronic artworks

(fig. 34. aRt&D Matrix with processpatching method)

4.3. aRt&D Methods overview

This investigation reveals the groundless devaluation of the arts in interdisciplinary collaborations. The explicit electronic art methods, provided as an outcome of this research, contribute to an improved profile of the electronic art contribution in multi- and interdisciplinary collaborations.

In electronic art, the collaborative aspect is unavoidable, and the next generation of artists will be teamworkers. The overview in the aRt&D Matrix is available for future collaborators as a guide to interdisciplinary collaboration between artists, technicians and (computer) scientists. Future collaborators have three categories to consider as the preferred method(s). *Processpatching,* as a method to support interdisciplinary collaborations between artists, (computer) scientists, and technicians, is a valuable addition to the widely used instrumental (multidisciplinary) problem solving approach. DIY reflects the independent artist's attitude.

Artistic aim, objective	Method	Characteristics	Group dynamics, team composition	Advantages / disadvantages	Theoretical context / matching approaches	Type of aRt&D, type of collaboration, application domain
Problem solving	***Reductive method***	Single or limited disciplinary problem solving approach, applied research, practical method	Technicians as facilitators, artists as engineer in single / limited disciplinary situation, no improvisation	Sharp goal, clear aim, useful for tool development, no-divergence, linear, predictable, assistance or facilitations rather than co-operation	Traditional methods in art, engineering, design, science and technology	Empiric approach, applied R&D, relevant in single- and multi-disciplinary teams, techno science, artistic innovations
Self-sufficient, self-supporting, rapid prototyping	***DIY and hacker method, Re-engineering, reverse engineering***	Mis-interpretation and re-interpretation, re-purposing technology, protest / activism via alternative methods, mostly small scale	Artist as enfant terrible, catalyst for creative thinking, innovation of artistic oeuvre (the latter relates to DIY)	Surprises, critical view, steep learning curve to become self-sufficient, suitable for rapid prototyping and user testing	Post-modernism, de-construction, Avant-garde, activism, critical theory, autonomy, relevant in multi disciplinary collaborations often autodidact multi-tasker, exchange with other independent operators, FLOSS development	Think-tank or brain storm approach, engagement, Critiquing, awareness, empiric or practical approach, single person multi tasking, artist-commentator, engineering, hackers
Innovating arts, re-contextualizing technology, creating new connections	***Process - patching***	(Re-)mixing and re-appropriating methods from scientific fields and (non) technologies, aesthetic driven, often large scale	Parallel and intersecting methods and approaches, from involved disciplines	Freedom to change methods re-contextualization, space for cooperation, ground for new discoveries and innovation	Post- Modernism critical theory, Fluxes, includes humanities, computer science, arts,	Basic research and experiments in social science, multi and interdisciplinary collaboration, art as method .Blend of techniques and methods, anything goes, Bricolage
	_Participatory method	experience design concepts, interaction desgin experiments	Often used tools for interdisciplinary collaboration: Third space, boundary objects	Ground for co-operation, experience oriented applications, difficult to combine with problem solving, improvisation	Post-Marxism, design theory, human centered H.C.I., ethnography, social sciences, communication design, computer sciences especially A.I., A.L.	Heuristic research, experience design
	_Art and design techniques and methods	focus on process and ittertive approach, thought from the end-user / participant's	mixed teams, parallel trajectories in one project	Focus on end-user/participant experience, ethics and aesthetics	industrial design, interaction design theory, H.C.I., theatre	product design, game design
	_Combination of all above and informal approaches	mixing, re-purposing and parallel approaches in one project	all of the above in new variations	knowledge needed from all included methods, appraoches and backgrounds	potentially all of the above	re-mix culture, interactive electronic artworks

(fig. 35. aRt&D Matrix final overview)

The Final aRt&D Matrix (fig. 35) serves as a reference framework for multi- and interdisciplinary collaboration, and articulates different angles and objectives towards technology development, as represented in technology-driven R&D and experience-oriented aRt&D, as a contribution to the shared knowledge among the participants.

The three major aRt&D methods contribute to an outspoken role of the artist in collaborations and thus to a higher profile for the electronic artist. The aRt&D Matrix reflects assimilation (rather than integration) of the arts in dynamic contexts, as the premise of this research. This is the next step in the process of gaining full recognition for artistic research and development as a valuable contribution in collaborative projects with (computer) scientists and technicians.

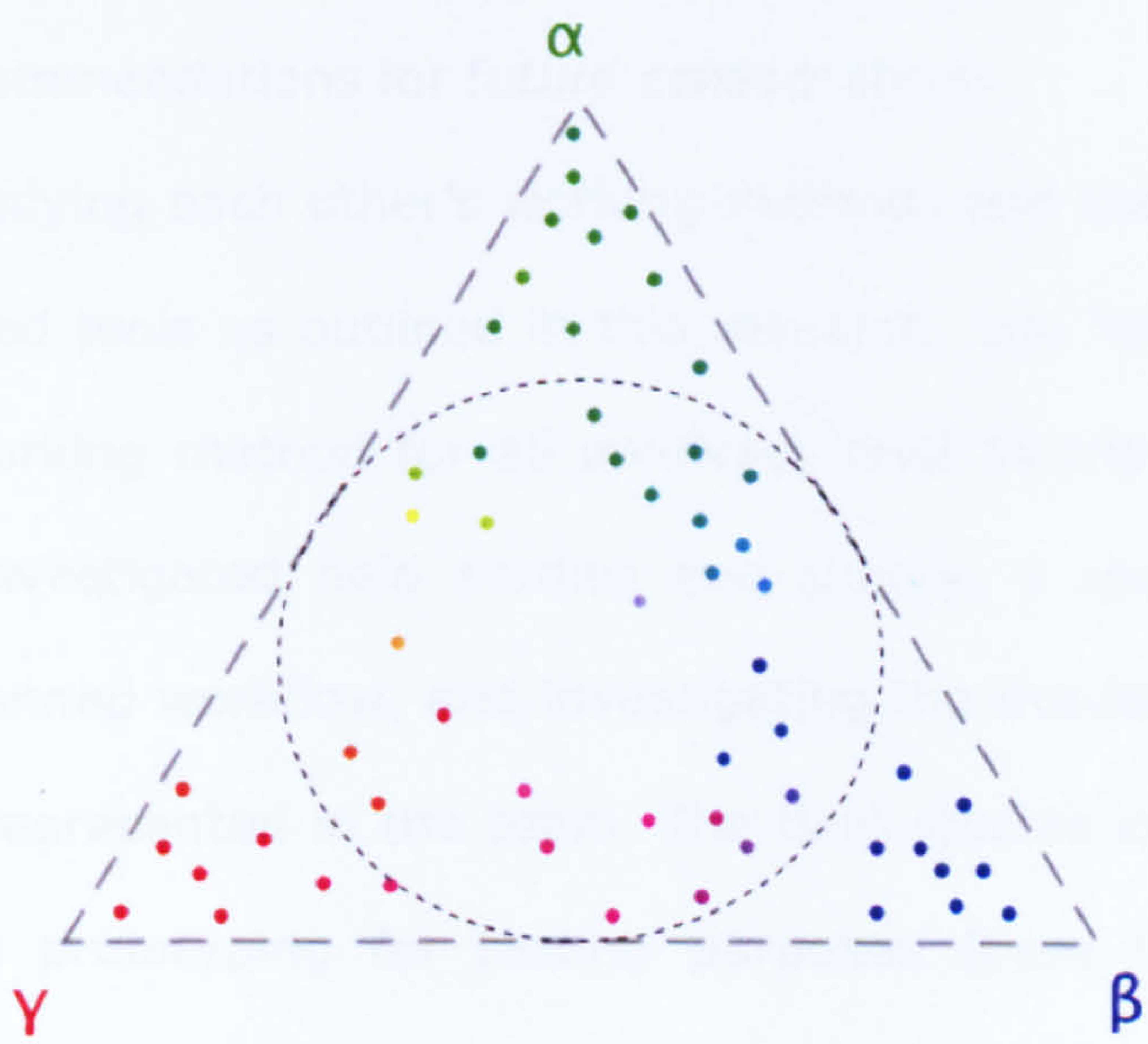
As shown in the aRt&D matrix above, connecting or *processpatching* is the support method for interdisciplinary collaboration that enables the collaborators to connect different research fields (technological and non-technological) and to exchange knowledge between the technical and/or scientific research and other fields. It offers a reference to the most frequently used methods and approaches to include the audience or participant in the creation process. The final aRt&D Matrix also emphasises the 'meta' view and iterative approach of the intrinsic electronic art *processpatching* method, which contrasts the tunnelled and reductive approach. I believe that the *processpatching* method offers a significant contribution to the renewal of all involved disciplines through the re-contextualisation of aRt&D and R&D activities. *Processpatching* is a supporting method for the *transvergence* practice. The electronic artist now has a toolset and several aRt&D methods at their disposal for effective collaboration and mediation between the disciplines.

Art practice, as discussed in this study, directed me to user-centred and experience design. Interface design and knowledge representation have been identified as today's two main research areas of interest for interdisciplinary collaboration. These research and development areas offer plenty of opportunities for renewal in the arts, (computer) science, and technical research, through the potential for wider application. In these areas, the artist acts as an aRt&D researcher in his/her own right; the role of the artist is complementary to the scientists or technicians. Artists, as specialists in this area, now have their own formalised tools and methods to build their practice, to share this practice and to take the lead in the *transvergence* zone.

The aRt&D methods as outlined in the aRt&D Matrix provide the basic parameters to establish a convenient interdisciplinary or multidisciplinary collaborative project, where the sum is more than the parts and where shared interest leads to something none of the individuals would have been able to realise.

4.3.1. Supporting tools and instruments for '*processpatching*'

The case studies discussed herein demonstrate a convincing picture that is useful for team members when commencing a collaborative project. To find out what the best method or set of methods for a specific project could be, the aRt&D Triangle is used as an instrument to inform the team members about one another's background knowledge and work methods. The aRt&D triangle shows the disciplinary distance of the collaborators, and from there, the likeliness of shared knowledge and/or methods. The case studies show that successful interdisciplinary collaboration is mostly achieved by the collaborators whose backgrounds are closely positioned in between the disciplines (3.1.1, 3.1.2., 3.1.3., 3.2.1.). The same case studies illustrate that multidisciplinary collaboration is more likely to be successful among people who are positioned far away from each other in the aRt&D Triangle.



(fig.36. aRt&D Triangle)

The case studies show different approaches to bridging the distance between disciplinary knowledge and methods. Firstly it is investigated if the team members share knowledge or have a common background, as shared knowledge or shared backgrounds often provide fertile ground for mutual understanding and methodological matches. For example, artists collaborate more easily with software and hardware engineers or techno-scientists when they have technical know-how or common approaches (3.1.1, 3.1.2., 3.1.3., 3.3.1.). Software or shared platforms also work as common ground for collaboration. Although the team members might have different levels of programming skills, it surely helps if they work within the same software environment. When the shared knowledge or common background is missing, the concepts of a Third space and the boundary object are useful tools to support a neutral ground for collaboration among people with different backgrounds (3.4.).

Finally some recommendations for future collaborators:

I recommend studying each other's working methods and knowledge fields, using the provided tools as outlined in this research, and investigating the most suitable working method for all involved, prior to the collaboration. Based on the investigated field studies and theory, I recommend fully analysing the planned workflow, and investigating the available technology and knowledge represented in the team. The field studies in this research show that rapid prototyping for testing purposes (here this was done according to a DIY or hacking approach) might save time, is more efficient and enables early user testing or participatory design sessions through which valuable information for future development, on both a conceptual and technical level, can be achieved. Do not hesitate to include various parallel or intersecting approaches and methods within one project, as this might optimise all available expertise and increase the enjoyment of collaboration! However, communicate this and plan this in advance with your team!

The concept of Third Space and boundary objects are recommended as tools for teams that consist of members from very remote disciplines where little or no knowledge is shared among the team members.

Use the aRt&D Matrix to indicate and refer to your own electronic art research and development approach and methods, as this offers a reference framework to compare it with other known methods and approaches. Feel free to extend the processpatching references in the aRt&D Matrix with your favourite methods and approaches!

4.4. Future work

Based on the conclusion above, several key issues can be identified as critical areas for future study.

