Design Research Society DRS
TEXTILE INTERSECTIONS
Loughborough University, London
20 - 23 September 2023

Generative Nishijin weaving with and for the body

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ABSTRACT:

Nishijin textiles possess a distinctive quality that is indigenous to Japan, exemplified by a diverse range of materials, weaving techniques, loom variations, and design methods. Recently the Japanese kimono industry has been facing a decline, primarily attributed to the growing influence of Western lifestyles in Japan (Cassim et al, 2017). Simultaneously, there is a global shift in textile design towards more intelligent and sustainable directions, driven by societal needs and technological advancements, including the utilisation of eco-friendly fibres and electronically enhanced textiles.

The present abstract serves as an introduction to a collaborative research project in Japan & UK, focusing on material technologies and pattern creation. The study investigates both traditional *kimono* fabric production and the exploration of new materials, such as high-twist yarns, utilising contemporary techniques facilitated by Processing and Clo3D software. By employing forward-thinking production methods and exploring the intersection of digital and physical material-making processes, the research aims to develop body-fit materials and patterns. Specifically, the research poses the question of how to approach the design of complex and three-dimensional woven textiles by employing a diverse range of digital and physical tools, enabling the creation of intricate woven structures.

Through the initial phase of this research, the study successfully achieved the creation of multidimensional and shape-changing cloth structures using zero-waste patterns as a construction method. The research primarily focuses on the transformative capabilities of materials and their role in supporting the design process for the (re)creation of sensory materials. By interpreting the traditional technique of weaving with multiple technologies, it is possible to create advanced materials.

Keywords: generative design; computational textiles; embodied interaction; material/body perception, Nishijin weaves

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1. Introduction

This collaborative project grew out of a previous collaboration with *Nishijin* weavers in Kyoto which formed part of the Textiles Summer School 2022 (Cassim et al, forthcoming)[1]. As a starting point for this research, we investigated 'the formal jacket *(haori*), designed to be worn over a *kimono* for additional warmth' (Marshall, 1988). As an initial experiment to deepen the relationship between design and loom, a pattern for a *haori*, a 'loom-to-body' garment made by draping a rectangular piece of cloth, was produced. 'All traditional Japanese garments are styled for minimal cutting or waste of the fabric while achieving sophisticated and graceful lines' (Marshall, 1988). The idea of zero-waste patterns serves as a foundational step in developing woven clothing patterns on the loom, utilising high-twist yarn. By combining physical computing techniques with Japanese jacquard loom technology, our project aims to manipulate textile patterns using digital tools such as Clo3D, Processing, and Grasshopper, enabling the visualisation of various woven pattern variations.

Our work delves into the interaction between materials, the body, and their interconnectedness within physical and digital contexts. We endeavour to create garments that transform our perception of woven structures. These structures are inspired by digitally encoded materials, dictating the weaving process executed on the jacquard loom. According to Albers (1961), 'being creative is not so much the desire to do something as the listening to that which wants to be done: the dictation of the materials'; this means altering the design process coming from a different direction.

Moving forward from the creation of the *haori*, our next project iteration involves the development of *sarouel* trousers and a jumpsuit as another example of a zero-waste pattern garment, serving as a proof of concept. To achieve this, we aim to create a digital visualisation tool capable of defining woven jacquard structures. The creation of the tool involves the development of software that directly interfaces with the loom software, facilitating the production of three-dimensional woven structures. Creating such software for digitally-enhanced textiles will streamline the workflow involved in designing woven structures and programming novel material cultures within the realm of textile design.

This research endeavours to demonstrate the application of new materials within the *kimono* industry, specifically targeting the reduction of material waste in both the prototyping and manufacturing phase. Ultimately, the goal is to foster the creation of innovative textiles by integrating digital tools and techniques.

2. Background and focus on Nishijin weaving:

Weaving occupies a significant place in the historical trajectory of textile production worldwide, serving as a primary mode of fabric creation. The qualities and applications of the final textiles are profoundly influenced by the choice of materials, fibres and the spinning techniques employed.

This study's focal point of weaving arises from a specific objective to shed light on Japanese looms and their fabrication processes. Incorporating technology into traditional crafts can be challenging due to the various ties involved such as cultural preservation, concerns on protecting intellectual property by artisans and communities or even reducing the craftsperson's freedom. However, the Japanese

[1] https://fabcafe.com/events/kyoto/tss2022_lecture/

narrow-width loom, due to its simplicity, allows for the incorporation of digital methods, blending tradition with innovation. Combining new technologies alongside the tools of tradition is a pioneering method. The decline of *kimono* culture has necessitated re-evaluating traditional Nishijin brocade production, leading prominent manufacturers like Morisan Co. Ltd[2] to explore new avenues. Notably, the adoption of polyester warps instead of silk has emerged as a strategic shift, prioritising the creation of various cloth goods.

