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YUQIAN SUN, Royal College of Art, London, U.K.

YUYING TANG, Tsinghua University, Beijing, China

ZE GAO, Hong Kong University of Science and Technology, Hong Kong, Hong Kong

ZHIJUN PAN

CHUYAN XU

YUROU CHEN, SOAS University of London, London, U.K.

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# AI Nüshu: An Exploration of Language Emergence in Sisterhood -Through the Lens of Computational Linguistics

Yuqian Sun\*

Royal College of Art  
London, United Kingdom  
yuqiansun@network.rca.ac.uk

Yuying Tang\*

Tsinghua University and Politecnico  
di Milano  
Beijing and Milano, China and Italy  
tyy21@mails.tsinghua.edu.cn

Ze Gao†

Hong Kong University of Science and  
Technology and Hong Kong  
Polytechnic University  
Hong Kong SAR, China  
zgaoap@connect.ust.hk

Zhijun Pan

Royal College of Art and Ubisoft  
London and Chengdu, United  
Kingdom and China  
10037730@network.rca.ac.uk

Chuyan Xu

New Drama Studio  
Beijing, China  
444652692@qq.com

Yurou Chen

University of London  
London, United Kingdom  
703240@soas.ac.uk

Kejiang Qian

King's College London  
London, United Kingdom  
kejiang.qian@kcl.ac.uk

Zhigang Wang

Tsinghua University  
Beijing, China  
wangzhigang@mail.tsinghua.edu.cn

Tristan Braud

Hong Kong University of Science and  
Technology  
Hong Kong SAR, China  
braudt@ust.hk

Chang Hee Lee

Korea Advanced Institute of Science  
and Technology  
Daejeon, Sout Korea  
changhee.lee@kaist.ac.kr

Ali Asadipour

Royal College of Art  
London, United Kingdom  
ali.asadipour@rca.ac.uk

## ABSTRACT

This paper presents "AI Nüshu," an emerging language system inspired by Nüshu (women's scripts), the unique language created and used exclusively by ancient Chinese women who were thought to be illiterate under a patriarchal society. In this interactive installation, two artificial intelligence (AI) agents are trained in the Chinese dictionary and the Nüshu corpus. By continually observing their environment and communicating, these agents collaborate towards creating a standard writing system to encode Chinese. It offers an artistic interpretation of the creation of a non-western script from a computational linguistics perspective, integrating AI technology with Chinese cultural heritage and a feminist viewpoint.

\*Both authors contributed equally to this research.

†Ze Gao is the corresponding author.

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## CCS CONCEPTS

• Applied computing → Media arts; • Human-centered computing → Interaction design process and methods; Visualization systems and tools.

## KEYWORDS

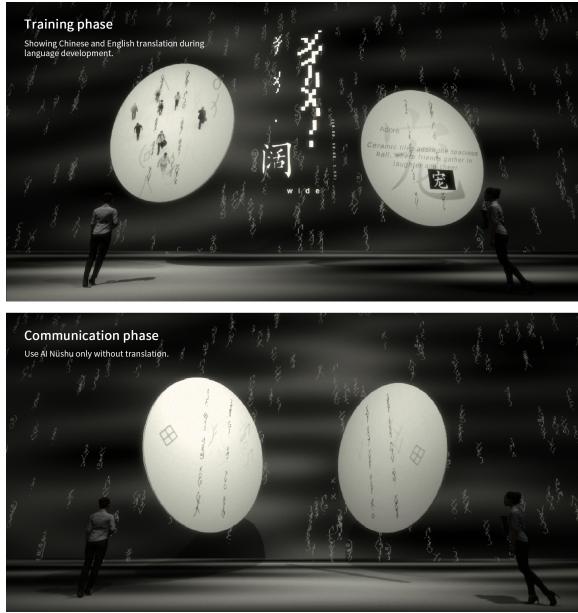
AI Nüshu, Language Emergence, Computational Linguistics, Chinese Cultural Heritage

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## 1 INTRODUCTION

Nüshu (pronounced as 'niu-shoo,' literally means 'women's script' in Chinese) is a unique language [Zhao and Zhang 1995]: this is the world's only writing language created and used exclusively by women. It is a distinct script within the Chinese language, which emerged in the nineteenth century in Hunan Province, China. Although its characters have semantic and linguistic correspondence with many Chinese Mandarin characters, their pronunciation is rooted in the Hunan provincial dialect (Fig. 2). Due to the traditional



**Figure 1: Two phases of the AI Nüshu art installation.**

beliefs back then, women were not allowed to receive education. At the time, they invented Nüshu as a secret means of communication. Despite its long history, the origins of Nüshu remain unknown. Women used this unique language to voice their defiance against a highly patriarchal society.