This thesis, and the body of research it collates and analyses, jointly provides the basis for analyses to draw upon and offer a future model or toolkit for use by interdisciplinary teams. Although the research is rooted in practice, it has been defined and extended in such a way as to offer a platform for future analyses in both theory and practice. I suggest further development of the tools for direct practical use for those who plan to start a multi or interdisciplinary collaboration. Future studies on this subject, as an extension of this research, should lead to an aRt&D handbook for project managers, teachers and students in the field. In particular, the uncovered practical details of implementing the *processpatching* method in practice is recommended as topic of further research and investigation for this handbook. Project management topics and methods are to be included as well in this future publication. This research can also be further developed into a practical guide for professional artists, technicians and scientists. Based on today's practice, this research also offers the basis for a toolkit to enhance today's interdisciplinary practice. The provided overview in the aRt&D Matrix could be used to update and upgrade the status of electronic artwork in an interdisciplinary setting with technicians and computer scientists. It is recommended to use this research material in the course of positioning art in the collaboration process with computer science and other disciplines. This research emphasises the intrinsic artistic methods and qualities that are complementary to computer science and engineering methods. This thesis aims to contribute to a larger theoretical framework about work approaches and methods and artistic research in general. It is recommended for educators and professionals to consider this study in their daily work as it provides material for students and professional artist to reflect on one's own work method. Moreover, this work provides key concepts for communication of artistic approaches and models for collaboration.

This study contributes to an understanding of the specific qualities and characteristics of practice-based research from the art and design field. I offer this thesis to future scholars as a resource in developing new measures of quality and evaluation criteria in the electronic arts. My original and substantial contribution to the relevant fields of knowledge is the provision of a new set of matrixes for this evaluation, as presented and discussed in these pages.

4.4.1. Recommendations for policymakers

Although the grant and subsidy system varies from each European member state, in general the processpatching approach is missing in discipline specific subsidy programs. This is problematic for artists as researchers; the value of their research lies in part in connecting the different disciplines, but by doing so, it easily falls in the discipline divide of the grant programs. The support programs for processpatching artists should not be focused on products a priori, but rather on basic or experimental research with a focus on active audience participation. The literature studies and case studies, drawn upon and analysed in this thesis, clearly show that artistic innovations, developed alongside technological and scientific methods in a rapidly evolving new media terrain, can most usefully be applied to both research and product development, resulting in a new potential for renewal in the Arts.

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Weibel Peter: The Unreasonable Effectiveness of the Methodological Convergence of Art and Science in Art @ Science Christa Sommerer , Laurent Mignonneau Laurent (editors) Published by Springer Vienna/NewYork, 1998 . ISBN 3-211-82953-9
Wijers Louwrien (editor): Art Meets Science and Spirituality in a Changing Economy Published by Academy Editions 1996, ISBN 1-85490-477-9
Wilson Stephen : Artificial intelligence research as art Paper SEHR vol. 4. issue 2: 1995
Wilson Stephen : Myths and Confusions in thinking about Art/Science/Technology , paper , presented at College Art Association meetings, NYC 2000
Wilson Stephen : Information Arts, 2003, published by MIT Press ISBN 0262731584

6.2. Material on the Web

6.2.1. V2_ Institute for the Unstable Media

www.v2.nl

DEAF
http://deaf.v2.nl
http://mediaknitting.v2.nl/

Archived material of V2_ events
http://archive.v2.nl/

6.2.2. Literature studies

Howard Becker
http://home.earthlink.net/~hsbecker/

Sara Diamond
http://ahds.ac.uk/creating/guides/new-media-tools/diamond.htm
http://www.horizonzero.ca/textsite/invent.php?is=3&file=1&tlang=0

Michael Century
http://www.nextcentury.ca/PI/PI.html

Bas Haring
http://www.liacs.nl/~haring/basharing/

Critical Art Ensemble
wwcritical-art.net/tactical_media/index.html

Anne Nigten

http://archive.v2.nl/v2_lab/papers_general/2004_nigten_tunnels.pdf

ISEA2006 call for project proposals
http://isea2006.sjsu.edu/

Yoland Wadsworth
www.scu.edu.au/schools/gcm/ar/ari/p-ywadsworth98.html

DJ Tiesto
http://www.tiesto.com/

The online archive of Man Ray
http://www.manraytrust.com/

Jodi
www.jodi.org/

Kristin Andersen, Margot Jacobs, Laura Polazzi
http://www.lockergirl.com/

Thecla Schiphorst, Sid Fels
hct.ece.ubc.ca/publications/pdf/CAST01.pdf

Phoebe Sengers et al,
http://www.cs.cornell.edu/people/sengers/

Panamerenko
http://www.panamarenko.be/home.php

'Patchwork Girl' by Shelley Jackson
http://www.eastgate.com/catalog/PatchworkGirl.html

Theo Jansen
http://www.strandbeest.com/

Catherine Richards
http://www.catherinerichards.ca/index.html

art+com / Joachim Sauter
www.artcom.de/~js

Jurriaan Andriessen
http://www.jurriaan-andriessen.nl/

Media art net
http://www.medienkunstnetz.de/mediaartnet/

6.2.3. Case studies

Info on the work of Sheelagh Carpendale,
http://pages.cpsc.ucalgary.ca/~sheelagh/personal/thesis/thesis.html

Info on the conference *Anarchives: Connection Machines*
http://www.v2.nl/2002
http://framework.v2.nl/archive/archive/node/event/minimal.py/nodenr-135524

Info on the *'Kurort'* project
http://dampf.v2.nl/co-prod/*'Kurort'*/index.php

Info on the *'M.U.S.H.'* project can be found at
http://www.eternalnetwork.org/mush/txteng.htm

Info on the work of Ben Schouten
http://homepages.cwi.nl/~bens/

Info on the work of Arnold Smeulders
http://carol.wins.uva.nl/~smeulder/

Info on the work of Christa Sommerer and Laurent Mignonneau
http://www.iamas.ac.jp/~christa/

Info on the *'whisper'* project can be found at http://*'whisper'*.surrey.sfu.ca/

Report *Data Perception* 2003, by Rens Frommé,
http://framework.v2.nl/archive/archive/node/text/.xslt/nodenr-151404

Readers *DEAF04*
http://www.deaf04.nl/

6.2.4. Software

'TX transfrom'
http://www.tx-transform.com/Eng/index.html
http://processing.org/

'Ma'x, 'MSP'
http://www.cycling74.com/

'softVNS2'
http://homepage.mac.com/davidrokeby/softVNS.html

'Pure Data'
http://puredata.info/

'Processing'
http://processing.org/

'Nato+55'
http://www.m9ndfukc.org

6.2.5. Related institutes and initiatives

Ars Electronica Centre
http://www.aec.at/

C3
http://www.c3.hu/
Banff New Media Institute
http://www.banffcentre.ca/bnmi/

CWI
http://db.cwi.nl/projecten/thema.php4?themanr=6

Daniel Langlois Foundation
http://www.fondation-langlois.org/

Hexagram
http://Hexagram.org

ISEA
www.isea-web.org/

M-Cult
www.m-cult.org/

Mars – GMD
http://www.imk.fraunhofer.de

MultimediaN
www.multimedian.nl

Rhizome
http://rhizome.org/

Steim
http://www.steim.org

Virtual Platform
www.virtueelplatform.nl

Waag Society
http://www.waag.org/

ZKM
http://www.zkm.de/

7. Appendix 1.
Accompanying material for the case studies

The following texts are taken from readers and contain contributions by others. The spelling has therefore not been corrected to British spelling and the grammar has been left more or less in tact, unless a rephrasing was necessary to clarify meaning.

7.1. Reader *Anarchives: Connection Machines* (part of)

Anarchives: Connection-machines

Symposium 05 Jul 2002

Moderated by Michel Punt and Anne Nigten

Short description of the symposium:

In our information and knowledge based society archives once again attract the interest of artists, art institutes, scientists and others. Archives and databases have become the basis for the development of knowledge. The opening up and ordering of archives is a time-honored way of reflecting on the social and cultural cohesion of groups of people and communities and the role of the individual therein. Concepts of this vary from the 17th century 'Wunderkammer' model to the metadata theories in our information and knowledge based society. The present application of digital technology makes it possible to arrive at a drastic linking of a great diversity of information, uncovering complex relationships and connections.

Data about the genes of humans, animals and plants, about our social and political preferences, our Internet behavior; everything is stored digitally and everything can be linked. Based on this information all sorts of economic, social and cultural scenarios and realities are being devised. It also raises essential social questions: Which databases and archives are being linked, and which are not? Which information either is or is not stored in these databases and who decides this? Which information can be applied by specific interest groups only? What is the public significance of these knowledge systems?

Besides a technological and scientific aspect this development also has a social and cultural element dominated by the notion that it is essential for the individual to be able to interact within this complex social and cultural (media) reality and to be able to transform it. In this situation there is a growing need for strategic tools and agents to play an active role in the way information is entered, edited and opened up. A growing number of artists and architects are developing (software) systems to (re)organize data into complex knowledge systems that offer their users insight and interaction. Databases, software engines and archives are increasingly involved in artistic interventions. Artists are looking into the cultural and artistic possibilities for redefining and/or reusing existing archives. Via the artworks that apply archives and databases new interpretations and archiving concepts are being generated, as well as new aesthetic experiences. How do failures occur in the (dis)connections between archives and what is the artistic potential of these breakdowns? In this process, artists and computer scientists share an interest in the development of software that can be applied to the field of art and culture. The conference Anarchives: connection-machines brings together a choice of scientists and artists who will present their research and their projects.

Participants:

Arnold Smeulders (NL), Professor at the University of Amsterdam (UVA), Faculty of Science, chair on Multimedia Information Processing, project leader of MultimediaN and director of the Informatics Institute.

Margarete Jahrmann (A), artist and journalist, studied at the Vienna University of Applied Arts and at the Gerrit Rietveld Academy Amsterdam. She has realised a variety of CD-ROMs, net projects, Superfem online performances, and Web 3D projects.

Ben Schouten (NL), Artist, entrepreneur (Desk.nl) and mathematician at the CWI (Center for Mathematics and Information Science) in Amsterdam. In 2001, he obtained his doctorate with a thesis on CD-ROM: Giving eyes to ICT! Or: How does a computer recognize a cow?

Thecla Schiphorst (CDN), media artist, choreographer, dancer, and computer systems designer and Associate Professor in the Computer Arts and Design Sciences Program at Simon Fraser University. Her formal education and training in computing science and dance form the interdisciplinary basis of her work.

Max Moswitzer (A), multimedia artist specialised in 3D simulations and artistic server design, graduated from the University for Applied Arts in Vienna. He regularly produces interactive applications and online installations, videos and Internet projects.

Marko Peljhan (SLO), born 1969, studied theatre and radio directing at the university of Ljubljana. In 1992 he founded Projekt Atol. He was coordinator of the Makrolab project (1997) an art/science station. Co-founder of Ljudmila - Ljubljana Digital Media Lab in 1996.

7.1.1. '*The Sleeping Giant*' by Arnold Smeulders

Content-based image retrieval Arnold Smeulders

Conference Anarchives: Connection-machines [2002]

archiving | images | image recognition

This text draws from a much bigger text which has appeared as A.W.M. Smeulders, M. Worring, S. Santini, A. Gupta and R. Jain: Content based image retrieval at the end of the early years, IEEE PAMI dec 2000. All references can be found in that paper.

0. The archive will speed us up - will halt us

If you try to imagine what life will be like hundred years from now, it must be frightening. For one, everyone can carry on in its pink-top an archive bigger than the life-long capacity of the senses. So, the relevant portion of the information reaching us can be stored and processed off-line. This must have the effect on the one hand that the processing of information and hence of life will proceed in an even faster pace. And, at the same time, it must have the effect that the development of life will be slowing down as all information is stored in an archive with its tendency to conserve what is there. (In 2002, on the one hand is the effort to write, rehearse and perform a theater play within 24 hours. This is the ultimate expression of the progressive archive-less times we live in. At the same time, the Dutch government requires now that all expenditures are accounted for, leading to extreme archive-conservatism.)

Archives are waiting for us as a huge giant asleep. If we wake the giant, what is it able to tell us? What language will it speak? Will we be able to understand the dreams it has in its mind? And, the giant grows and grows by interconnections. Will it be a force stronger than ourselves?

I cannot answer these questions. What I can do is give an overview of the possibilities and impossibilities of accessing a visual archive and the current bottlenecks.

1. Content based image retrieval - at the end of the early years

There is something about pictures that no words can convey. Consider Munch"s The scream, or a performance by a video artist, or even the average Mondrian. It has to be seen. The same holds for of pictures of the Kalahari Desert, a dividing cell or the facial expression of an actor playing King Lear. It is beyond words. Try to imagine an editor taking in pictures without seeing them, a radiologist deciding on an X-ray from just a verbal description. Pictures have to be seen and searched for as pictures, by object, by style or purpose.

Research in content-based image retrieval today is a lively discipline, expanding in breath. As it happens during the maturation process of many a discipline, after early successes in a few applications, research is now concentrating on deeper problems, challenging the hard problems at the cross roads of the discipline from which it was born: computer vision, databases, and information retrieval.

At the current stage of content-based image retrieval research, it is interesting to look back towards the beginning and see which of the original ideas have blossomed, which haven"t, and which were made obsolete by the changing landscape of computing. In February 1992, the USA-based National Science Foundation organised a workshop in Redwood, CA, to identify major research areas that should be addressed by researchers for visual information management systems that would be useful in scientific, industrial, medical, environmental, educational, entertainment, and other applications. There are earlier attempts, such as the 1979 conferences on databases and pictorial applications in Florence, but nothing of much interest for today was reported there. In hindsight, the workshop can be marked as the beginning of research in content-based retrieval.

