Knitting the Sea Slugs – a Demonstration of a Human-AI-Machine-Material Assemblage

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Figure 1: Knitted first prototype of *Jason mirabilis* and *Dendrodoris krusensternii*.

ABSTRACT

This project explores the nuance of human-AI collaboration using domestic knitting machines alongside a simple, task-based, AI algorithm addressed through the research framework of more-than-human design. The textile design task is to use a broad range of knitting techniques to develop textile prototypes that mimic sea slugs, specifically the New Zealand nudibranchs *Jason mirabilis* and *Dendrodoris krusensternii*, both chosen for their colourful, organic looks. The final outcome consists of a series of textile swatches and prototypes along with a booklet documenting the digital patterns and thought processes of the development.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Interaction design**.

KEYWORDS

Knitting, Digital Craftsmanship, Reflection, Design, Textile, Art

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1 INTRODUCTION

Designers and artists who work with textiles, particularly knitting, are beginning to adopt Artificial Intelligence (AI) into their creative practices as it becomes more generally known and more easily accessible. The current adaptation of AI for knitting fabrication is mainly implemented through image generation such as Midjourney [28], Dall-E [31], or StableDiffusion [38]. Other computer-supported implementations of knitting textile fabrication include optimisation [1, 3, 12, 20, 26], computation augmentation [2, 6, 36], digital interfaces [9, 40, 44, 47], creative algorithmic explorations [12, 15, 17, 18, 25, 32]. However, the combination of the creative process with algorithmic support in knitting is much less explored, unlike the field of Architecture where there is a long tradition for parametric and algorithmic designs.

In this project, we explore the nuance of human-AI collaboration with a domestic knitting machine (hereafter referred to as the 'machine') using a simple, task-based AI algorithm on the computer. AI, as a general term, covers a vast area of algorithms with different expertise. Previous research has found that knowing AI's capabilities allows designers to use AI tools better and that as a result value creation is closely related to specific AI's task expertise [46]. In the context of this project, we focus on the pattern-making ability of an extremely simple genetic algorithm to see how it would influence the creative outcomes.

This project adapts the framework of more-than-human design, where the material and the knitting machine are also seen as more-than-human designers [30, 41] in the craftsmanship tradition [19, 34]. The knitted textiles are also seen as outcomes created by the human-AI-machine-material assemblage [11]. Through the iterative auto-ethnography and process documentations of both the objective and the subjective perspectives, such as thought processes, reflections, data, photographs, choreography, and time, as an attempt to create a detailed depository of the happenings within the human-AI-machine-material assemblage that would portrait the interplay within the assemblage.