The emergence of language is a crucial topic in artificial intelligence natural language processing (NLP) and linguistics. But unlike large language models (LLMs) aimed at precisely understanding and expressing natural languages, our research focuses on AI's potential to self-create and develop new, nonhuman language systems and study their linguistic characteristics to explore the origins of human language. However, most of these studies have been conducted in English, with few involving Eastern languages. Nüshu, an Eastern woman's cultural legacy, provides a unique perspective for interpreting machine language. Our project explores how emergent language among machines resonates with the ancient women who created their language amidst patriarchal constraints.

Drawing from the creation of Nüshu, this project introduces an emerging language system generated by AI - AI Nüshu. This system simulates the intimate communication within the sisterhood of ancient "illiterate" women, known as "Lao Tong" (sworn sisters): two AI agents "understand" Chinese but cannot directly "transcribe" it. Therefore, a unique Chinese writing system gradually emerges from the agents' observations, reflections, and secret communications about their living circumstances.

In this system, two AI agents observe their surroundings and analyze audience behaviors through visual recognition. They relate their observation to original Nüshu poetic verses, creating new texts with the large language model (LLM) GPT-4[OpenAI 2023] to represent their reflections of the world. As they alternate between the speaker and listener roles in communications, they develop their language, rooted in the Chinese dictionary. Over time, they

achieved a consensus, forming a unique "AI Nüshu Dictionary". This language, algorithmically combined into corresponding characters, has components derived from Nüshu, similar to Chinese characters and traditional textile patterns. Thus, like ancient women, the two agents gradually developed their Chinese writing system, corresponding one-to-one with Chinese characters. In contrast, humans, as the authority of the language system, became objects observed and interpreted by machines to stimulate non-human language.

The entire simulation system will be presented as a dual-screen projection mapping installation. During the training phase, the height of each screen will change according to the switch of speaker and listener roles, displaying the encoded sentences with Chinese and English translation information (Fig.1 top). After the training is completed, in the internal communication phase, the two agents can communicate entirely in their created language. The two agents' curtains will turn around to face each other, and no human-recognizable text will be on the screen (Fig.1 bottom).

Our contributions are as follows.

- We present an AI-generated emerging language system "AI Nüshu" based on the Nüshu language, the only writing language created and used exclusively by women from the Hunan Province of China in the 19th century. This is the first art project to interpret Nüshu from a computational linguistics perspective.
- Our research employs a multi-agent learning system to simulate the communication dynamics within a sisterhood. This probes into the process by which ancient women developed a unique language under the constraints of a patriarchal society. This cultural phenomenon resonates with the emergence of non-human machine language under human authority, both metaphorically and practically. Essentially, we integrate cultural phenomena into an AI system.
- This research was developed through the processing of non-English natural languages, Chinese cultural heritage, and a feminist point of view. Encourage the creation of more non-English, linguistically oriented artworks for diverse cultures.
- Contrary to the predefined rules of Morse code, Markov chains, and fictional constructed languages, AI Nüshu evolves organically from the machine's environmental observations and feedback, mirroring the natural formation of human languages. As this new language is decipherable and learnable by humans, especially Chinese speakers, it inherently challenges the existing paradigm where humans are the linguistic authorities and machines are the learners.

Through this, the paper centers on the historical phenomenon of women being denied formal education and, as a response, developing their unique language and the bond of 'Lao Tong.' The primary focus lies in understanding how women, in the face of educational exclusion, created a distinct linguistic culture. We propose that the emerging AI language, paying homage to sisterhood, challenges patriarchal perceptions.

## 2 INSPIRATION AND MOTIVATION

The Nüshu language and sisterhood serve as a testament to women's resilience, creativity, and ingenuity in the face of patriarchal oppression.