Why did it take so long to get the exploration of visual material started? Before 1995 the machine power, the capacity and reach of the Internet and the availability of digital sensors was underdeveloped to bootstrap any serious use of image exploration. But just after the NSF-workshop, things were to change quickly. The Mosaic Internet-browser was released spawning the web revolution that very quickly changed all cards. In the same era a host of new digital vision sensors became available. The number of images that the average user could reach increased dramatically in just a few years. Instantly, indexing tools of the Web or digital archives became urgent. And, in science, the visual image databases and exploration of the visual content has drawn considerable attention ever since. In order to appreciate the current state of affairs we need to discuss some basic observations which hold true for all images and all observers - man or machine alike: the sensory gap and the semantic gap.

The sensory gap is the gap between the object in the world and the information in a numerical/verbal/categorical description derived from an image recording of that scene. A computer can only process the numerical information derived from an image, so it is important to realise how much information is lost when converting an image into a digital description. For narrow image domains with a limited and predictable variability in its appearance a special digital language might be developed, but still the challenges are considerable. In the narrow domain of frontal views of faces, they are usually recorded against a clear background and illuminated with white frontal light. Where each face is unique and has large variability in the visual details, there are obvious geometrical, physical and colour-related constraints governing the domain. Still the same person could render a thousand different recorded faces depending on mood, beard, weather, time of day, make-up, glasses, lighting position, incident shadows, clothes, hair-cut, frame of photography and so on. And this is yet a relatively narrow domain. The domain would be called slightly wider had the faces been photographed from a crowd or from an outdoor scene. In that case also clutter in the scene, occlusion and a non-frontal viewpoint will have a major impact on the digital description. For a broad class of images, such as the images in a photo-stock, the gap between the feature description and the semantic interpretation is generally wider still. The sensory gap makes the description of objects essentially uncertainty in what is known about the object. The sensory gap is particularly poignant when a precise knowledge of the recording conditions is missing. The 2D-records of different 3D-objects can be identical. Without further knowledge, one has to decide that they might represent the same object. Content-based image retrieval systems may provide support in the reduction of the uncertainty through elimination among several potential explanations, much the same as has been done in natural language processing. In short, the sensory gap introduces an uncertainty in any description of an image as a thousand (slightly) different images are mapped on the same description.

I guess most of the current disappointment with standard retrieval systems originates from the semantic gap. The semantic gap is the lack of coincidence between the information extracted from visual data and the interpretation that the visual data have for a user. The semantic gap is best illustrated by pictures each holding a chair. When searching for a chair we may be satisfied with any object under that name. That is we search for man-defined equality. When we search for all one-leg chairs, we add an additional geometrical constraint to the general class. The same holds when searching for a red chair, now adding a colour constraint in the search, not a geometrical condition. When we search for a chair perceptually equivalent to a given chair, at least it must be of the same geometrical and colour type and we are down to the sensory gap. Finally, when we search for exactly the same image of that chair, literal equality is requested, still ignoring the variations due to noise in the image and we are in the realm of image processing. Where a linguistic description is contextual, an image in an archive is not and may live by itself. So closing the semantic gap will at least include contextual search, a topic barely touched upon in science. Systems like [Chang, Rui] are collecting images from the Internet and inserting them in a predefined taxonomy on the basis of the text surrounding them.

When sorted on their purpose of image search, we discriminate three types of systems:

1. Searches by association at the start have no specific aim other than find interesting things. It often implies iterative refinement of the search,

the similarity or the examples with which the search was started. Systems in this category typically are highly interactive, where the specification may by sketch or by example images. The oldest realistic example of such a system is probably by [Kato]. The result of the search can be manipulated interactively by relevance feedback [Hiroike, Frederix]. To support the quest for relevant results, also other sources than images are employed, [Swain].

2. Target search may be for a precise copy of the image in mind, as in searching art catalogues [Qbic95]. Target search may also be for another image of the same object. This is target search by example. Target search may also be applied when the user has a specific image in mind and the target is interactively specified as similar to a group of given examples, [Cox]. These systems are suited to search in catalogues.

3. Category search aims at retrieving an arbitrary image representative of a specific class. It may be the case that the user has an example and the search is for other elements of the same class. Categories may be derived from labels or emerge from the database [Swets]. In category search, the user may have available a group of images and the search is for additional images of the same class [Ciocca]. A typical application of category search is catalogues of varieties, with a domain specific definition of similarity.

The pivotal point in content-based retrieval is that the user seeks semantic similarity, but the database can only provide similarity by data processing. This is what we called the semantic gap. At the same time, the sensory gap between the properties in an image and the properties of the object plays a limiting role in retrieving the content of the image.

We discussed applications of content-based retrieval in three broad types: target search, category search and search by association. Target search is closest to computer vision research. Category search is much more challenging and requires on-line learning or visual data mining. Search by association is hampered most by the semantic gap. As long as the gap is there, use of content-based retrieval for browsing will not be within the grasp of the general public as humans are accustomed to rely on the immediate semantic imprint the moment they see an image. New ways of presenting and learning from archives are necessary here. In general, I would formulate as the challenge for image search engines: to tailor the engine to the narrow domain the user has in mind, via query specification, via learning from past, and via current interaction.

2. The state of the art - a few practical tips and a disappointing conclusion

To enhance the image information, retrieval has set the spotlights on colour, as colour has a high discriminatory power among objects in a scene, much higher than gray levels. The purpose of most image colour processing is to reduce the influence of the accidental conditions of the scene and sensing *that* is another definition of the sensory gap as discussed above. Progress has been made in tailored colour space representation for well-described classes of variant conditions. Also, the application of geometrical description derived from scale space theory will reveal viewpoint and scene independent salient point sets thus opening the way to similarity of images on a few most informative regions or points.

In the description of the image one usually starts from assuming strong segmentation of the image. The alternative to do no segmentation at all is unattractive as one mixes aspects of all objects in the image into one soup of numerical descriptions. Strong segmentation is the precise outline in the image for each individual object. This is an incredible complex task, human can do in the second they see the picture, even if they have never seen the topic of the picture before. There is no chance a machine can perform this general task in a hundred years, simply because humans use one third of all the brainpower to achieve this. Luckily - and it took years to realise this - for retrieval a total understanding of the image is rarely needed. Of course, the deeper one goes into the semantics of the pictures, the deeper also the understanding of the picture will have to be, but even understanding the semantic meaning of the image does not require strong segmentation. A weaker version of segmentation has been introduced in content-based retrieval. In weak segmentation the result is a homogeneous region by some criterion, but not necessarily covering the complete object silhouette. It results in a blobby description of objects rather than a precise segmentation. Salient features of the weak segments might capture the essential information of the object in a nutshell. The extreme form of the weak segmentation is the selection of the perceptually most salient points as the ultimately efficient data reduction in the representation of an object quite likely drawing human focus-of-attention.

Whenever the image itself permits an obvious interpretation, the ideal content-based system should employ that information. A strong semantic interpretation occurs when a sign can be positively identified in the image. This is rarely the case due to the large variety of signs. As data sets grow big and the processing power matches that growth, the opportunity arises to learn rather than to know the signs. One type of approach is appearance based modeling, learning from examples. That works but only if the recording conditions are highly standardised, like frontal well illuminated faces only. A better approach is one-class classifiers, from examples carefully describing the limits of a class of objects [Tieu, Tax]. An interesting technique to bridge the gap between textual and pictorial descriptions is to exploit information is called latent semantic indexing [Sclaroff]. The search is for hidden correlates of features and captions. In a broad class of images and the enormity of the task to define a reliable detection algorithm for each of them.

Similarity is an interpretation of the image based on the difference between two elements or groups of elements. Any information the user can provide in the search process should be employed to provide the rich context required in establishing the meaning of a picture. The interaction should form an integral component in any image retrieval system, rather than a last resort when the automatic methods fail. Already at the start, interaction can play an important role. Most of current systems perform query space initialization irrespective of whether a target search, a category search, or an associative search is requested. But the fact of the matter is that the set of appropriate features and the similarity function depend on the user goal. Asking the user for the required invariance, yields a solution for a specific form of target search. For category search and associative search the user-driven initialization of query space is still an open issue. We make a pledge for human-based similarity rather than general similarity.

User interaction in image retrieval has, however, some different characteristics from text retrieval. There is no sensory gap and the semantic gap from keywords to full text in text retrieval is of a different nature. No translation is needed from keywords to pictorial elements. We identify six query classes: exact and approximate and ranging from spatial content, image, image groups, and all combinations thereof. When accessing spatial content, some form of (weak) segmentation is required. A balance has to be found between flexibility on the user side and scalability on the system side. Query by image example has been researched most thoroughly, but a single image is only suited when another image of the same object(s) is the aim of the search. In other cases there is simply not sufficient context. Queries based on groups as well as techniques for prior identification of groups in data sets are still promising lines of research. Such group-based approaches have the potential to partially bridge the semantic gap while leaving room for efficient solutions.

A critical point in the advancement of content-based retrieval is the sensory and semantic gaps. The size of the sensory gap between the image data and the computer processed description - for a discussion see above - is enormous but in recent years some of its structure has become better known and even some partial fillings have been achieved. The size of the semantic gap - the distance between the image and the immediate understanding of a user not available to a machine - for a discussion see above - is formidable. The scientific progress is interesting but negligible to the size of the gap. Use of content-based retrieval for semantic browsing in general domains will not be within the grasp of the general public as they are accustomed to rely on the immediate semantic imprint the moment they see an image, and they expect a computer to do the same. Specific situations may work. The aim of content-based retrieval systems must be to provide maximum support in bridging the semantic gap between the simplicity of available visual features and the richness of the user semantics. The best way to resolve the semantic gap comes from sources outside the image by integrating other sources of information about the image in the query. Information about an image can come from a number of different sources: the image content, labels attached to the image, images embedded in a text, and so on. We still have very primitive ways of integrating this information in order to optimize access to images. Among these, the integration of natural language processing and computer vision should come first.

Arnold Smeulders smeulders@science.uva.nl

7.1.2. *'The semantic gap'* by Ben Schouten

The semantic gap, words and images

Ben Schouten

If computers can be seen as calculators, then the question arises whether intelligence and particularly visual intelligence can be produced by mere calculations. Unfortunately, this question will not be answered in this presentation. One thing is certain; we have taken a road to (visual) intelligence. We may wonder where this road will bring us and where we are now. Archiving concepts become available in industry, society and art.

Recognition is definitely a part of visual intelligence. It relates an emotion, experience or visual input to an earlier event. Image recognition is based on having seen something before. Our brain is effective in this. Human beings are able to understand and work with concepts. Computers are far less intelligent.

To a certain extent concepts can be expressed in language. Language enables the description of concepts; we are able to explain what we see. Although it is a tedious task, someone escorting a blind person can describe the things he sees to him. Even harder it is for the blind person to imagine what has been described. The mapping from image space to concepts is not one-to-one, after all: "A picture may be worth a thousand words".

In contemporary multimedia applications, an image is described by features, like the colour or shape of an object. This is a many to one mapping and as a consequence, there is no one-to-one reverse mapping. A car can be red. But there are a lot of other objects with a red colour.

As we can learn from the human seeing-eye dog, one way of doing is to describe the content in language, as done in the case of keywords. But then a more intelligent way of looking for similarities is required. 'Visual information retrieval' (VIR) systems process visual content in a way human beings do. 'Content based image retrieval' (CBIR) is based on the fact that images can be retrieved because of their similarity to other images.

One can distinguish three core components of these systems:

Content extraction

Describe the content in such a way that it can be processed. 'Feature extraction' is one way of doing this. An image or video is described according to several features like colour or texture.

Similarity

Once the content has been described, the system has to define how similar this content is to the content of other images. As a result, one has to define metrics approximating to what extent the different images, represented by their features are similar.

Interfaces

For the user to communicate with the system, interfaces should be able to display and compose visual information. As the content of images is subjective, an intelligent system should be able to manage this subjectivity.

In the domain of 'visual information systems', information can be processed for several purposes:

Compression

MPEG 4, 7, 21 add standards for describing content in multimedia databases, besides mere compression.

Retrieval

To browse, query and download information from the web or other information databases.

Visualization

In the field of art and design for instance, visual information depends on personal appreciation. Applications should give way to examine visual information as it appears and query by visual means.

Security and authentication

Document ownership, access and facilitation. Authorizing or blocking content (pornography). Filtering.

Quality control

Visual inspection of products like textiles.

Delivery on demand

Personal Content as in television on demand. Extracting personal content from a larger and more general content quantity. Indexing.