This paper concentrates on the unique structure of Japanese Jacquard looms, which have evolved and still are in their own distinct manner since their introduction from Lyon, France, to Nishijin, Japan, in 1873 (Voorwinden & Ueda, 2022). With a rich tradition spanning over a millennium, Japanese artisans have honed their expertise in designing and crafting narrow fabrics on looms tailored for *kimono* production.

Looking at revising traditional Japanese woven structures, we explored novel materials and techniques, including the integration of parametric design methodologies, coupled with the profound knowledge base in smart textiles possessed by both researchers, as well as a deep respect for Japanese culture, new avenues of possibility are unveiled, enabling the creation of innovative materials for not only the Japanese textile industry.

Figure 1 Japanese gold brocade, applications are used in temples

The unique construction of Japanese Jacquard looms, their specialised tools, and the potential for intricate textile design prompt an exploration of integrating parametric methods into textiles. These precision-engineered looms produce intricate patterns reminiscent of embroidery techniques, utilising non-shrinking materials for 3D effects. Moreover, the double cloth construction, with its two layers, opens up possibilities for programming materials two directions.

2.1. Characteristics of Japanese Jacquard looms:

The development of Japanese Jacquard machines coincided with the growth and evolution of the Japanese *kimono* industry; however, the waning prominence of kimono culture has led to a restriction in the production areas of these machines, which are now predominantly found in Kyotango and Nishijin (Kyoto Prefecture) and Kiryu (Gifu Prefecture). 'Over the last hundred years, the *kimono* has fallen increasingly into disuse in Japan. As lifestyles become busier, there is less time to spend on dressing and caring for clothes' (Marshall, 1988).

Weavers in these regions are dedicated to crafting intricate narrow-width fabrics specifically intended for *kimono and the obi* sash worn with it. The Japanese Jacquard machines employed by these skilled artisans represent a fusion of the traditional Jacquard machine and a dobby mechanism akin to the

[2] https://www.mori-san.com/

compound-harness draw loom. The Japanese Jacquard system offers unique functionalities, comprising three integral components, namely the *fumise,* '*boutou,* and 'Jacquard'.

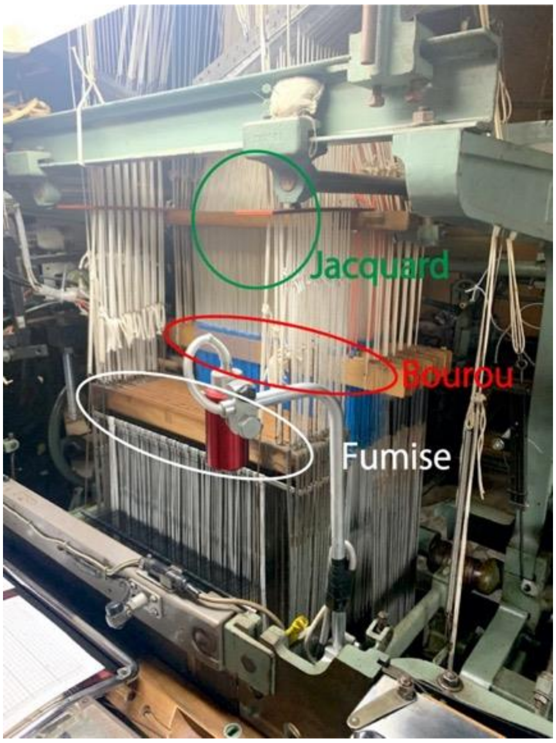

Figure 2 Japanese loom structure demonstrating the different systems

The warp yarns are meticulously threaded through all the machine components within this system. The *fumise*, acting as a dobby mechanism, exerts downward pressure on the yarns, facilitating the creation of large motifs reminiscent of embroidery. On the other hand, the *boutou,* also a dobby mechanism, is responsible for generating the ground weaves, encompassing textures like tweed and satin weaves. The weaver can fashion intricate patterns utilising a limited number of Jacquard hooks by threading multiple warp threads together through the Jacquard heddle.

This elucidation of the Japanese Jacquard system is derived from 'The Innovative Development of the Jacquard Weaving Machine in Japan.' (Voorwinden & Ueda, 2022). It underscores these machines' distinct characteristics and operational features within the context of the Japanese textile industry.

2.2. Characteristics of '*Hatcho Nenshi*'- high twist yarn

In Japan, not only the machines but also the materials are unique. Even today, most *kimono* fabrics are made from *chirimen*, a crepe fabric with a finely textured surface, and the essential material for making this fabric is a high-twist yarn called *hatcho nenshi*. (Ueda et al., 2021).