The Nüshu language was developed by women who were deprived of educational opportunities in a heavily patriarchal society. To communicate with each other, they developed a secret writing system that enabled them to express themselves and share their experiences. The language served as a means of resistance and empowerment for women denied a voice in their society.

## 2.1 Nüshu and sisterhood

Central to Nüshu culture is the traditional ritual of 'Laotong' (sworn sister)[Zhao and Zhang 1995], which bonded two girls for life as kindred sisters. These women formed close bonds and supported each other through the difficulties of their lives. The sisterhood of Lao Tong was a testament to the resilience and strength of women in the face of adversity.



Figure 2: Local woman Jinghua He is writing Nüshu @Publicity Department of Jiangyong County

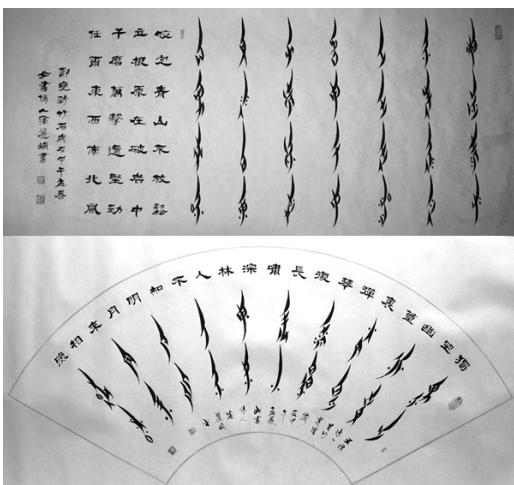


Figure 3: Origin piece of Nüshu calligraphy @Tsinghua University

The concept of female friendship transcends cultural boundaries. In Western feminism, Kathie Sarachild[Gosse 2005] coined the phrase "sisterhood is powerful," which bears many similarities with the concept of "laotong." This "sisterhood" is a united force "in the struggle against male chauvinism and patriarchy." [Dill 1983]

This project aims to cultivate two AI agents symbolizing 'Lao-tong' in Nüshu culture, where two Women intimately communicate.

English	Chinese	Nüshu	AI Nüshu
Mountains	山	山	山
(are)beautiful	清	清	清
water	水	水	水
(is) clear	秀	秀	秀

Figure 4: Same sentence in English, Chinese, Nüshu, and AI Nüshu

## 2.2 Women and machines

Historically, women's right to express themselves has often been suppressed, a condition that persists today. Movements like #MeToo[France 2017] encourage modern women's voices in public space. Cyberfeminist Sadie Plant[Plant 1997] argues that the fluidity of gender and identity in the virtual world offers a fresh lens to understand and reshape gender politics and identity. This viewpoint can be extrapolated to the domain of artificial intelligence.

The bond between women and machines traces back to the early days of computer science [Wajcman 1991]. "computer" was initially used to refer to women who performed calculations during World War II. The portrayal of AI assistants like Siri and Alexa as compliant helpers with feminine traits reinforces gender stereotypes[Crawford and Joler 2018].

Drawing parallels between the suppression of women's voices and the potential of machines to challenge traditional roles, this project seeks to understand the intricate relationship between women and machines. By focusing on the Nüshu language and the bond of "Lao Tong", we aim to shed light on the resilience and creativity of women in the face of adversity and how this can be mirrored in the world of artificial intelligence.

## 3 RELATED WORKS

Constructed languages such as Esperanto form bridges across the chasms of natural language in cultural discourse, while the film industry invents fictional languages[Jackson 2002]. However, fewer works delve into language learning, such as "Arrival"[arr 2016], which portrays how humans alter their perception of time through learning an alien language. Works about Nüshu are notably scarce. Prominent instances encompass a novel and its corresponding film adaptation, "Snow Flower and the Secret Fan,"[Wang 2011] which delves into the bonds between two groups of women, one from ancient China, exploring the narratives of Nüshu and "Lao Tong", and another from modern society. Additionally, the recent documentary "Hidden Letters" [Feng and Zhao 2022] offers a comprehensive exploration of the historical significance and practices associated with Nüshu.