Manipulation

Content being processed in a way that new content is created. Examples are art, music and video.

http://framework.v2.nl/archive/archive/node/text/.xslt/nodenr-136433

7.1.3. Report on *Anarchives: Connection-Machines* by Sandra Fauconnier

Anarchives: connection-machines

Report by Sandra Fauconnier (fokky@v2.nl)

Archiving and "data knitting" is V2_'s yearly theme for 2002, although it might be a rather atypical topic for an institute for unstable media. In his introduction to the conference "Anarchives: connection-machines", Alex Adriaansens explained this decision by showing how we permanently live in archives; the world itself can be considered an archive, essential for our acting in the present. V2_ is fundamentally interested in the short-circuits established through unforeseen connections between information clusters, and in the role of interactivity in this.

The Anarchives conference dealt with these interests. A very diverse group of scientists and artists presented their respective views on archiving; an equally broad and differentiated audience attended the program. Michael Punt, one of the moderators, emphasised this by expressing his own interest in the difference between experience and describing it, the paradox between the apparatus and the subjective, mirrored into the diverse views expressed during this conference.

Ben Schouten, the first lecturer, visual artist and researcher, presented his research areas within the Centre for Mathematics and Computer Science (CWI), in the field of image analysis and content-based image retrieval. Here, the research team tries to establish 'visual intelligence' that enables computers to adequately recognize visual material. At this point, this problem is tackled by combining low-level, content-dependent metadata (image features such as colour, structure) with semantics - content-independent annotations established by archivists. Schouten here pointed to a third aspect - ordering archives through emotions and meaning (Maturana) - or, the importance of enabling the user to reorganize the database in an entirely subjective way. Bridging the 'semantic gap' between image features and personal, historical and generally cultural metadata is still a largely unsolved problem.

The project *'Polar'* by Marko Peljhan and Carsten Nicolai deals with subjectivity in an entirely different way. *'Polar'* (2000) is an installation whose aim is to materialize the exchange of data, through network protocols, into a tactile experience, approaching the internet ("the matrix") in an organic sense. The installation is designed as a physical place, with a clear inside and outside, featuring a visual tracerouting display, a skin cell growth module (the biological element) and a water module for visualizing vibrations. The installation draws upon an analogy with Solaris - a science fiction novel by Stanislaw Lem and a motion picture by filmmaker Andrei Tarkovsky. The story of Solaris describes a planet as a living being, influenced by observation; the installation *'Polar'* treats data flows in a similar way. The *'Polar'* system contains a dictionary which grows by analogy, sending the dictionary words to a large number of search engines and incorporating the search results as new entries in the dictionary. Marko Peljhan describes how such a space triggers surprising situations, even if one knows the system very well.

Margarete Jahrmann then presented the Nybble Engine, a project she developed together with Max Moswitzer. The Nybble engine is a nonlinear program framework in which nybble engine movies (NEMs) - real-time network movies - are generated as a result of so-called nybble engineering. Nybbles or tetrads stand for 4 bits, enough to represent any number and a conventional idea in natural science. In the nybble engine, three-dimensional data objectiles result from the data generated through nybble engineering. Both users and bots within the system can influence its architecture; thus enabling co-authorship of the machinic.

In a very contrasting presentation, Arnold Smeulders spoke about the archive as a 'sleeping giant.' Like Ben Schouten, Smeulders focused on the difficulties and even impossibilities of content-based image retrieval.

Smeulders emphasised the difficulties that computers ('dull translators') have with the attachment of meaning to image data. For very specific domains, such as the study of the structure of the human brain, so-called dedicated segmentation (recognition of reoccurring patterns) is a step in the right direction, but in this way, each new topic would need a new computational model. Smeulders ended his presentation by re-emphasizing the semantic gap between words and images.

Thecla Schiphorst then presented the *'whisper'* project – currently an artist in residence project at the V2_Lab. The project is still in its conceptual phase and is based on engineering small wearable devices and handheld technologies, resulting in a participatory installation which will be first presented during DEAF_03. The *'whisper'* system constructs networked messages, based on inferred states of the participating bodies. Schiphorst mentioned the concept of 'pulp fashion', coined by Susan Kozel, as a metaphor for the impermanence of physical states. The context of *'whisper'* is experiental body practice – methodologies in theater practice for creating a certain body state. Older research projects of Schiphorst include experiments in choreographical composition and movement notation, together with e.g. Merce Cunningham, and archival projects. *'whisper'* incorporates the notion of 'future memory' – the project incorporates a living semantic data archive, making it possible to dynamically represent memories; the computational equivalent of precognition or electronically enhanced telepathy. This allows the devices and participants to anticipate potential future behaviors and state.

The panel discussion at the end of the program dealt with the large difference and the common issues between these presentations. Anne Nigten outlined a few crucial subjects of this day - the importance of domain-specificity as touched upon by Arnold Smeulders; the meaning of objects; the notion of subjectivity, which returned in one way or another in several presentations. There was some discussion about the importance of authority and leadership within archives, where most panelists took a different stance, but the need for at least preparatory data analysis was commonly clear. Next, the issue of contextualization was mentioned as one of the attributes necessary for introducing meaning into a system. In the Nybble engine, contextualization is a spontaneous process; Ben Schouten referred to the need for communication as a guiding principle and a necessity for the creation of context, also being less authorative than mere leadership.

Finally, the topic of self-organizing systems, mentioned by many of the speakers, was discussed.

Ben Schouten

http://www.cwi.nl/~bens/

How much information?

http://www.sims.berkeley.edu/how-much-info/

'Polar' (CAST / ARTLAB10)

http://www.canon.co.jp/cast/artlab/artlab10/

Margarete Jahrmann's Nybble Engine

http://www.climax.at/nybble-engine/

Arnold Smeulders

http://carol.wins.uva.nl/~smeulder/

Thecla Schiphorst: *'whisper'*

http://lab.v2.nl/projects/*'whisper'*.html

7.2. *Data Perception* reader (part of)

March 1st 2003 ,13:00 - 17:00

V2_Groundfloor, Rotterdam

Short description by Anne Nigten

As we become more immersed in our digital environment, it occurs that data that are more significant can not be seen as neutral entities. A cultural, physical, intellectual, scientific, evolution has been set in motion changing our (digital) perception drastically. This change of perception is perhaps one of the subtlest, yet central questions confronting us today by reflecting our immersed behaviour in abstract and distributed spaces. A small subset of modalities crucial to our experiences is related to navigation, retrieval and perception. The future mastery (navigation / retrieval / perception) and knitting of these modalities or qualities into a single experience is likely to change our 'Data Perception', in the larger sense of the word, irrevocably. *Data Perception* tries to get a grip on some parts of this very diverse impact such as that upon 2, 2.5, 3 dimensional environments, dynamic or static information, familiar geometries or abstract topologies, mapping data spaces or assigning metadata. This all together generates a pressing need to exchange ideas and be cognizant of the role of the artist in questioning, in shifting paradigms, and leading the way into new representations and their readings.

Data Perception addresses these issues directly by bringing together diverse speakers in a participatory half-day workshop. Speakers will present and demonstrate their own project specific requirements and solutions. These solutions have, more often than not, been driven by the nature of the data itself. The participatory nature of the workshop will be set early by giving (non-technical) overviews to current scientific and artistic activity in the field. This workshop aims to foster discussion and exchange among specialists from different disciplines and backgrounds.

Background Information

The seminar tries to get a grip on how we perceive information. Although this is a rather large area for a one afternoon seminar, it seems relevant to start discussing *Data Perception* due to the increasing importance of mediated experiences in our daily life, where we have to interface a dynamic augmented reality built from elements of both the physical and synthetic worlds.

Data Perception will emphasize knowledge integration from different domains, or to phrase if after the DEAF 03 theme; this event will be a knowledge knitting session, which could foster new ideas through exchange of concepts. *Data Perception* will deal with the aspects of our perception where mathematics, art, design and information visualisation meet. It should be stated that the deliberate choice has been made to focus on the visual aspects of perception in this event, however the importance of other sensory experiences essential for perception are fully acknowledged.

On could deduce from the references given in the speaker's papers that narrowing down the domain would eliminate the cross-disciplinary approach aimed for. We are dealing not only with a large array of disciplinary backgrounds but also with very different types of data in the field of visualisation: varying from statistical graphics, thematic cartography and social dynamics. From several discussions preceding this seminar, some meta-issues could be distinguished including navigation, retrieval and interaction as key elements of perception. Investigating these topics brings forward an important question: how do our experiences in synthetic environments relate to those in the physical environment? Which parts of our physical perception are useful to take into account when interacting with abstracted data bodies and which new perceptual aspects are to be added? How does the representation of live physical or 'real-live' events influence perception in the virtual world?

Perception and abstraction in 2D and 3D

Metaphoric environments or representations of the physical world has, in the last decades, served to bridge the two realities and create forms of data spaces to which we can adapt easily. However, as we explore the possibilities of synthetic and networked environments and take into account its specific characteristics, metaphors become insufficient. The ocean-like feeling generated by endless data spaces brings about yet another set of navigation and retrieval obstacles unknown from representations. Navigation was a topic of discussion in the design process of the Data Cloud developed by V2_ in collaboration with ArchiNed. This environment had no equivalent in physical reality. A deliberate choice had been made to represent the information (the objects inserted by the users) in a non-hierarchical way. One of the key questions here was: which design methods and routines are comprehensible for navigating abstract multi dimensional information spaces? Here augmented aspects of perception come into play. When leaving behind (often limiting) metaphors one seems to run into trouble figuring out good navigation techniques enabling the user/ participant to move around in a 'fluid' or 'natural' way. The *'Promenade'* project created by Márton Fernezelyi and Zoltán Szegedy-Maszák from C3, shows us interface solutions for mixed realties, the visitor navigates the environment by physical movement in a 'tracked' space. The two realties are interfaced in a three dimensional way. The navigation of the participant in the physical space is here taken as a parameter for building or enriching the synthetic environment. Sheelagh Carpendale has been working on solutions for navigation and retrieval in information spaces. Her lenses, which include searching techniques such as zooming, are striking in their elegance. Using two-dimensional techniques to achieve a semi 3D effect, her work is interesting in that it works around the tedious aspects of navigating 3D abstract spaces.

Interesting but for which purpose?

The type of information and the goal to be achieved needs to be taken into account while comparing the very different types of work presented. Nevertheless, while we want it all, the immersive effect as well as the aesthetics should not be overlooked. This all should be taken into account while comparing the artistic work and scientific research projects included in this event. In his scientific work Ben Schouten has researched several very specific search and retrieval methods. Here the user profile has been very specific. His thesis shows a user interested in the content, as well as the approach the makers of the application take towards the content retrieval. The research shows that content can be retrieved in a very precise and iterative way. But this also brings along questions; what happens with a user who would like to look and retrieve the stored information from a very different field of interest, not implemented and thus not supported by the makers (researchers, developers)? What do proof of concept, generation of specific artistic or cultural experience or communication of an idea have to do with the renewal of perception? Which elements are most interesting in understanding the way we perceive information dealing with augmented realties?

Context and interaction

The context regarding the domain as well as the relations between the objects seems crucial. For search and retrieval we're getting used to the flexibility offered by (object oriented) database driven applications. Based on their metadata tags, objects can be re-organised following the user's interest. Clustering mechanisms and patterns for re-organization of information are subject of research, to enable the visitor to filter out the noise in huge information repositories. This approach serves well for pre-defined content. The contexts and relationships of information become unpredictable in a virtual environment in which the user becomes participant, and thus actively involved in the environment's (co-)creation process. The freedom provided in these 'open' environments depends on the purpose of the application; its participants create the richness, the design and the content. Like the series of Data Cloud projects by V2_ , the '*Demedusator*' project by C3 is such a shared virtual world, developed by its visitors. These types of environments are built from more than just content and its metadata; social patterns and interaction patterns are often used as parameters for visualizing the connections and dynamics of the virtual environment. The visualization of chat postings showing some parallels with Warren Sack's work can be read in Annie Tat and Sheelagh Carpendale's "Visualizing Human Dialog". Their work is focused on dynamic visualization based on social and linguistic analysis. This is partly implemented in the Code Zebra project by Sara Diamond, her team in which moderated dialogues, and discussions are analysed. From these parameters animal patterns are generated which correspond to the 'moods' or characteristics of the posting. Another way to look at interaction as main parameters for visualization and feedback can be experienced in the '*whisper*' project by Thecla Schiphorst, Susan Kozel and their team. In '*whisper*', Julie Tolmie applies her visual notation research to abstract spaces which are based on non-linguistic expression methodologies taken from mathematics, physics, visual art and performing art. Using parameters taken from the body, positions in space are used for creating social or interaction maps. Besides visualization, these maps also include sound and bio feedback (via small devices attached to the body) triggered by the same social and bodily parameters.

Code Zebra and '*whisper*' explore new interaction patterns, which differ from task driven interaction design. The systems learn from the personal involvement of the audience and the central position of the participant becomes a key factor in achieving engagement and truly immersive experiences. Open environments, including their unpredictable outcome, bring us new insights, new user interaction interpretations and ultimately, new perception.

