material programming

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INTRODUCTION & OBJECTIVES

The Material Programming Project aims to index, develop, and evaluate new open-source software for digital knitting. Responding to the limitations of existing closed, machine-specific systems, the project foregrounds the unique characteristics of knit as an additive manufacturing process and explores how computational approaches can expand the possibilities of knit design. By creating an accessible index of existing projects, co-developing novel tools for knit patterning and structure, and convening a community of practice through reading groups and workshops, the project promotes equity, creativity, and accessibility in digital knit. In doing so, it advances a vision of end-user programming and empowered computing that diversifies both what knitting software can do, and who is able to contribute to its making.

The project team combines expertise in knit research, industry practice, open-source development, and creative technology, grounded in extensive professional and educational experience.

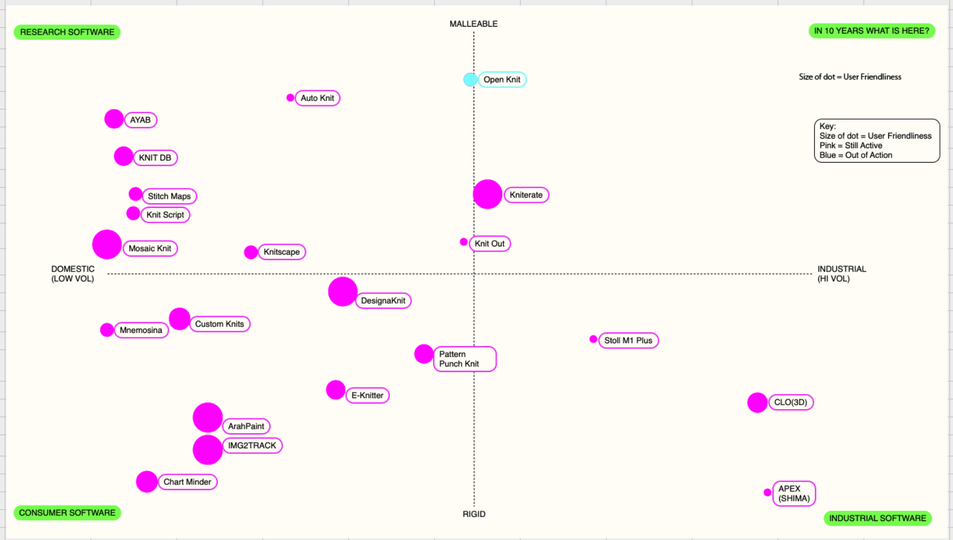
The work engages students, knit textile designers, software engineers, and researchers, ensuring relevance across academic, industrial, and creative communities.

By enabling interdisciplinary collaboration, the project addresses current technological and creative challenges while advancing innovation, enterprise activity, and the development of future knowledge in digital knit and textiles more broadly.

In doing so, the project establishes a foundation for sustainable, open, and collaborative approaches to textile technology development.

OPEN KNITTING TOOLS DIRECTORY

Open Knitting Tools Chart : For more information please see
OPEN KNITTING TOOLS DIRECTORY



What makes something *malleable*?
- Open to unexpected use
- Less opinionated about the 'right' way to use
- Different avenues for adapting tools

What makes something rigid?
- Closed source code.
- Less adaptable
- Monolithic (not always)

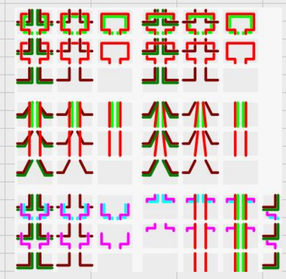
What makes something domestic?
- Requires skilled input from the person making it
- Can refer to the type of machine e.g domestic knit machine (silver reed/brother)
- Low volume manufacture

What makes something *industrial*?
- Capable of using a full range of automation
- Can refer to machine type (STOLL / SHIMA SEIKI)
- Intended for high volume manufacture