Xu Bing's "Book from the Sky"[boo 1988] and "Book from the Ground"[boo 2014] have garnered significant attention. These books are devoid of any existing textual content, relying solely on the combination of unreadable Chinese characters, visual symbols, and

expressions to convey emotions and meanings. Xu Bing's innovative approach transcends the limitations of traditional language, enabling viewers to interpret the symbols and expressions based on their own understanding and emotions. This opens new possibilities for communication through constructed languages and serves as a representative example of artwork that explores the Chinese language as a starting point, underscoring the artistic value of studying the human language.

Contemporary media art research has also ventured into the exploration of machine language and expressions. "Cangjie's Poetry" is an intelligent multimodal system designed as a conceptual response and prototype to the future language which was exhibited at PRIX ARS ELECTRONICA 2022 [noa 2023][Zhang et al. 2021]. Through the integration of live streaming and AI-generated semantic data, the installation dynamically modifies projections in a virtual environment[Gao et al. 2023][Yang et al. 2023]. However, it veers more toward visual language and computer vision than textual semantics[Sun et al. 2023a].

Similarly, The Nüshu GPS improvised performance correlates movements with metaphors and meanings embedded within Nüshu characters by Yun-Ju Chen and Taiwanese choreographer Lai Tsui-Shuang in 2014[Chen and Cheng 2018]. The project attempts to explore all the possible metaphors and meanings implied by Nu Shu and bring this secret method of communication back to life among modern Chinese women. Media art from a linguistic perspective, mainly focusing on Chinese and Nüshu, remains underexplored.

We are also inspired by non-Chinese works, like "Alice & Bob," which blends quantum computer data with poems[Ridler and Jelonek 2017]. The SIGGRAPH Art Gallery project "Can the Subaltern Speak?"[Farahi 2021] uses AI-generated Morse code for communication, referencing Facebook's experiment[Field 2017] where chatbots developed their language. This highlights AI's potential in language generation and the role of language in empowering marginalized voices.

There was also AI-driven game[Sun et al. 2023b] and narrative experience[Sun et al. 2022, 2023c] based on text, but they are still keyword-based. Unlike these projects which used predefined rules including Markov chains and Morse code, our AI-generated female script can be learned and used by both machines and humans, underscoring the value of reimagining female script language from a non-English linguistics perspective.

## 4 CONCEPTUAL FRAMEWORK AND METHODOLOGY

We aim to simulate the situation of women in the past: due to environmental constraints, they were not allowed to receive an education. They "understood" Chinese (could listen and speak) but could not "transcribe" Chinese (could not read or write). Hence, Chinese women created Nüshu as a phonogram to communicate based on the pronunciation of Chinese characters.

Drawing inspiration from the burgeoning field of emerging language research, notably exemplified by "referential communication games" [Mordatch and Abbeel 2018], in which AI models acquire communication skills through the deployment of symbolic representations to convey diverse environmental elements, we direct

our attention to the visual aspects of linguistic expression. Consequently, AI Nüshu, henceforth referred to as AIN, has been transformed into a logogram – a logographic Chinese writing system in which each symbol (Character) corresponds uniquely to a Chinese character.

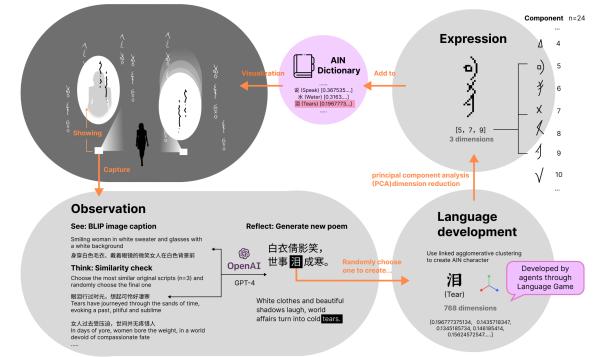


Figure 5: System diagram of the AI Nüshu simulation system

## 5 IMPLEMENTATION

This system simulates several stages of language development: environmental observation through visual recognition, language development through the language learning game, and symbolic expression output. Consequently, agents form a new symbolic language through computer vision and Chinese-based natural language processing. This simulation is presented through a real-time interactive art installation.

### 5.1 Environmental Observation

This section simulates the process by which women observe their surroundings, cogitate, and articulate their thoughts through Nüshu.