Info on this event and the festival can be found at:

http://deaf.v2.nl/deaf/03/archive/node/Event/show.py?nodenr=145540&frame=1&domain=deaf03

http://deaf.v2.nl/deaf/03/festival/dataperception/

7.2.1. An introduction on *Data Perception* by Julie Tolmie

Visualisation, navigation, and mathematical perception: a visual notation for rational numbers

Julie Tolmie

In *'Data Perception'*, the principal duality we encounter is that of the immediacy of the image. Specifically, it is often said that 'visual meanings are relatively non-hierarchical and immediate' (Michael Punt in '*Anarchives: Connection Machines*' reader), but in the field of data perception are we not explicitly questioning this notion? Are we not explicitly trying to encode 'meaning' or extract 'meaning' from data we perceive through our senses?

The fact that we do this with highly varying levels of knowledge of what this sensory experience is supposed to represent, and how it has been selected and encoded, complicates the question considerably.

Furthermore, we rely on our respective discipline specific frameworks and representations to discuss what we 'see' beyond 'immediacy'. These frameworks and representations are not neutral. They do not translate directly from one to another.

Part of the exchange on *Data Perception* would seem to be some critical analysis on just what we are being presented with, along with an attempt to fly with, and harness, the unexpected.

How much of the mathematics does the individual want to know? Are they prepared to engage with the conceptual model, the algorithmic details, or the shortcomings of its projected 2D or 3D representations? And how much is the scientist / mathematician prepared to let go of what they think they are seeing (or should be seeing) and 'feel' their way, immersed in the information object which is created?

The next big question centers on just how conservative we are with representations, and just how young this field and its evolving environments are. It took 300 years from the beginnings of a spatial notation for (western) music until the beginnings of a notation for rhythm. It was artists who challenged musical conventions and brought about these developments...

Musical notation is a human construct. It's symbols and their meanings are learned. Widespread conventions for human recognition of specialised visual objects, visual processes, visual gesture inputs, visual navigable information repositories with zoom, filter etc. and / or machine recognition of all of the above, in short, conventions for *'Data Perception'*, are likely to take just as long to develop on a relative timescale - especially since they would challenge the immediacy of the image by encoding many layers of sophisticated intertwined representation that would need to be acquired or learned, whether by human or machine.

Compress 300 years to 50. Imagine that we have an integrated environment with far more subtle mappings than straight data analysis /

visualization. How would you as artists challenge the current operational metaphors? Can you contextualise your current work as part of such an integrated perceptual environment? What have been the key factors or domain specific issues in the narrowed problem you have solved? Would user driven multiple modalities in an integrated perceptual environment enable a significant change or widening of your approach? If not, why not?

7.2.2. *Data Perception* Day schedule

March 1st 2003, 13:00 / 1 PM - 17:00 / 5 PM

Location: V2_ groundfloor, Eendrachtsstraat 10, Rotterdam

7.2.3. Presentation by Sheelagh Carpendale

Visualising Human Dialog and Developing a Probe for Exploring 3D Data Representations Presentation by Sheelagh Carpendale

We live in a time of rapid advances in available CPU power and memory. However, the common sizes of our computational display spaces have only minimally increased or, as in the case of hand held devices, actually decreased. Making effective use of the available display space, or the screen real estate problem, has long been a fundamental issue in information visualization. I consider this problem to have two components: representation and presentation.

Representation is the act of creating a basic image that corresponds to the information, such as creating a drawing of a graph. Presentation is the act of displaying this image in a way that emphasizes and organizes areas of interest. For example, a map (the representation) of the city in which one lives may be presented with one's route to work magnified to reveal street names.

This distinction is important because it has allowed me to investigate presentation space independent of specific representations and has resulted in the development a generalised framework, *'EPS'* (Elastic Presentation Space). *'EPS'* provides a way of relating previous seemingly distinct presentation methods, facilitating the inclusion of more than one presentation method in a single interface.

This framework is unique because it encompasses many previous presentation techniques and introduces a broad range of new ones. Initial work with *'EPS'* focused on using various techniques to adjust 2D representations, providing detail while maintaining context. The concepts developed in EPF have proven to be extensible to three-dimensional data representations. This involves methods of providing access to the internal or obscured regions of 3D layouts while maintaining the spatial context of the complete representation.

7.2.4. Presentation by Ben Schouten

The Exploration of Visual Information by Visual Means by Ben Schouten.
(see also 7.1.2. reader *Anarchives: Connection Machines*)

Ben Schouten's thesis, 'Giving eyes to ICT - How does a computer recognize a cow?' is available for download from http://deaf.v2.nl/deaf/03/festival/dataperception/

7.2.5. Presentation by Zoltán Szegedy-Maszák and Fernezelyi Márton

'Promenade' and 'Demedusator'

Zoltán Szegedy-Maszák and Fernezelyi Márton

In the presentation we focus on the issues of real time VR visualization, and user-interaction design. By presenting some projects realised during the past five years, we intend to point out the important changes in interaction and perception, dramatically changing our paradigms of information spaces.

The on-line project, *'Demedusator'* from 1998 is a virtual world developed by its visitors. From the visitors' point of view, it is an interactive VR space to be inhabited by their own uploaded multimedia files. From the technical point of view, *'Demedusator'* is a visualization of an open database, where any user can place multimedia objects, along with their additional metadata-informations, descriptions. In this project the dynamically generated VR space is the interface and the visualization of the database at the same time.

From 1999 our interest has turned towards immersive VR installations, and to the development of user interfaces suitable for exhibitions. The technical development of the wireless 3Dpos position tracker opened a wide range of new possibilities, but also posed many important questions in terms of interaction- and visual design. New methods in real time 3D visualizations like Augmented Reality are dramatically shifting the paradigms of content-rich and well-organised information spaces from traditional, (hyper)textual (meta)data-structures towards context-sensitive systems.

'Demedusator'

'Demedusator' is a shared virtual world developed by its visitors. Any creative participant can "publish" his/her creatures - be it a complete virtual world or sound, movie, picture - by placing them in a 3D world explorable by any (Web)surfer. People can reflect on the existing content by uploading something near them, or they can create "a village of their own" by uploading its parts as contents placed in the same 3D area. The infinite container-space of *'DEMEDUSATOR'* is ready to be inhabited: any pioneer can find an unsettled space-segment for his/her new virtual home.

The spatial location of the contents creates an evident link between them: objects in the same space-segment create the context for their neighbours. The aim of *'DEMEDUSATOR'* is to enhance this simple "link-catalizing" nature of the 3D world: the newer versions of the system will provide multiple ways for the authors to create various types of links between the contents, and the ability for viewers to browse only the related objects by downloading subsets of the entire *'DEMEDUSATOR'* world (worlds which consist only of the linked content, regardless of their original location).

The "interface" of the multimedia publication is the Cryptogram-system: *'DEMEDUSATOR'* enables the users to add their parts to the VRML scene, but the uploaded files (first) appear to the observers in the form of encrypted sculptures (Cryptograms). The original content can be decrypted (viewed) by touching the silent objects. The system of the Cryptogram-encryption offers a way to explore the world without necessitating the downloading of all multimedia files initially: visitors can browse the context and decrypt the desired content of other linked objects.

In 1945, an engineer named Vannevar Bush published an essay entitled "As we may think", in which he presciently described a machine (the MEMEX) that is generally regarded as the literal blueprint for the Net and the World Wide Web. The "infostructure" Bush sketched out - including a proposal for what is now known as hypertext - was destined to be realised in what we now know as the Internet. But the vision Bush described is far more sophisticated than what we call today "Web": MEMEX, the virtual computer, is a container able to handle any kind of information (we could say "multimedia data"), and provides a very complex and customizable "linking system" with various "trails", created by the users. The browsers of the 1990s lack many of the linking features of MEMEX: for example those open and customizable "trails" that are nearly impossible to implement using basic HTML.

'DEMEDUSATOR' recalls these questions: the explorable 3D world is based on a database which ke*'EPS'* track over the uploaded files, their locations, links, trails and attributes. The VRML file received by the visitors is

generated from these well-organised data, offering the possibility to download subsets of the entire world: objects far from each other in their 3D locations, but bound to each other by links/trails can be embedded in a "subset-world", where the related pieces of information are located next to each other.

7.2.6. Presentation by Brigit Lichtenegger

Perception of 3-d and 2-d visualizations for virtual environments: 'DataCloud' and Amicitia

Brigit Lichtenegger

These days we have to deal with large amounts of data. We have high bandwidth and high capacity hard disks. In a couple of minutes we download an entire library, but then what? A picture tells us more than a 1000 words. How can we make use of the natural abilities of the human eye and brain to focus, zoom and recognize patterns? How can we present these large amounts of data in a way that is attractive, fun and meaningful?!

V2_ will present 2 projects, *'DataCloud'* and Amicitia. *'DataCloud'* is a 3D collaborative information environment. Users can add different media objects, which are related to each other by their metadata. The entire underlying database is visualised in a so called object space. Depending on the user's interest the cloud can be reorganised so that objects that have a lot in common will be closer to each other than less related objects.

Amicitia is a 2D web interface to the archives of several European content providers. It presents search results by placing the keyframes representing the videos in a spiral pattern, called Phyllotaxis. The keyframes in the middle match the query better than the ones on the outer circles.

Both projects are internet applications for the common PC user. This automatically implies a set of limitations concerning bandwidth usage, input devices (mouse and keyboard), and output device (a regular monitor). Furthermore, both applications allow users to add objects, giving these environments the ability to expand.

Though the 3D object space of *'DataCloud'*2 is an abstract space (no horizon, no shadows), it makes use of 'normal' human navigational skills. For example, you see more detail in an object that is close to you. Looking at this object from a greater distance will give more information of it's relation to the environment. Furthermore, you can see what's 'behind' an object. However, the use of 'distance' also brings complications with it. Visual as well as navigational. Users require different means of navigation across variable distances, while perspective also may hide information from vision. Furthermore, the environment might me mapped into 3D space, but how 3D is it really when it's projected onto a 2D screen (2.5D)? To map the keyframes in the Amicitia object space the Phyllotaxis algorithm was used. This algorithm is based on plant growth patterns and it makes sure that the keyframes are always distributed on the screen in an attractive manner. It ensures that the entire screen is used and that the keyframes are always equally spaced, whether there are 2 or 1000 objects.

Brigit will demonstrate the solutions, as well as the complications encountered while developing these projects. The main focus will be on the difference between 2D and 3D interfaces.

Dataviews and 'DataCloud's

This presentation was a part of panel 2 ('Knowledge Visualization: Methods and Technologies for Representing Knowledge') of the experts' workshop 'Perspectives on Networked Knowledge Spaces', organised by MARS media lab in 2002. The full text has been reduced to include only *'DataCloud'* 2 and Amicitia.

Introduction

In this text, two V2_Lab projects will be briefly introduced and the different mapping algorithms used in these projects will be described in more detail. The user interfaces developed within the projects are different in nature, but have in common that they all disclose a complex content set.

In the *'DataCloud'* 2.0 prototype, 363 media objects (images and texts) are represented as spheres in a 3D constellation, a 'cloud'. The user can 'fly' through this cloud and open the media objects by clicking on them. The way in which objects are positioned in the cloud can be reorganised.

The Amicitia prototype enables its users to find video fragments in a predefined archive created by four European broadcast organizations. Search results are presented as key frames in a spiral pattern. Users can store video fragments in their personal collections and arrange them in storylines.

'DataCloud' 2.0

http://'*DataCloud*'2.v2.nl

The aim of the *'DataCloud'* project is to create a virtual environment that can be used to facilitate discussion and knowledge exchange around a specific theme. *'DataCloud'* 2.0 is an information space containing a vast collection of media objects. Each media object is of a specific type - image, video, text, 3D model, sound file - and has its own characteristics. These characteristics (meta-data) are used for organizing and querying the information space. Users perceive the entire information space as a 'cloud' through which they can 'fly' and which they can reorganize as desired. After an examination of their meta-data, objects in the cloud can be viewed and added to personal collections and storylines. Authorised users can add and edit objects. This functionality makes *'DataCloud'* 2.0 an effective information tool that can support a community. The technical framework on which *'DataCloud'* 2.0 is based will eventually be published as open source software. It can therefore be used by other organizations and for other purposes.

3D mapping: 2D elastic network mapped onto an invisible sphere

The mapping mechanism used in *'DataCloud'* 2.0 was developed from a 2D elastic mapping algorithm created by Gerald de Jong. (http://www.beautifulcode.nl) This algorithm has been adapted and projected onto an invisible 3D sphere.

Initially, all objects in the database are presented as virtual spheres and spread equally over a 2D canvas. The algorithm then adapts the distance of every object to every other object in a number of iterations. (about 10,000 iterations are used) The attraction or repulsion factor is a mix of different factors:

use of similar words in the 'title', 'description' or 'free keyword' fields of both objects;
use of similar words in the 'obligatory keyword' field of both objects;
whether both objects have the same creator or owner;
whether both objects have been created on the same date;
whether both objects have been put in the database on the same date;
whether both objects have the same 'section' (a section is like a directory);
a random factor.