Case Study : Exploration of Knit Out and Auto Knit

Process:	- We will work through and test out the tools in the directory. - Link together the tools to generate a range of different test files intended for use with the Kniterate. - Clearly test and document each attempt. - Exploring Knit Out and AutoKnit - working to create different files compatible with the Kniterate. - Knit out and test the results of the knitted samples from Knit Out and Auto Knit.
Initial Findings:	- Despite both programmes are adapted from the Kniterate, the way that the files are made is still really different. - This points to how idiosyncratic different machines can be and how many approaches there are for constructing knitted textiles. - In attempting to adapt this software for our own use, we are coming to understand a much deeper set of relations and differences between industrial knit techniques. - When creating knit files the software automatically sets the file to be used with the Shima Seiki machine, often when we convert it too a Kniterate format there are still big differences in the file that are not compatible. Often these machines are imagined as isolated from one another -- even though knitters may be trained on each individually, it's restricted to a closed and proprietary software ecosystem
Core Questions	- What is the longer life of these tools? (Currently they are both being maintained by a single research group) - How does this tool get adapted for a wider range of machines and users? - To what extent can we feed back into this design? - What does the intermediate / simulated form of representation mean for the final outcome? - How do these pieces of software get adapted more fully for a range of machines? - Industrial knitting machines and their proprietary software have evolved largely in isolation from one another. What does it mean to make a more general tool without losing the expressiveness associated with specialised tooling and machinery?

REFERENCES
A Compiler for 3D Machine Knitting, McCann et al, 2016
The Knitout File Format Specification, McCann, https://textiles-lab.github.io/knitout/knitout.html
Autoknit Github Repository, https://github.com/textiles-lab/autoknit



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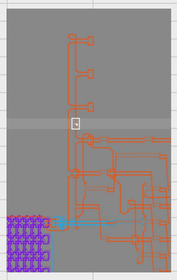

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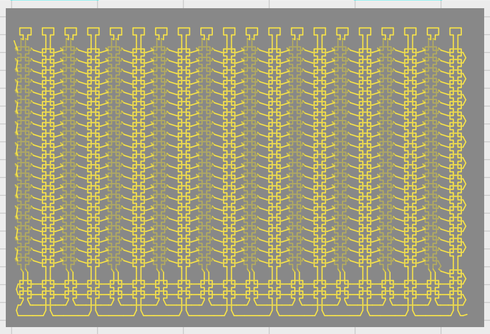

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Notes on images:
1, Stitch Icons using the KnitOut software. Representing the range of stitches available.
2, A file using the AutoKnit software, creating an 'egg' shape. This image is mid transition of creating the file - showing where the stitches will be mapped out.
3, A file using the KnitOut software and visualiser. This cropped section shows where the cast on edge does not match up correctly with the knitted piece - The purple stitches represent the cast on edge, the orange stitches represent the knitted piece. This is interesting as we are getting to see how the software is creating a cast on edge, even though it will not knit out successfully.
4, A file created in Autoknit from the 'egg' shape. The shaping is shown to the right side of the file.
5, A file to create a 1x1 rib - shown in the KnitOut visualiser.

KNIT TECH READING GROUP

The Knit Tech Reading Group (KTRG) meets monthly to discuss contemporary research in knitting technology. Participants are interdisciplinary, and come from both industry and academia. The group is run under the Chatham House rule: 'When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed.'

The aim is to convene practitioners and researchers from a wide range of backgrounds to further discussion of questions such as: what are the idiosyncrasies of knit as a medium? why is knitting like that? when designing tools for the creation of knit textiles, what kinds of task and operation have been under-considered? how do we evaluate the quality (in terms of craftsmanship, design, and ease of use) of new advances in knit technology? how can software tools (made using code) work with and for experienced knitters, and how can or should they work for people with no knit experience? Each group, two pre-readings (normally research papers) connected by a theme guide the conversation.
Chatham House. (n.d.) The Chatham House Rule. Available at: https://www.chathamhouse.org/