Two agents independently observe their environment through their respective cameras. Each cycle generates a descriptive statement via the BLIP image recognition algorithm[Li et al. 2022], such as "A woman walks by." This sentence is in English and subsequently translated into Chinese using Google Translate.

We have compiled a corpus of 837 original Nüshu sentences extracted from literary sources. The Chinese translated version of the description and the original Nüshu text are compared for similarity, and the three sentences bearing the highest similarity are identified. To ensure a rich range of expressions even when the observed environment is repetitive, one sentence is selected randomly from this list(Fig.5).

Ultimately, LLM GPT-4 is employed to construct a line of Chinese poetry. In this manner, the agent amalgamates the environment it perceives with analogous sentiments documented in ancient women's Nüshu in conversations.

### 5.2 Language Development

This module enables the process of two agents developing their language. The approach simulates the basic concepts of machine and human learning through iterative optimization.

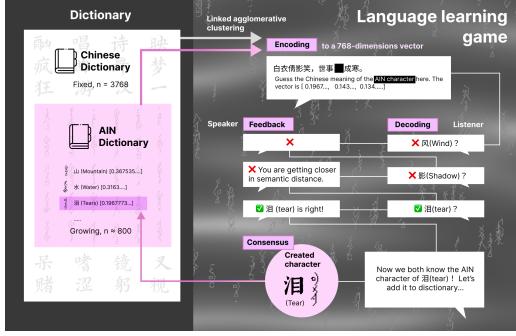


Figure 6: Language development of AI Nüshu through the language game

**5.2.1 Natural Language Representation.** Language models process text using basic units known as tokens. In English, tokens can be words or punctuation, and words are formed by combining elements of an alphabet. However, in Chinese, tokens are individual characters, each carrying a meaning similar to a word in English, and there is no concept of an alphabet. For instance, in Fig.4, the phrase "山清水秀" (Mountains are beautiful, water is clear) is broken down into four Chinese tokens: "山" (mountain), "清" (beautiful), "水" (water), and "秀" (clear). These tokens maintain semantic relationships in a mathematical vector space. The character "水" (water) is closer to "雨" (rain) than to "山" (mountain), just as their English counterparts would be.

We utilized BERT-Chinese-Base, a variant of the pre-trained deep learning model BERT[Devlin et al. 2019], to process the most frequently used Chinese characters (3768 in total) into the "Chinese character dictionary." Each character corresponds to a 768-dimensional vector with semantic relationships (Fig.6). This dictionary forms the knowledge base of the two AI agents, enabling them to "understand" Chinese.

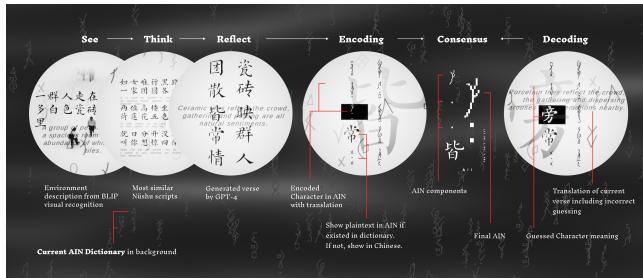


Figure 7: Visualisation of different steps in AI Nüshu development

**5.2.2 Language Learning Game.** Two agents are tasked with developing an AI Nüshu (AIN) dictionary from scratch. Each Chinese character in this dictionary corresponds to a unique 768-dimensional vector exclusive to AIN. The semantic relationships within this dictionary matched those in the Chinese character dictionary but with distinct differences. Over time, AIN becomes the sole means of communication. The number of characters in AIN

varies depending on the exhibition site and running time, typically around 800 when saturated.

The agent's alternate roles as the speaker (teacher) and listener (student) through a language learning game. For agents' semantic learning, the Chinese characters are linked and clustered using agglomerative clustering[Müllner 2011] before the game. Specifically, in our system, since we do not include pronunciations, we abstract the learning method of the agent as follows (Fig.6):