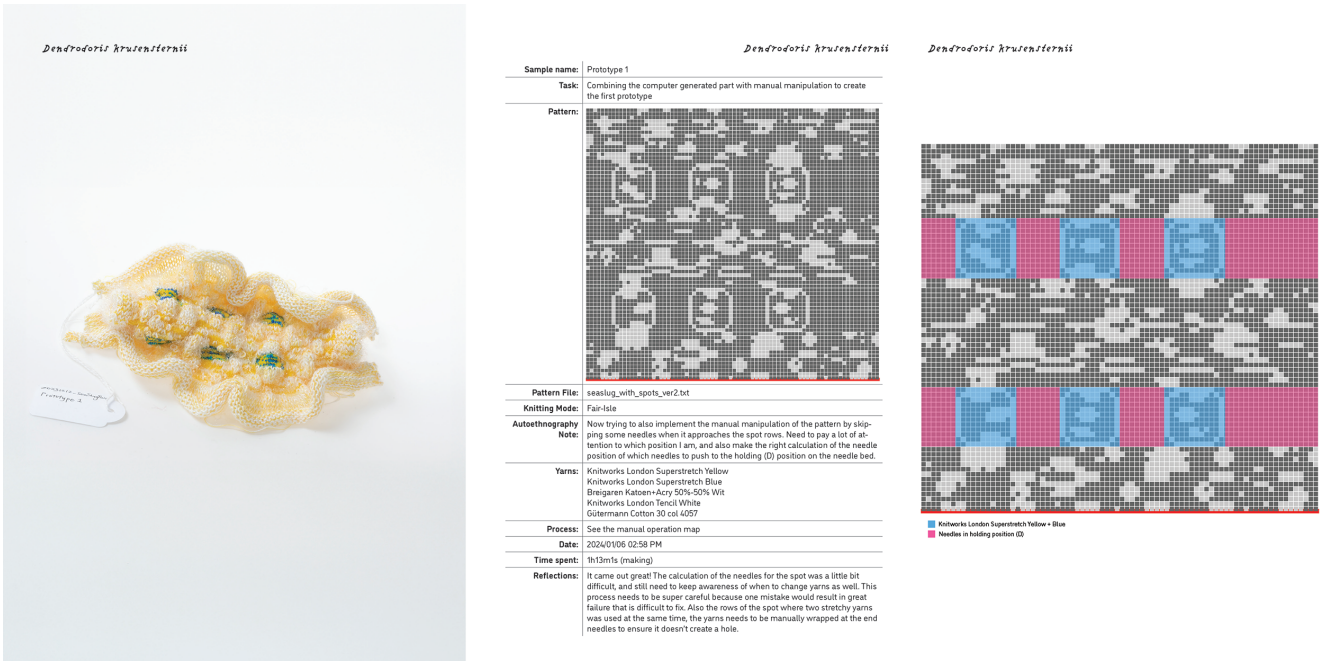

Figure 2: Excerpt from the booklet

2 RELATED WORKS

HCI research acknowledges the presence of fabrication machines, materials, and AI [5, 7, 19, 30, 41], and that the making of textiles is a collective process of the human-AI-machine-material assemblage, in which each has its own agency within the process. Such a framework shifts the perspective of AI as a tool towards AI as a more-than-human designer, which urges for a different lens to look at it as a more-than-human collective process.

Creative implementation using generative AI in textile-related fields has become visible, especially within the field of fashion [8, 21, 24, 27] with tools specialised in generating garments [29, 37], recommendations [22, 39, 43], or even as common as taking part in ideation[23], and many more. These generative AI implementations are mostly based on AI algorithms that are trained on a large image-text dataset, which makes the authorship and originality debatable [13]. Beyond the fashion domain, in the textile realm, generative AI is still weak in generating proper usable textile textures and structures due to the fact that image generative AI works on images rather than patterns and structural logic. As a result, using generative AI to assist in the making of textiles requires further translation into actionable elements. This corresponds with the finding from Yildirim et al. that, by focusing on sharing knowledge on the capabilities of AI, potentially addresses the gap between the capabilities of AI and the designer's needs and thereby broadens how AI can potentially be used in design [46]. At the same time, creatives are often looking for AI to deliver disruptive and strange, unexpected outcomes rather than provide solutions [4]. Furthermore, the concern of agency and originality when using AI tools [45] brings deeper questions around art labour and copyrights which is beyond the scope of this demonstration [35] but lays an important background for where generated data comes from.

Coming back to the more-than-human design framework with the same question of how AI can integrate into the established collective process of human-machine-material assemblage, based on a meeting between its capabilities and the designer's need, we constructed a setup of a simple 0 and 1 matrix manipulating genetic algorithm to participate in the creative development of textile design tasks. We did this in order to investigate if the perspective shift might bring new insight into the so-called human-AI collaboration studies.

3 KNITTING THE SEA SLUGS

The First Author (hereafter FA) is an Asian PhD student in the field of design with a background in Biology, Computer Science, Cultural Studies, and Critical/Speculative Design. She has been a practising artist in international settings for more than 15 years in the field of art and science. Knitting and textiles are not FA's expertise, but she has amateur experience, having worked with domestic knitting machines for three years and some training in Stoll industrial knitting machines. With this background, the project takes artistic considerations as its first priority with design observations added on top of this practice. This approach is chosen with the aim of centring the artistic practices in order to reveal important nuances that are, in turn, at the core of the creative processes of design research.

For this project, FA adapted a popular textile creative process as practised by textile design students across institutions: Starting from visual ideation, doing yarn swatches and simple swatches, and then continuing to more sophisticated swatches, and finally, the

final prototype. This approach is chosen to centre the perspective from the craftsmanship tradition to explore different technology engagements. Sea slugs were chosen to become the creative goal due to FA's previous experience with turning biological structures into knitted textiles and to allow more freedom than a typical knitted wearable garment where more precise calculation is needed for practicalities. Sea slugs *Jason mirabilis* and *Dendrodoris krusensternii* from the book 'Super Sea Slugs – a guide to the sea slugs of New Zealand' written by Richard C. Willan and Niki Davy [42] was chosen for their interesting shapes and colours that attracted the FA instinctively. The yarns were chosen from FA's collection of yarns.

The creative process is recorded through photographs, auto-ethnography, digital patterns, and an annotated portfolio [14, 33]. The whole process will be displayed in the format of a booklet, along with the samples from each stage. The booklet is the diary collection of the auto-ethnography notes, along with images of each sample, displaying the complete timeline of the process.