For every object pair, the attraction or repulsion factor has been precalculated and stored in the database.

When the *'DataCloud'* 2.0 starts up, the reorganization algorithm is executed with no objects selected and with the default mix of factors. The result of this reorganization is a pretty homogeneous constellation of spheres in the form of a 3D arc.

If the user executes a search, the objects that contain the search word(s) in their 'title' field are highlighted in yellow. If the user executes reorganization after this, the user can influence the mix of factors used in the reorganization algorithm and the cloud will be reorganised around the highlighted objects. The result of this reorganization varies a lot. Different constellations are generated and the highlighted objects are placed in the centre of the cloud.

The mapping algorithm used in *'DataCloud'* 2.0 is already a big improvement on the 2D mapping algorithm used in *'DataCloud'* 1, 'DataWolk Hoeksche Waard'. However, there are some problematic issues in *'DataCloud'* 2.0:

Scalability

Currently the *'DataCloud'* 2.0 demo contains 363 objects, and these objects are all presented as spheres in a cloud that is built with Java3D technology. Some performance tuning has been done, but still a pretty fast PC is needed to interact smoothly with the cloud. What will happen with much larger clouds is currently unclear.

Occlusion and disorientation

The *'DataCloud'* 2.0 features a true 3D cloud that is made viewable using a 2D screen, and users interact with it using a regular mouse. Because of this, navigation and viewing is not as smooth by far as they would be in a real-world setting. Two aspects are particularly troublesome: users get disoriented if they zoom into the cloud too deeply, and quite often objects are hidden behind other objects, particularly after reorganizations.

Little variation in metadata

'DataCloud' 2.0 uses the content of the project 'Genetics of the Wild City' by Stealth Group. In this project, urban city planning in Belgrade, or rather the lack thereof, was researched, modeled and documented. Only two people entered the entire database of objects in a few days and only 3 sections were used. Further more, a lot of objects have keywords in common. This makes for a cloud that does not have much variation and thus appears pretty 'flat'.

In short, the use of a true 3D cloud of data objects, although promising, has some downsides. In the current *'DataCloud'* 2.0 prototype the most problematic issues are performance, disorientation and a simplified reorganization algorithm. However, the *'DataCloud'* is a long-term project and these issues will be addressed in the future.

Amicitia
http://lab.v2.nl/projects/amicitia.html

As a cooperation between NAA, ORF, BBC and SWR, Amicitia is aimed at disclosing the European audiovisual archives and making possible a workable digital archiving of television and video content. In Amicitia the different European archives are being centralised and made digitally accessible for professional users and eventually for the general public as well. The V2_Lab is responsible for the development of the user interface, focusing on an associative and intuitive search and retrieval of audiovisual material. An innovative hybrid media interface enabling the user to create personal story lines from news items from different sources.

2D mapping: Phyllotaxis spiral algorithm

The Amicitia Public Web Access interface was developed after *'DataCloud'* 2.0 was finalised. For the development of Amicitia a prototyping tool (Macromedia Director) was used, as opposed to *'DataCloud'* 2.0s 'real programming languages' Java and Java3D. This allowed for quick development of a prototype with a lot of functionalities: advanced search, video player, personal collection and storyline.

For Amicitia the 'true 3D' approach was abandoned because of the problematic issues mentioned earlier, and because of the different nature of the Amicitia project: it was a demonstrator project, not an open source data visualization tool. After quite some research the phyllotaxis algorithm was found to be an interesting alternative. This algorithm, based on plant growth patterns (http://www.math.smith.edu/~phyllo/) had apparently not been used anywhere in a user interface.

The phyllotaxis algorithm constructs a set of spirals based on the Fibonacci number sequence. The Fibonacci sequence is 0, 1, 1, 2, 3, 5, 8, 13, ... (add the last two to get the next). This means the 'anchor points' on every spiral are at a predefined location, and this principle can be used as a coordinate system.

The spiral set can contain any number of spirals, so basically an infinite number of linear axes can be used. Left-turning spirals do not touch each other, and right-turning spirals do not touch each other. If both left- and right-turning spirals are used, these spirals cross one another at certain locations, which could have a certain conceptual meaning. This is an aspect to the phyllotaxis that is not used in the Amicitia prototype.

Basically, the phyllotaxis algorithm in the Amicitia prototype is used to present a variable number of search results (keyframe images) on a predefined 2D canvas in a nice-looking spiral form. Better search matches are closer to the center of the spiral, and less relevant matches are further away. If there are only a few matches, bigger keyframe images are presented (the spiral appears to be zoomed in), and if there are a great number of matches, the keyframes presented are smaller. (the spiral appears to be zoomed out) If the number of search matches outnumbers 100, the matches are split over spirals with 100 keyframes.

All keyframes in a spiral are of the same size; transparency is used to enable the user to see the individual keyframes, which overlap slightly in the spiral. Rolling over a keyframe gives it 0% transparency and enables the user to click and get a menu with manipulation options.

In short, the phyllotaxis algorithm provides a scalable visual presentation method with no occlusion, which optimizes the size of preview images on a canvas, and looks nice and inviting to use.

Conclusion

Hopefully this text inspires the reader to start researching and creating new data visualization methods and user interfaces that make use of these methods. Different methods are appropriate for different purposes. To keep updated on the data visualization efforts in the V2_Lab, be sure to check the V2_Lab website regularly: http://lab.v2.nl

7.2.7. Report on *Data Perception* by Rens Frommé

The Notational Shift from a linear-text-based to a three-dimensional-spatial way of Data Perception
Rens Frommé

Workshop
Data Perception March 05th 2003

The ways we communicate and express ourselves in music, arts and science is very much dependent on the formal languages in use. For monks in the 11th century, their formal language, music, was associated to the linguisitic structure of the phrase sung to God. Throughout the twelfth, thirteenth, and fourteenth centuries the mechanics of notation were in a state of rapid change, produced and paralleled by an evolution in musical style, the progress of which lies mainly in the field of rhythm. This resulted in the intricate rhythmic structures of the School of the Notre Dame of the 14th century, where music was composed by the calculated partitioning of its time dimension. This mathematical, representational system could not have been understood, or even imagined by the monks of the 11th century. Julie Tolmie, one of the leading scientists in the emerging field of data visualization, used this historical analogue in her introduction of the workshop *Data Perception* to show that we are on a similar treshold. According to Tolmie we are currently, in the mastery of the new visual notation space, closer to the monks of the 11th century than to the School of the Notre Dame.

Just like musical notation, *Data Perception* is a human, cultural construct. We recognize the possibilities of percieving data, by reflecting our immersed behavior in abstract and distributed spaces, but we don"t even begin to understand the consequences. A small subset of modalities crucial to our experiences is related to navigation, retrieval and perception. The future mastery and knitting of these modalities or qualities into a single informative experience is likely to change our '*Data Perception*'. It took 300 years from the beginnings of a spatial notation for western music untill the beginnings of a notation for rhythm. Conventions for *Data Perception* are likely to take just as long to develop on a relative timescale -- especially since they would challenge the immediacy of the image by encoding many layers of sophisticated intertwined representation that would need to be acquired or learned, whether by human or machine.

The workshop tried to grasp some parts of this notational shift and the impact it will have upon conventional techniques of visualizing information, such as 2, 2.5 and 3 dimensional environments, dynamic or static information, familiar geometries or abstract topologies, mapping data spaces or assigning metadata. Speakers presented their own creative solutions, mostly driven by the nature of data itself. The first step in the paradigm shift away from the traditional, linear text-based model of dealing with visual information was proposed by Ben Schouten.In his presentation, he addressed the urgent need for intelligent visual information retrieval systems. Most of the current systems are based upon the theoretical assumption that visual signification cannot be done without natural languages. This tendency in modern thought even received a special label "verbocentrism" -- for instance, while Roland Barthes stimulated the interest in visual semiotics with his pioneering articles published in the late 1950s and early 1960s, he simultaneously strongly questioned the possibility of an autonomous visual language.

In order to explore visual information by visual means, you first need to develop a system in which recognition has its place, according to Schouten. Image recognition is based on having seen something before. It relates an emotion, experience or visual input to an earlier event. Instead of using keywords to extract the meaning of an image, a more intelligent way of looking for simularities is required, based on visual features and concepts. To bridge the so-called "semantic gap", we could use new, interdisciplinairy approaches.

Sheelagh Carpendale, in her research, tried not to explore specific characteristics of data, but instead investigated presentation space independent of specific representations. Using the limitations of the available display space on a computer screen, she developed Elastic Presentation Space (*'EPS'*); a generalized framework to master different kinds of data through the inclusion of more than one presentation method in a single interface. *'EPS'* offers for example different lenses (round / square / fish-eye) to view or zoom into different kinds of data. The result is striking in its elegance; a stretchy information space which allows you to play around with different 2D and 3D representational techniques on for example, a geographical map. Scrolling over different areas resulted in different forms of magnification, providing detail, while maintaining the spatial context of the complete representation. Another interesting application allowed users to focus into 3D cubic graphs and disentwine relations/lines between nodes in the graph. These applications look very promising for disseminating and visualizing large amounts of various data and object-relational archives in a user-friendly way.

So, by using methaphors, *'EPS'* succeeds in bridging different contexts to create new forms of data spaces to which we can adapt easily. However, as we explore the possibilities of synthetic and networked environments and take into account its specific characteristics, metaphors become insufficient. The ocean-like feeling generated by endless data spaces brings about yet another set of navigation and retrieval obstacles unknown from traditional representations. The context and relations between the objects seem crucial here. However, in a virtual environment in which the user participates and is actively involved in the environment its co-creation process, these contextual parameters become unpredictable. These problems were adressed in the project presentations by V2_ and C3. Here, augmented aspects of perception come into play, indicating yet another phase in the shift towards new spatial information languages.

Brigit Lichtenegger of V2_ presented the project *'DataCloud'* 2, a 3D collaborative information environment. In *'DataCloud'* the user can add different media objects, which are related to each other by their metadata. The entire underlying database is visualised in a so-called object space. Depending on the user's interest the cloud can be reorganised so that objects that have a lot in common will be closer to each other than less related objects. Users require different means of navigation across variable distances, while perspective may also hide information from vision. *'DataCloud'* raised questions on how to incorporate (or expand on) human navigational skills in the navigation of the data space. *'DataCloud'* beautifully showed that new methods have to be developed in realtime 3D visualization, methods that are dramatically shifting the paradigms of content-rich and well-organised information spaces from traditional (meta)data structures towards context-sensitive systems.

Heralds of such context-sensitive systems were proposed by Márton Fernelezelyi and Zoltán Szegedy-Maszák from C3. Their *'Demedusator'* and *'Promenade'* projects showed interface solutions for mixed (data) realities, the visitor navigates the environment by physical movement in a "tracked" space. The two realities are interfaced in a threedimensional way. It first started as a web project, but soon developed into an installation with a stereoscopic projection to visualise the dataspace, in which objects could move dynamically. However, navigation turned out to be problematic for unexperienced users. To study and improve the collaboration between users, they are now working together with neuroscientists on a new project, called Camouflage, to develop an augmented reality experience.

Data Perception touched on a lot of promises and problems the young discipline of data visualization has to offer: the evolution of abstract notation systems, navigations through abstract 2D, 2,5D and 3D data spaces, the play of the mutable modalities in new media and technologies, the challenge of defining recognizable visual linguistic elements. The workshop showed that these topics are all intimately related. Encoding these interrelationships directly or indirectly into computer based environments is non-trivial, but already happening. Imagine that we have an integrated environment with far more subtle mappings than straight data analysis/visualization. How would artists then challenge the operational metaphors? Would user driven multiple modalities in an integrated perceptual environment enable a significant change in the cultural practice?

As Julie Tolmie showed in her presentation, conceptual and representational shifts in notation and thought often came out of the arts. The visual artifacts she presented, evolved from collaboration with mathematicians, with visual artists/performers and with those working in data perception/visualization. Only through communicating across the borders of each discipline, can we look beyond the linguistic constraints towards a visual language. So, as the untaught monks of this age, we all need to artistically play around with data, in order to acquire this new language.

7.3. Description of the *MediaKnitting* workshop

Short description of the *Media Knitting* workshop, led by Amy Franceschini (USA) and Guy Van Belle (B)

Collaboration between developers and artists from different disciplines often results in merged media or new media formats. *Media Knitting* is a three-day hands-on workshop for artists, engineers, and designers working with software to knit various media formats and applications together for live or real-time interactive performances. The scope of the media used for collaboration in *Media Knitting* will include video, streaming media, audio and 3D modelling. In this workshop thirty participants will work together to discover and patch each other's domains together by means of software and human interaction. Several experts will be brought in from the commercial software field for Mac and Windows as well as from the field of 'open source' and 'free software'. Among the software facilitated for this workshop are Max-MSp, Jitter, V2_Jam, PD, Blender, Cyclops, BigEye, gstreamer, Nato, MoB, FreeJ and Touch 101. Participants are encouraged to bring their own laptop and software as well. The participants and the workshop leaders will work together on the realisation of performances or media jam sessions. The end result of the workshop will be presented in an informal media concert open to the DEAF audience.