KTRG #1 (23 July 2024) - Visualisation and Language		**Research Methods:**
Language and Accessibility	Knitting is fragmented by many micro-languages (patterns, software, academic systems). Projects like Stitch Maps try to unify notation, but no shared standard exists. Accessibility is a key concern as industrial tools are powerful but costly and complex, while hand-knitting is more open but less scalable. Should knit even have a universal, translatable language? Devalues the knowledge and skills?	Reflective Practice & organisational learning (Donald Schön) Design as a conversation with materials where practitioners reflect in and on action. The questions in the group function as reflective prompts, not just for individuals but collectively, helping participants examine assumptions and practices.
Visualisation of Knit Structures	Knitting is rule-based but inherently 3D and tactile, making it difficult to represent in 2D grids, stitch maps, or CAD tools. Visualisation helps simulate structure and behaviour but (often?) captures only appearance rather than performance and function. Cross-disciplinary comparisons (architecture, CAD) show similar contracts with mathematical calculations vs material reality.	
Materiality and Human– Machine Interaction	Tactility is central to knitting: learning, communication, and creativity come through hands-on play, mistakes, and material experimentation. Digital tools expand possibilities (simulation, automation, scale) but risk distancing designers from embodied knowledge. This creates a tension between efficiency and maintaining the craft's tactile essence.	

KTRG #2 (29 August 2024) - Representation and Knowledge		**Research Methods:**
Indexing and Representation of Knit Textures	The Knitpick project demonstrates how databases, graphs, and computational representations can encode knit structures. Raises questions about whether knitting needs graphic representation, and what is lost or gained in the translation from material practice to abstract diagram. Comparison with Latour's idea of 'immutable mobiles', diagrams that stabilise and transport knowledge, shows how knit notations function as tools of communication, simplification, and power.	Generative Design Research (Sanders & Stappers) In participatory contexts, Sanders & Stappers talk about using tools that 'make the invisible visible' and give shape to participants' tacit knowledge. Our open questions here act as generative probes encouraging participants to express experiences and values that may be difficult to articulate otherwise.
Intention & Culture	Hand knitting encodes knowledge in the artefact itself, while computational approaches often abstract away intention, story, and cultural context. Discussion of 'orphaned information' when patterns are preserved but without the culture or machinery needed to reproduce them (patterns without cultural or material context). Emphasis on the ethics of pattern design, cultural preservation, and respecting forms of textile knowledge that don't align with machine-readable systems.	
Power Dynamics & Embodied Knowledge	Computational databases can shift power dynamics in the knitting industry. Who encodes, who accesses, and who benefits? Concerns that abstraction strips away the emotional, tactile and storytelling aspects of hand knitting. Debate over whether graphic representation and digital systems enhance or erode craft knowledge, and how intention differs between human and machine knitting.	

KTRG #3 (25 September 2024) - Automation and Autonomy		**Research Methods:**
Automation, Alienation, and Control	The text draws parallels between early industrial textile automation (Luddite revolts, the 'machinery question') and contemporary knitting machines (Stoll, Shima, Kniterate). Concerns about loss of autonomy when machines dictate processes or strip away embodied, material knowledge. Users describe both fascination with programming and grief at the alienation from tactile making.	From participatory design traditions, questions serve as scaffolding. In the group, they allow people with diverse relations to knitting (hand knitters, programmers, academics, designers) to share perspectives on equal terms, shifting authority from 'the expert' to the group.
End-User Programming and Accessibility	Inspired by Ink & Switch's essay, the idea that software should allow users to move gradually from using, inspecting and modifying. Raises a moral imperative avoid a digital divide where only an elite of 'high priests' (programmers) have control. Examples include Excel hacks, Rhino plugins, and simpler machine interfaces (Kniterate) as steps toward more democratic design tools	
Power Dynamics & Embodied Knowledge	Discussion of AI as a potential collaborator that could 'learn style' and support creative decision-making. Parallels with music and other creative tools. Skill and tacit knowledge remain essential even with powerful technologies. Highlights ongoing power dynamics, who designs the systems, who gets to program them, and whose knowledge is preserved or erased.	