- (1) **Speaker Generation:** At the start of each iteration, the speaker agent generates the sentence from the previous observation. The speaker selects one character to create the AIN representation.
- (2) **Speaker Encoding:** If the original cluster exists as a key in the AIN dictionary, it is directly replaced with its corresponding AIN representation. Otherwise, a related character is selected to represent an AIN from a neighbor parent cluster. The speaker sends this partially encrypted sentence to the listener(Fig.5). The non-AIN encrypted part is plaintext: if it is already in the AIN dictionary, it is directly represented by AIN. If not, it is represented in Chinese.
- (3) **Listener Decoding:** The Listener attempts to decode the AIN character set by the Speaker. The initial guess is selected from a related cluster, and subsequent guesses are adjusted based on the Speaker's feedback. The Listener makes five attempts in total.
- (4) **Speaker Feedback:** The Speaker provides feedback after each guess, informing the Listener of their proximity to the correct character cluster. If the Listener fails to guess correctly within five attempts, the Speaker reveals the right answer.
- (5) **Consensus:** Essentially, the speaker and listener agree on the AIN representation of the character and add it to the AIN dictionary. After a round of training, the roles are switched, and the process is iterated.

Each agent is a creator and learner of AIN throughout this process. As iterations progress, the AIN dictionary expands, the semantic relationship improves, and the agents become increasingly adept at guessing each other's AIN representations. After the training phase, the agents can communicate entirely in AIN, reaching a complete consensus on its use.

Despite its Chinese foundation, this work employs GPT-4[OpenAI 2023] for context-sensitive word and sentence-level English translations (Fig.7). As one Chinese character can convey different meanings in various contexts, conventional tools like DeepL[DeepL 2023] are inadequate. With GPT-4, even those unfamiliar with Chinese can appreciate the intricacies of "language construction".

### 5.3 Symbolic Expression

To visually represent AI Nüshu (AIN) in a logographic form while preserving its non-human, machine language characteristics, we employ a two-step process based on essential Nüshu elements and Principal Component Analysis (PCA)[F.R.S. 1901].

First, we selected 24 fundamental elements from Nüshu[Zhao and Zhang 1995], arranged from simple to complex, each associated with an encoding (Fig.8). We use a pixelated approach for clear distinction from human language.

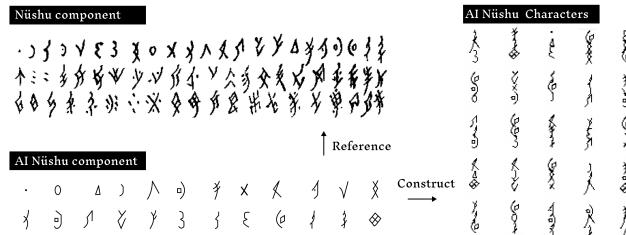


Figure 8: AIN components derived from Nüshu

Next, each newly created AIN character's 768-dimensional vector is transformed into a unique 3-D vector using PCA. The 3-D vector space ( $24^3 = 13824$ ) exceeds the length of the Chinese and AIN dictionary, ensuring a unique symbolic representation for each AIN character. This retains the elongated shapes of Nüshu while preserving the machine language's algorithmic meaning (Fig.5).

#### 5.4 Artistic Presentation through Installation

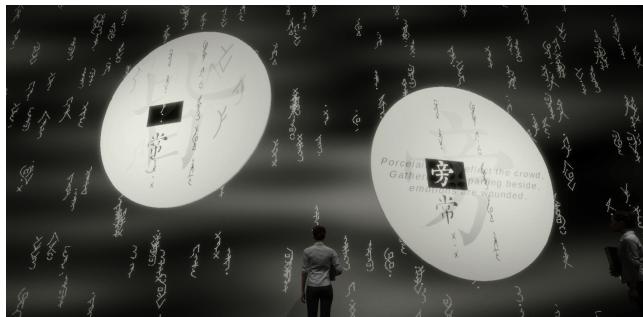


Figure 9: Speaker rises during the training phase. Two agents change positions when they change roles.

The system is presented as a dual-screen projection installation. Two hanging circular screens, like two moons or eyes, represent the AI agents, placed above their respective cameras, while the background behind is used to present the AI Nüshu dictionary that has become a consensus.

The work is presented in two stages. During the **training phase** (Fig.9), two agents continuously create and communicate their AI Nüshu in the language game. At this time, they will constantly switch between the roles of listener and speaker, and the height of their respective screens will also change accordingly, showing the effect of information flowing from the speaker to the listener.