Documentation material can be found at:
http://deaf.v2.nl
http://mediaknitting.v2.nl/
http://www.v2.nl/Archive/V2Video/quicktime/mediaknitting/mediaknitting_T1.mov

Background information

Preparation and format of the workshop
Preceding the workshop there were several meetings with Guy van Belle, and online exchange with Amy Franceschini, we discussed several models for workshops encouraging people to work together. The model applied for *Media Knitting* was related to the Bauhaus model for collaboration. The workshop leaders intended to let the collaborations among the participants come into existence organically, while encouraging people to reconsider their personal methods and habits to explore new ways of working. There was no force put upon people to work together, also the workshop leaders were not instructed to pay special attention to certain workshop participants. The goal of this workshop was to explore new territory both in a technical as in a disciplinary way. The final presentation was a media jam, an informal presentation where the audience could walk in. This format was preferred from a formal presentation. A formal presentation often causes stress a less open attitude during the workshop, not wanting a

noncommittal attitude from the participants, there was decided a media jam could serve as an informal presentation to close down the workshop.

Selection of the proposals

The applicants for this workshop were selected after the following criteria:

The jury included representatives from different disciplines who reviewed the proposals in two rounds, the round focused on the quality of the work (knowledge and ideas) and the motivation for collaboration (expectations and intentions for the workshop)

The second review of the remaining proposals focused on the workshop constellation here the diversity of disciplines and gender represented was the main criteria.

The participants represented a broad range of disciplines, from visual arts, theatre, interaction design, audio art, soft- and hardware engineering, architecture, computer science etc.

7.4. Affective systems reader (part of)

Affective Systems
seminar 11 November, 15:00- 17:30

The seminar aims to give an idea of the state of the art in affective systems by presenting both theoretical and experimental results from different disciplines, and by having a moderated discussion with the authors/creators and the audience about the assumptions, ambitions and approaches that underpin the work.

Researchers and experimenters in various disciplines are trying to equip machines with some understanding of subtext and context of interaction, rather than only literal commands and feedback. This requires the machine to be able to perceive and reason about emotional cues in human interaction, as in intonation, facial expression and body language, and to form expectations of how its own behavior might affect the human. Conversely, given an adequate internal representation for that purpose, machines could perhaps be made to express emotions in and of themselves. Would such efforts really help improve the quality of human-machine interaction? And could similar techniques be applied in other areas, such as simulation experiments in the social sciences, or synthetic character and narrative generation in the interactive arts?

7.4.1. Presentation by Phoebe Sengers

http://www.cs.cornell.edu/people/sengers/

Phoebe Sengers is a computer scientist and a cultural theorist. Her work practice is one of reflective design. Sengers is a faculty member in the new Information Science program at Cornell, part of the Faculty of Computing and Information, with a joint appointment with Science & Technology Studies. From 1999-2001, she did research in agents, avatars, virtual environments, and computer graphics in the Media Arts Research Studies group at the GMD Institute for Media ommunication in Bonn, Germany. She has been active in the Narrative Intelligence research community. In 1998-1999, Phoebe was a Fulbright Guest Researcher at the Center for Art and Media Technology (ZKM) in Karlsruhe, Germany.

EXPERIENCE AS INTERPRETATION

[This is an abridged version of a paper by Phoebe Sengers, Kirsten Boehner, Geri Gay, Joseph "Jofish" Kaye, Michael Mateas, Bill Gaver, and Kristina Höök]

Dealing with complexities of change

As Wright & McCarthy [1] argue, theories, categories, and models of human experience used in Human-Computer Interaction (H.C.I.) by necessity abstract from users' lived experiences, often inadvertently losing the details that make them rich, relevant and personally meaningful.

They point out, for example *that*, while we can speak of and program for an abstract category of frustration, the user's actual lived experience of frustration with a two-timing lover will in many essential details differ markedly from frustration because a software package has crashed again - and these are precisely the kinds of details that make up rich and meaningful experiences for people. While formal models can offer useful guidelines, we can be seduced into confusing formal model for lived experience.

Affective computing is one area in which H.C.I. has already developed approaches for allowing computers to address a wider range of human experence. Picard [2] and colleagues in intelligent systems research argue that models divorcing reason, a computational construct, and emotion, a seemingly non-computational construct, are untenable and ineffective, not only because cognitive science is demonstrating that reason itself has an emotional component [3], but also because emotion is an essential part of human experience of computing, and must therefore be considered in H.C.I..

Much of the work in affective computing focuses on ways in which computers can become aware of and reason about human emotional states (e.g. [2, 4, 5, 6]). These theories often are subject to Wright & McCarthy's critique of formal H.C.I. approaches to experience, by abstracting away from people's lived experiences, focusing instead on emotion as an abstract informational unit. In communication between computers and people, emotion is encoded , transmitted, and decoded.

A possible alternative approach to affective computing draws on the numerous challenges and revisions of the delivery-based communication models that propose a counter view of communication as one where meaning is co-constructed. The communication of emotion may be portrayed not as a discrete state being transferred between sender and receiver but as a process of coordinating meaning. Based on this insight, in our own work we seek primarily not to identify emotional states but to draw the user's attention to the indicators and subsequent inferences made about emotions. Rather than creating a black box system that senses indicators and uses refined algorithms to present the resulting emotion or to pronounce the perceived emotion back to the user, in our work, designers draw the user into the sensing and inference process. Processes of detection and inference about experiences are, then, collaborative between user and system. We strive to make the user critically aware of what indicators are available for interpretation, how these indicators are interpreted, and the resulting effects of this interpretation.

By focusing on emotion as experience, we are able to fish with a wider net in the sea of human experience. While current affective computing is necessarily based on formal models of emotions such as that of Ortony, Clore, and Collins [5], in our work, we are also address fuzzier and more ambiguous human-related emotion-like experiences such as 'moods' or 'vibes.' At the same time, shifting to a constructed, interpretive notion of emotion leads to a set of new research questions around emotions or moods in social relationships. How do groups of users experience one another's moods or a collective mood? What role can interactive systems play in helping groups or pairs of users in coordinating senses of each other's emotions?

Experience as interpretation

User experience, in this model, cannot be understood without reference to interpretation. We understand user interpretation as the process by which people use meaning-making to make experiences real for them in their own lives. In particular, we are interested in how users create experiences of complex technical systems. User interpretation is currently of interest in the user experience community, since analyzing how users come to understand and relate to technical systems can allow them to be built more effectively. It is also a topic of discussion in the critical design community, which asks a different set of questions: what messages are implicit in our designs? How do users reappropriate and alter the meaning of technologies? What are our social responsibilities as designers with respect to how users come to interpret and respond to our designs? (e.g. [7, 8]). Finally, it is an important topic in Science & Technology Studies, which seeks to understand and document the interpretive flexibility of technologies, or the ways in which users reappropriate and give new meanings and definitions to technology in practice (e.g. [9]). We are interested in all of these issues, and particularly in developing a dialogue around interpretation between these communities. We are particularly interested in extending ideas from these literatures to systems with some AI capabilities, where the system is itself also engaging in some kind of interpretation of the user's behavior and/or generating complex behavior that needs to be dynamically interpreted.

The fundamental conundrum of design for interpretation on which all these communities agree is that, while technologies can suggest different interpretations, a particular interpretation is never guaranteed - it always depends on the context in which the technology is being interpreted and the often unexpected uses to which it is put. Gaver, Beaver & Benford [10] have suggested that a process of "co-interpretation" between designer, system, and user is perhaps the best way to understand how meaning occurs. In all these communities, there are serious theoretical and empirical questions around whether and to what extent meanings can be built into objects and how that might affect design practice in general and in H.C.I.. If we consider users to be flexibly coming up with their own interpretations, it becomes difficult to imagine how designers can create systems that reliably engage particularly kinds of experiences in somewhat foreseeable ways.

At the same time, considering user interpretation in the design process opens up new possibilities for adapting literary strategies to design practices to stimulate new interpretations of and experiences around systems. Gaver, Beaver, & Benford [10] argue, for example *that* we can and should design ambiguity explicitly into systems, for example to allow users to project their own meanings onto them. Exagerration can be used to raise issues around the underlying meaning of technology or simply to explore the design space. Defamiliarization, or taking objects out of context to assign new meaning to them, is another useful literary strategy for opening up the design space.

Similar possibilities arise from the use of Artificial Intelligence techniques that themselves actively interpret patterns of human activity and generate responses as a function of these interpretations. Such ambient intelligences are able to actively participate in human contexts, not by attempting to completely and formally model the context, but rather by participating in the context as a non-human subject engaged in the shared construction of meaning. Such systems become an "alien presence" which, through its idiosyncratic interpretations and responses, open unusual viewpoints onto everyday human activity, providing opportunities for contemplation..

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7.5. ***Wearable Turbulence*** **reader (part of)**

'Wearable Turbulence'

Seminar, November 10th 2004, 15:00 - 18:00

As wearable computing strives to infiltrate our daily lives, evidenced in current scientific research, on runways, and in the industry's undeniable obsession with mobility, we, the users, are trying to catch up with the hype. Is this new smart-wear empowering us, facilitating our daily tasks and helping us to improve our social communication skills? Or are we becoming more vulnerable and arguably more disembodied, as our insides are thrust onto the outside, and constant connectivity becomes the norm? What are the implications of translating, transmitting and accessing sensory data, emotions and instinct through wearable, technological intermediaries?

This seminar will examine the underlying struggle between the public and the private in the field of wearable computing, showing a variety of cutting-edge approaches to human-centered computing, and highlighting recent applications in context-aware computing and networked relationships. The seminar will also invite reflections on the reasons for and benefits of wearable technologies, and expectations for the near and far future.

Sha Xin Wei

http://www.lcc.gatech.edu/~xinwei/

Sha Xin Wei's practice ranges from collaboratively built responsive environments to gesturally nuanced sound and video media. These works explore how people create playful relations with one another in the presence of dense, continuously evolving responsive media. Since 1997, Sha Xin Wei has worked with the art research group, sponge, which he co-founded in San Francisco to produce public experiments in perception, phenomenology and desire.

Major projects include the TGarden play spaces, Hubbub public speech-painting, the Sauna urban immersion installations, and Membrane calligraphic video. Sha Xin Wei is now embarking on the Softwear Instruments project which explores how subjects emerge under fields of gesture in sensate, gestural, media-saturated fabrics and other active materials. Collaboratively and individually, Sha Xin Wei has exhibited event/installations in prominent experimental art venues including Ars Electronica Austria, V2 The Netherlands, Banff Canada, Future Physical United Kingdom, and Postmasters New York. These works have been recognized by awards by major cultural foundations such as the Daniel Langlois Foundation for Art, Science and Technology, the LEF Foundation, the Creative Work Fund in New York, and the Rockefeller Foundation.

Prof. Sha received A.B. and Ph.D. degrees in mathematics from Harvard and Stanford Universities, and taught computational media and critical studies of techno-science at Georgia Tech. He directs the Topological Media Lab, which he founded in 2001 to carry out art research in experimental phenomenology and technologies of performance. In 2004-2005, he is a Visiting Scholar at Harvard and MIT, writing about topological media.

Bradley Rhodes
http://www.bradleyrhodes.com

Dr. Bradley Rhodes (US) is a research scientist at Ricoh Innovations in California, specializing in intelligence augmentation, wearable & ubiquitous computing, software agents and "other things that make people smarter." He received his PhD in 2000 from the Software Agents group at the MIT Media Lab, where he was one of the early participants in the wearable computing project and designed an augmented-memory system called the Remembrance Agent. From 1996 to 2000 Bradley lived the life of a cyborg, integrating wearable computers into his daily life as a part of MIT's wearable computing "living experiment."

7.5.1. Christa Sommerer & Laurent Mignonneau

http://www.iamas.ac.jp/~christa/

Christa Sommerer (AT) and Laurent Mignonneau (FR) are internationally-renowned media artists working in the field of interactive computer installations. They currently work as researchers and artistic directors at the ATR Media Integration and Communications Research Lab in Kyoto, Japan and as Associate Professors at the IAMAS International Academy of Media Arts and Sciences in Gifu, Japan. They also hold a position of Visiting Research Fellows at MIT Center for Advanced Visual Studies in Boston USA.

Mignonneau and Sommerer have collaborated since 1992, and their interactive artworks have been called "epoch making" (Toshiharu Itoh, NTT-ICC museum) for pioneering the use of natural interfaces to create a new language of interactivity based on artificial life and evolutionary image processes. Their collaboration has been influenced by the combination of their different fields of interest, including art, biology, modern installation, performance, music, computer graphics and communication.