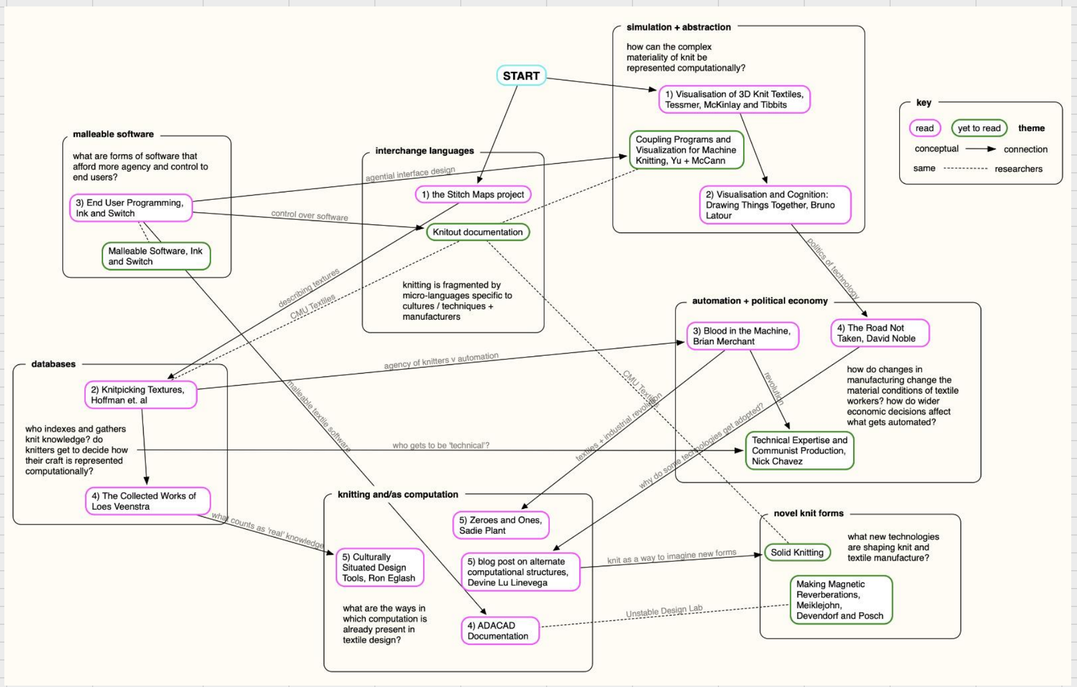
KTRG #4 (29 October 2024) - Multiplicity and Communication		**Research Methods:**
Communication & Silos	There is concern about siloed knowledge and hierarchies. Designers, programmers, linkers, and manufacturers often lack dialogue, which limits creativity. The development of new CAD and textile tools raises questions of accessibility, inclusion, and cultural preservation, whose expertise is included, and whose gets sidelined? Participants emphasise the need for bridges between cultures of practice (industrial, academic, domestic, artistic) to avoid textiles being overlooked by dominant software models.	Speculative and Critical Design (Dunne & Raby) Many of the group's questions do this 'What is the craftsmanship of knit notation?' These are not answer-seeking but provocations that open new ways of thinking.
Democratisation	Loes Veenstra's 500 sweaters highlight intuitive, diverse, and personal approaches to making, contrasting with industrial systems that enforce standardisation. Domestic knitting machines, hand knitting, CNC systems, and software like AdaCAD all embody different 'opinions' about process and design. Reflections on how tacit knowledge, trial and error, and embodied practice coexist uneasily with codified, programmable systems.	
Technology & Social Forces	Building on David Noble's Forces of Production, the group questions the idea that 'successful' technologies are inherently superior. Instead, technological adoption is shown to be shaped by power, cultural norms, and economic dominance, not just technical merit. In knitting and weaving, this plays out in which machines, CAD systems, and software gain dominance often reflecting institutional or corporate priorities rather than makers' needs.	

* Following a pause, the group reconvened, echoing Groten's view of collectives as experimental media, where discontinuity becomes a site for renewed collaboration.