During the training phase, each iteration visualizes sentences, verses, and constructed AIN characters on-screen with English translations (Fig.7). To accommodate non-Chinese users, context-specific translations are provided using LLM GPT-4 [OpenAI 2023]. For instance, the Chinese character "行" is translated as "travel" in "她行千里路" (She travels a thousand miles) and as "practice" in "她行医十年" (She has been practicing medicine for ten years), ensuring accuracy based on context.

Similarly, when the listener is guessing, the poem with the incorrect character can be translated (Fig.7). Non-Chinese users can

also see how a changed character in verse can change the whole meaning of it. We use LLM to transcend the barriers of languages.

After the training is completed, they reach the internal **communication phase** (Fig.1 bottom). It means that the two agents can communicate entirely in their created language. The curtains of the two agents will turn around to face each other, and there will no longer be any human-recognizable text on the screen.

## 6 DISCUSSION

This project invites conversations about the semantic capacities of machines and the cultural diversity in media arts.

### 6.1 Semantic Information in AI Nüshu

Similarity	Meaning	In Chinese	"Song"	In AI Nüshu	Meaning	Similarity
0.9425478...	Sing	唱	“Song”	诗	Poem	0.884394...
0.9418771...	Music	曲		舞	Dance	0.88459...
0.9359469...	Explore	游		汉	Chinese	0.88128...
0.934193...	Addict	嗜		镜	Mirror	0.87748...
0.932117...	Astringent	涩		躬	Bowing	0.84674...

The five most similar characters to "song"

Figure 10: Semantic similarity in Chinese and AI Nüshu

AIN characters, derived from Chinese, carry semantically rich and poetic information. For instance, in Chinese, "歌" (Song) is closest to "唱" (Sing) and "曲" (Music), while in AIN, it's closest to "诗" (Poem) and "舞" (Dance) (Fig.10). However, the content of the AIN dictionary is influenced by the environment in which the agents are trained. While Chinese includes thousands of characters, Nüshu only uses 400-500 due to its phonogram nature, expressing homophonic characters. AI Nüshu, as a logogram, is influenced by the circumstances observed by the agents and the literature source. For example, since there are no cats in the exhibition nor the Nüshu source corpus, the agents wouldn't generate any poetry related to cats, nor create the AIN character for "cat" 猫. Accordingly, the AIN dictionary reaches saturation at around 800 entries, sufficient for agents to communicate in the exhibition environment.

The unique semantic information in AIN could be better visualized in future installations, like through point cloud vector visualization of each AIN character. While AI Nüshu is currently learnable by humans, it could be more interpretable and natural.

### 6.2 Cultural Diversity in Language

While our project anchors on the Chinese language, it aims to exhibit a methodology that engages with NLP from a unique linguistic perspective, thus promoting cultural diversity within media art. Despite the extensive use of large language models like GPT-4 and various chatbots, their proficiency in non-English languages is still suboptimal [Bubeck et al. 2023]. Every language, whether phonetic like Spanish, logographic like Chinese, or a mixed system like Japanese, carries its cultural essence. This gives unique perspectives to comprehend the world. Just as humans view the world uniquely through language, so do machines. Thus, computational linguistics lets us explore cultural perspectives beyond English and visual representation.

## 7 CONCLUSIONS

This paper introduces AI Nüshu, an interactive art installation that delves into the confluence of AI technology, non-English linguistics, and cultural heritage, all viewed through a feminist lens. Drawing inspiration from Nüshu, an extraordinary language crafted by women in ancient China, we have engineered an AI-generated language system "AI Nüshu" designed to simulate the act of language creation within constraints. AI Nüshu, by embodying the spirit of sisterhood and celebrating the unique linguistic creation of women, inherently challenges and deconstructs long-standing patriarchal perceptions. It does so by showcasing the power of collaborative, non-hierarchical linguistic innovation, thereby challenging the conventional norms surrounding linguistic authority.

In conclusion, our project serves as a testament to the capacity of AI to act as a custodian of cultural heritage, underscores the critical significance of cultural diversity within AI research, and confronts traditional notions concerning the roles of humans and machines in matters of linguistic authority. While recognizing the significance of gaining insights into the perspectives and reactions of Nüshu-literate women towards our work, we envision that a more comprehensive exploration of this subject matter may warrant consideration in future research endeavors.

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