3.1 The AI Algorithm

The AI algorithm was developed by FA using Python on the basis of a genetic algorithm, which does not require a pre-trained dataset. Each time, two parent patterns were plotted by FA and then hybridised using the algorithm, generating a set of patterns with different mutation rates as a gallery to be selected from. The algorithm goes through each digit of the two matrices (the two parents) with the same dimension that consists of 0 and 1 and randomly selects between the digits of the same position between the two matrices with a specific mutation rate that changes from 0 to 1 or from 1 to 0. Then the algorithm assigns fitness to each generated matrix according to two conditions: 1) if the matrix has more than eight of the same digits continuously in a row, then a penalty is assigned, this is to avoid long floats, and 2) if the matrix has more than four of the same digits continuously in a column then a penalty is assigned, this is to avoid too many tucks. Matrices with higher fitness are selected and output as text files along with images for ease of reading. This algorithm is very primitive and aims merely at generating pattern variations that might be more knittable in order to facilitate a faster exploration of the knitting-scape.

3.2 Documenting the Crucial Nuances

The documentation format takes inspiration from biology research lab journals from FAś previous education training and annotated portfolios as proposed by Portfolio of Loose Ends [16], along with auto-ethnography diaries to record cognitive processes, temporalities, reflections, practical information, and finally digital files that allow the whole choreography of creative knitting to happen. Considering that the creative process is organic and nuances might not fit into the preliminary settings, a draft documentation template was used as a guideline but developed during the creative process as well. The documentation form differed during different stages and was revised multiple times by reviewing all the complete process records. The revision was to ensure that the documentation matches the needs of each stage of the creative process. The final documentation format is presented in the booklet, although all the photographs, drafts, and notes were kept during the creative process as shown in Figure 2

The documentation contains four major categories of information: 1) human interpretations, reflections, and decisions of the information provided by the knitting machine and the material, 2) digital plotting of needle choreography (in digital patterns) and human choreography (manual manipulations), 3) physical facts such as machine, material, textile swatches in images 4) temporality that influences the performances of all participating entities. These categories are being recorded based on the theories of human cognition that exist within the 'Embodied, Embedded, Enactive, and Extended' [10], to fully know what the other agencies within the assemblage are thinking is impossible, we could still plot the surrounding landscape [30]. In this proposal of DIS demonstration, the knitted textile samples along with the booklet of documentation as shown in Figure 1, 2, and 3 will be exhibited together to create a detailed representation of the occurrence of the specific human-AI-machine-material assemblage while making the textile nudibranchs *Jason mirabilis* and *Dendrodoris krusensternii*.

4 CONCLUSION

This project demonstrates how humans, a simple genetic algorithm, a knitting machine, and materials could mutually inform and interact with each other. The booklet and samples also reveal the nuances of the negotiation, collaboration, reflection, and modifications at different levels between the human's embodied cognitive space, pattern generation, machine control and choreography, and material performances in response to knitting structures. Although the creative process in this research is highly personal to the FA due to the fact that each designer would have their own creative process, it illuminates the vibrancy of multifaceted interactions within the human-AI-machine-material assemblage where the final textile creation is the co-contribution of the four groups of entities.

ACKNOWLEDGMENTS

The images in the booklet are photographed by FA and extended to the monochrome background using Photoshop Generative Fill function while the main objects remain untouched. The Python code for the AI algorithm that generates knitting patterns was coded with the support of ChatGPT.

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jason mirabilis

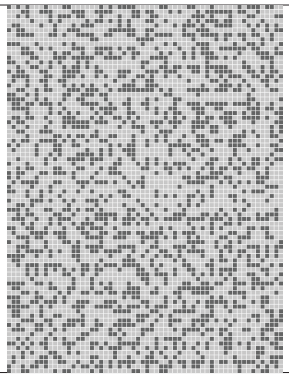
Sample name:	20231213_SeaSlugOne_20231219_1415_m03_i0_tile1 with Tencil Yarn in turns
Task:	Combining the computer generated part with manual manipulation to emphesis the tuck stitches
Pattern:	
Pattern File:	20231213_SeaSlugOne_20231219_1415_m03_i0_tile1.txt
Knitting Mode:	Tuck
Autoethnography Note:	The transparency is very interesting, maybe this alternating yarn technique can be used with the mutated patterns? The Tincel yarn was used for 4 turns, and then switch back to wool yarns for two turns, and then switch to Tincel, such back and forth.
Yarns:	Knitworks London Tincel Pink B&F supermerino Yarnitaly col. magenta
Process:	Knit 2 rows with B&F supermerino + Yarnitaly col.magenta, then 4 rows of Knitworks London Tincel Pink
Date:	2023/12/27 04:17 PM
Time spent:	34m26s (making)
Reflections:	It turns out amazing. The Tincel yarn highlights the yarn routes of tuck stitches. This is too beautiful to be ignored. However, because of too many tuck stitches in a row, it is difficult to knit and creates loads of errors. Some editing is needed. The knit was terminated half way so I can see the effect earlier, just in case it turns out not as nice. But the result is amazing.

Figure 3: Excerpt from the booklet

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