Mobile Feelings

© 2002-03, Christa SOMMERER & Laurent MIGNONNEAU
IAMAS Institute of Advanced Media Arts and Sciences, Gifu Japan in collaboration with France Telecom Studio Créatif, Paris

Background

Mobile phones have intruded our daily lives like hardly any other technology since the television and the desktop computer. While mobile phone users are generally glad to embrace the enormous advantages of being reachable any-time and any-where, a reduced sense of privacy combined with the involuntary witnessing of anonymous people's private businesses has created a strange and sometimes awkward form of self-awareness and attention towards others. Mobile phones have transformed ordinary people into actors who narrate their most private details on the theatrical stages of train stations, restaurants, public spaces, streets, meeting areas, and any other social gathering places.

Concept

"Mobile Feelings" is an artistic project that explores the ambivalence of sharing personal information with an anonymous audience. Instead of communication via voice or images to people we know, "Mobile Feelings" lets people communicate with strangers through virtual touch and body sensations including smell and sweat using specially designed mobile phones.

As opposed to application-based systems in the area of "affective computing" [1], "wearable computing" [2], "robotic user interfaces" [3] and tactile interfaces for handheld devices [4], "Mobile Feelings" aims to create unusual and unsettling sensations of sharing private body sensations with complete strangers over a mobile phone network.

Description

Users at the exhibition are provided with specially equipped "Mobile Feelings" phone devices. These devices host miniature bio-sensors and actuators that capture the users' heartbeat, blood volume pressure and pulse, skin conductivity, sweat and smell. All data can be sent to other anonymous users who can perceive and feel these most private sensations through actuators, vibrators, ventilators, micro-electromechanical and micro-bio-electrochemical systems which are also embedded in each "Mobile Feelings" device.

"Mobile Feelings" devices communicate with each other through a standard mobile phone network and users can move around freely to use their devices anywhere and anytime just like normal mobile phones.

Besides capturing and transmitting the various body data, the "Mobile Feelings" devices also display images of the other connected users. When a user touches her device and selects one of the displayed persons, she can receive this person's body sensations, through for example a tickle, a vibration, a small wind or humidity, a pulse, a push or a slight stroke, creating a strange and perhaps erotic ambiguity.

Mobile Art for Daily Life

"Mobile Feelings" works anywhere and anytime and the physical location of people becomes completely irrelevant.

"Mobile Feelings" proposes an art form is this not any more location- or context based but instead becomes integrated into people's daily lives.

"Mobile Feelings" is an artistic project that investigates how technology has transformed our social and individual lives [5] and how we have accepted a reduced sense of privacy in exchange for connectivity and mobility. The project also explores how the sense of "touch" still remains one of our most private sensations, which we often avoid to share with strangers [6] and still lack a concise language to describe [7].

Finally, "Mobile Feelings" explores novel forms of mobile communications that might as well include smell and sweat as more private ways of "feeling and communicating with each other over distance." In our aim to get media art off the walls and out into people's lives, "Mobile Feelings" presents another step towards the merging of art, life and society.

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7.5.2. Tom Donaldson

http://www.thisisclutch.com

Tom Donaldson is an engineer and inventor. He graduated from Cambridge with a Bachelors in Engineering and Masters in Information Theory. He has worked professionally creating new technologies for a wide variety of corporations. He set up and ran Escape Velocity, an artificial intelligence software company delivering deep personalisation to the mobile industry. He also launched Sessami, the UK's first mobile entertainment channel, nominated for a WAP award.

Medulla Intimata

Medulla Intimata is responsive video jewellery. Video displayed on a screen emebedded in the jewellery is generated in real-time in response to the wearer's emotional state by monitoring the dynamics of conversations in which they are engaged.

Medulla Intimata extends traditions of video portraiture. The source video is drawn from a database of self-portrait video clips of the wearer, with different imagery and visual styles reflicting different moods. The jewellery is individually designed for each wearer. The narrative of the piece, from how it interprets conversation through the moods that become the most important, to the generation of the output video, is all designed to reflect and interpret the wearer.

Medulla Intimata explores how video can be made more intimate by embedding it in objects that have rich symbolic and cultural associations. Jewellery plays a wide range of social roles, from signifying attachment (through wedding rings, for example), denoting wealth or class (diamonds and pearls, for example) to attraction and self-expression. The video screen in Medulla Intimata becomes a jewel, radiating colour and texture changes through the jewellery, changing the mood of the whole piece. From a distance, a viewer only sees a highly personal piece of jewellery. As they approach, they notice the video, and approaching closer still, the content of the video. As they enter into conversation with the wearer, they become aware that the video is responding to the their conversation, and begin to play with the piece while trying to maintain a natrual conversation with the wearer.

Medulla Intimata explores social performance. Every interaction in a social setting starts as a performance of selves, a formal dance of introduction and a search for expression. Medulla Intimata provides a medium in which to visualise this informal social performance, allowing the interactors to monitor and feed off their mutual performance, and others to act as sporadic audience.

Medulla Intimata is about vulnerability. It opens up the wearer to scrutiny and continual observation. It displays private responses in public, and it takes the audience along a journey right into the neuroses of the wearer, who must fight to maintain a normal social interaction while their body and mind is openly on display.

7.5.3. Kristina Andersen

http://www.lockergirl.com/

Kristina Andersen (DK/NL) works with interactions and concepts to create unusual objects, protocols and experiences using iterative processes informed by games and play. She holds an MA specializing in wearable computers, an M.Sc [distinction] specializing in tangible objects in virtual spaces, and was a research fellow at the Interaction Design Institute Ivrea (IT), where in collaboration with Margot Jacobs and Laura Polazzi she worked on the FARAWAY project. The latter researches and creates interactions using sensory and symbolic aspects of emotions in order to convey a sense of presence between people who are physically distant but emotionally close.

Other recent projects include *'whisper'*, in collaboration with Thecla Schiphorst and Suzan Kozel, where the emphasis lies on using physiological data as input for an audio-visual environment and responsive intelligent garments. She is currently artist in residence at STEIM (Studio for Electro-Instrumental Music) in Amsterdam working on 'ensemble', a set of sensor-based wearable musical controllers developed for musical experiences for children. She is mentor at dasarts and honorary visiting design fellow at the University of York.

Playing it out, Kristina Andersen

As we try to create wearable experiences that are indicating new and

different uses of our bodies, our clothes and our interaction with the other bodies around us, we have the choice to either just trust our own personal experience and desires or try to find ways to involve others in a collective dreaming of 'that which does not yet exist'.
In the following i will give some examples of ways and methods to do this with examples from the following projects: IF ONLY (with Laura Polazzi and Margot Jacobs), *'whisper'* (with Thecla Schiphorst, Susan Kozel and a large team) and 'ensemble'.

Casting a spell - playing a game

The IF ONLY project explores the emotions related to being emotionally close while physically distant and questions how we can access and collect these private and subjective aspects of human experience? IF ONLY uses games to create artificial contexts where people can engage themselves with real emotional involvement. The key concept is to use game play in order to engage and immerse the player both emotionally and logically. The games create a conceptual framework that sustains the players' suspension of disbelief as they immerse themselves into the idea. These frameworks can help support the player to express otherwise inaccessible emotional needs, to envision a possible future or alternative reality and to enable collaborative and situated concept development.
Casting the spell of a game involve allowing the player to choose to enter into a state of 'makebelieve', in order to play, one must believe in this alternative world as if it was the 'real' one.
This is dependent on the fact that the experience of the game is safely confined within the game space and does not necessarily have consequences in the outside world. By entering into playful and fantastic procedures, games can provide an alternative reality that allows people to let down their guard, access the unconscious, express how they feel and think and cross boundaries they might not have otherwise crossed.

Prototyping and learning from experience

A game creates a complete experience where we can try out how something might feel without everyday constraints. The same elements are found in theatre, magic and storytelling. Any one of these can be used to prototype an experience and they are in fact very similar methods.

The *'whisper'* project used theatrical effects to prototype how the experience of sharing body data would feel. Elements of the experience were investigated using very simple technique in the format of short theatre workshops. One workshop focussed on listening by giving participants earplugs and asking them what they could hear, while another used sewn together shirts to model the feeling of being connected to a stranger in an unfamiliar way. In this way an experience prototype is *'any kind of representation, in any medium that is designed to understand, explore or communicate what it might be like to engage with the product, space or system'[1].* It allows us to explore contextual, sensorial, physical and cognitive factors that define an active engagement into an interaction.

In a similar fashion 'ensemble' is a speculative project created to investigate how analogue sensors are perceived and understood through the emerging intuitions of children. The sensors are put in garments and given to children to play with. Through playing a game they know very well [dressing up] the children take control of the experience and figure out how things work and can be used on their own. Through their experiments i am learning how sensors on the body are perceived, how they feel and how precise they are.

It is becoming my experience that by playing on the threshold between the everyday and the unexpected we can find ourselves spaces where we can explore and play our way to the systems and objects we cannot yet imagine.

[1] Buchenau, M. and Fulton Suri, J. (2000).
"Experience Prototyping", Proc. of DIS , ACM, 2000

More information can be found here:
http://www.ifonly.org
http://www.clownsparkles.com
http://*'whisper'*.surrey.sfu.ca/why.html

7.5.4. Report on *Wearable Turbulence* by Remco La Rivière

November 13th, 2004

'Wearable Turbulence'

Review by Remco La Rivière

The first in a series of three seminars, *Wearable Turbulence*addressed questions that arise when computers become part of our garments or otherwise wearable. Bradley Rhodes, Christa Sommerer and Kristina Andersen each presented their views in a two hour session, moderated by Sha Xin Wei.

After having introduced the speakers, Wei proposed some relevant topics of discussion. For instance, Wei pointed out that terms like 'portability', 'ubiquity' and 'wearability' are significant for the field's vocabulary. All these terms are related to the whereabouts of technology, whereas 'ubiquity' in particular can also be thought of as an adjective of environment. Another interesting topic that Wei brought up, is the dichotomy 'inside' and 'outside' that takes on various forms. Think of indoor vs. outdoor, inside or outside the skin and public vs. private. A last topic Wei suggested concerned method. In the discourse of wearable computing, should we approach wearable computing from a design point of view, would art be an effective approach or is science the most reasonable method?

In their talks, the participants unfortunately didn't quite react to the topics Wei suggested, which doesn't mean a lot of other interesting things came up.

Bradley Rhodes elaborated on what it's like being a cyborg by refering to what he called 'lessons from the living experiment'. Part of this living experiment was Steve Mann, probably the most infamous cyborgs among all fellow cyborgs. Just like Wei, Rhodes thinks it's important to render intelligible the term 'wearable' itself. The question 'what is a wearable anyway' leads to partial definitions that include 'pocket or cloth based', 'constant access' or 'works without full attention'. The most important argument however, is that technologies should be an extension of the self, seamlessly integrated and augmenting the senses. The question about why we should wear technologies answers Rhodes by revealing the technologies' background. Wearable technologies are a solution in domains dealing with multitasking like medicine and military: they execute secondary and supporting tasks when one's brains, hands and other bodyparts are occupied.

Christa Sommerer created the work 'Mobile Feelings' together with Laurent Mignonneau in which they explore touching and breathing as novel ways of telecommunication to comment on the unwanted sharing of personal information that mobile telephony gave rise to. This is why Sommerer fundamentally disagreed with Rhodes; technology should be operated with full awareness and be less transparent. Also, she argues that there should be an option for switching it off, otherwise we tend to forget the presence of the technologies and get used to their controlability and traceability. In terms of design, 'Mobile Feelings' was designed from a uselessness point of view, thus preventing the technolgy to be used as surveillance technology.

The last participant of this seminar is Kristina Andersen whose work is oriented on notions of tangibility versus intangibility. In her work, she very much relies on the principle of 'the willing suspension of disbelief' and aims for a certain kind of experience prototyping. 'If only' is one of her projects that illustrates this very well. It examines what emotions are being experienced when people are emotionally close while physically distant. This implies that the project seeks to gain access to subjective and private experiences. In her project 'ensemble' this is achieved by playing around with sensors, or rather, letting children experiment with wearables that very much resemble ordinary clothing but are actually technologically enhanced by sensors. Depending on the way a single cloth is being operated on or how several of them interact, the wearable's sensors produce sounds that trigger certain types of behavior.

All in all, this seminar dealt with the various technological aspects that define what wearables are, but even more, the seminar focussed on the affective aspects that are involved. Wearables imply a certain degree of personalization of technologies that in turn start to function as a defining entity of personality itself. This is where ethical questions about the openness of personal information confront efficiency questions concerning the useful tools that wearables can be. The discussion on wearbles also offers new perspectives on what factors matter in attributing meaning to mass-produced entities.

8. Appendix 2.

8.1. DVD DEAF03

Data Knitting documentation

8.2. DVD DEAF04

Affective Turbulence documentation