		Research Methods:
Computational Aesthetics & Representation	Choices in computing structures are framed as aesthetic decisions as much as technical ones. Knitting is seen as inherently algorithmic, but representations (icons, building blocks, stitch symbols) often strip away nuance such as tension, tactility, or 3D form. The discussion questions how much information can or should be encoded in software, and what remains in the knitter's embodied knowledge.	This group aligns with Anja Groten's research on design and collectivity (PhDArts, 2022), where collective formats are approached as experimental media sites where collaboration, process, and form are as significant as outcomes. Groten, A., 2022. Designing for and with collectives: how to work together (yet stay different)? PhD. Leiden University / Royal Academy of Art The Hague (PhDArts).
Multiplicity of Models & Conditionality	Participants emphasise that knitting can be understood through many computational lenses: algorithms, matrices, conditional logic, ethnomathematics. Different models are suited to different tasks, rather than a single 'ideal' representation. Knitting is described as 'not one dimensional', some knitting tools reinforce rectangular thinking, while understanding hand & machine knitting allows 3D approaches.	
Industrial Tools, Accessibility, & Futures of Software	Contrast between industrial machines (e.g. Stoll, Shima, Raynen) and more open or experimental tools (Knitout, AdaCAD, self-made looms). Concerns that commercial software is reductive and prioritises efficiency over expressiveness, leaving creativity to remain in the mind of the user. Questions raised about the future of knitting software ecosystems, who develops them, what aesthetics and assumptions they carry, and how accessible they are to different communities.	

The repetition of themes within the KTRG discussions highlights the persistent tensions around automation, alienation, and control. This cyclical return resonates with Alex Martinis Roe's To Become Two, foregrounding collective processes of thinking and making, emphasising how collective discussion itself becomes a form of situated knowledge-making (Martinis Roe, 2018). Martinis Roe, A. (2018) To Become Two: Propositions for Feminist Collective Practice. Berlin: Archive Books.

KNIT TECH READING GROUP SESSION GRAPH



WORK IN PROGRESS & NEXT STEPS

Knit Software Usability and Creativity Questionnaire

This questionnaire is adapted from the USE questionnaire (Lund, 2001) and creativity support tool evaluation frameworks (Hewett et al., 2005). It has been tailored to the context of knitting software and digital tool design, where usability and creativity are central to evaluating how tools support craft-based practices.

Participants are asked to rate each statement on a 7-point Likert scale (1 =Strongly Disagree, 7 = Strongly Agree).

Section 1: Usefulness (practical affordances of knitting software)

1 The software helps me accomplish tasks I want to do in knitting.
2 The functions of the software meet my needs as a knitter/designer.
3 The software improves the quality of my knitted designs or prototypes.
4 Using the software increases my efficiency in producing or testing designs.
5 The software enables novel tasks or workflows that would otherwise be difficult or impossible.

Section 2: Ease of Use (accessibility of tools for diverse users)

1 I find the software easy to learn, regardless of prior knitting or coding experience.
2 I can complete tasks quickly using the software.
3 The interface and workflow are intuitive to navigate.
4 It is easy to identify and correct mistakes when using the software.
5 I can use the software effectively without constant reference to instructions.

Section 3: Satisfaction (integration into practice and community)

1 I am satisfied with my overall experience using the software.
2 I enjoy using the software in my knitting or design practice.
3 I would recommend the software to other knitters, designers, or researchers.
4 I feel confident using the software to achieve my goals.
5 The software fits well into my broader workflow, whether craft-based, technical, or interdisciplinary.

Section 4: Creativity Support (knit as an experimental and generative medium)

1 The software supports me in exploring multiple design ideas.
2 The software helps me generate new or unexpected outcomes in knit design.
3 The software encourages experimentation, iteration, and play.
4 The software makes it easy to adapt, modify, or refine existing designs.
5 The software supports collaboration, sharing, or reuse of designs within a community.

Section 5: Open Feedback (themes of openness and user agency)

1 What do you find most useful about this software?
2 What do you find most frustrating or limiting?
3 In what ways could the software better support creativity in your practice?
4 Are there features you wish the software had, particularly in relation to openness, customisation, or user agency?

References
Lund, A. M. (2001) 'Measuring usability with the USE questionnaire', Usability Interface, 8(2), pp.
3–6.
Hewett, T., et al. (2005) 'Creativity support tool evaluation methods and metrics', Creativity Support
Tools, pp. 10–24.

* This questionnaire will be trialled with students and practitioner-users in a series of workshops, in order to evaluate both usability and creativity support in practice, drawing on the frameworks of Lund (2001) and Hewett et al. (2005), and to refine our understanding of how open, user-led tools for knitting can be situated within broader craft and design practices.

ual: university of the arts london

Colour code:	
Red: fc010	
Burgandy: 8f2321	
Green: 00ff00	
Dark Green: 007d00	
Grey: ececec	
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