Hatcho nenshi refers to a silk yarn that undergoes a high twisted process under flowing water and is employed explicitly as the weft for the renowned *Tango Chirimen* in the Kyotango region of Kyoto Prefecture.

One distinctive feature of *hatcho nenshi* lies in its wet twisting technique, which involves subjecting the silk yarn to significant twisting while immersed in running water. Before the twisting process, the outer layer of the raw silk yarn is coated with sericin, a proteinaceous substance. Upon contact with hot water, the sericin layer softens and becomes pliable, allowing for better handling. By incorporating water into the spinning process, the viscosity of the sericin is maintained, ensuring its adherence to the yarn during subsequent drying. As a result, *hatcho nenshi* exhibits a stable and tightly twisted structure, characterised by its thickness and enhanced twist properties. This contrasts with the dry twisted yarns commonly encountered in other countries.

Considering the application of 3D generative design, using *hatcho nenshi* emerges as a powerful and valuable material choice. Notably, not only silk but also polyester is frequently used in the *kimono* industry, thereby offering the potential to manipulate both the design and material composition to create innovative textiles.

3. Approach: Promoting Japanese Textiles through Innovation: Exploring the Intersection of Tradition and Smart Applications

In this section, we outline our methodology for advancing Japanese textiles by integrating innovative approaches rooted in tradition while embracing the potential of smart applications. The goal is to bridge the rich heritage of Japanese textiles with the evolving field of smart textiles, which have gained significant interest in recent years. Smart textiles, defined as fibres, yarns, fabrics, or end products capable of responding to environmental stimuli in a controlled manner (ASTM International, 2020), offer new possibilities for textile design and functionality.

To begin, we draw inspiration from the origins of smart textiles, particularly wearable computing (Post et al., 2000) and ubiquitous computing (Weiser, 1991), as discussed by Buso, A., McQuillan, H., Jansen, K., and Karana, E. (2022). These early developments have paved the way for integrating computing capabilities into textile processes, enabling programmable patterns and enhanced design flexibility. Notably, we highlight the 'Kniterate', a compact desktop digital knitting machine which exemplifies the intersection of smart technologies and traditional knitting practices. Digital designs can be seamlessly translated through the accompanying software into seamless zero-waste knitted garments, facilitating accessible and customisable production. The translation within the software demonstrates the advances within the knitting industry. There is no comparable tool within woven design yet.

Building on this foundation, our methodology centres around leveraging the unique characteristics of Japanese looms and materials to create three-dimensional fabrics. We tap into the expertise of the researchers, who bring their respective fields of knowledge in woven and smart textiles to maximise the potential of loom structures and materials. Dr Kaori Ueda brings a breadth of theoretical and practical design approach in historical Japanese sources and materials. Her created physical woven structures have been influences by the digital processes created by Bine Roth. The woven processes, guided by the specific loom setups, establish conventions that influence software availability and accessibility for designers. This inherent complexity presents an opportunity to explore woven structures using parametric design methodologies and coding techniques. By identifying commonalities and connections between these areas, we aim to simplify and democratise the design process for woven fabrics.

In our investigation, we place emphasis on two key aspects: visual effects and designed for the body structures. By incorporating these elements into woven textiles, we seek to create new aesthetics that redefine the possibilities of not only Japanese textiles. Visual effects encompass a range of techniques, such as intricate patterns that simulate embroidery or the manipulation of colours and textures. On the other hand, designing for and with the body prioritises integrating textile materials that adapt and conform to the wearer's body, enhancing comfort and functionality.

Our methodological approach aims to promote Japanese textiles by innovating from tradition. By bridging the gap between traditional craftsmanship and emerging smart applications, we envision new avenues for creative expression and sustainable textile design. Combining tradition and technological enhancements allows us to enter the new renaissance in the art of making. It allows us 'to combine skills and often highly time-sensitive manipulation of these technologies alongside the tools of tradition (...), producing individual, crafted products of exceptional quality that retain the soul of the material and the skill of the human hand, while also benefiting from the precision, efficiency and increasingly unrestricted structural parameters of digital design and fabrication' (Lucy Johnston, 2015). The following section will delve into the specific techniques and technologies employed in our research, providing a detailed account of our findings and contributions to the field of Japanese textile innovation.

3.1. Design process

One can approach the design process from different directions, either with an idea already in mind or by being given the resources of material and structure. Various possibilities and effects are created, and the choice will impact visually and conceptually. For this approach, we have decided to explore two directions:

1.) Designing for complex material qualities - based on material experiments and observational studies determining the weave structure and output to determine fabric and pattern construction.

2.) Computing materials for a digital design process: Using digital programmes (Processing, Rhino, Illustrator & Clo3D) to visualise and demonstrate the influence on textiles and garment pattern making.

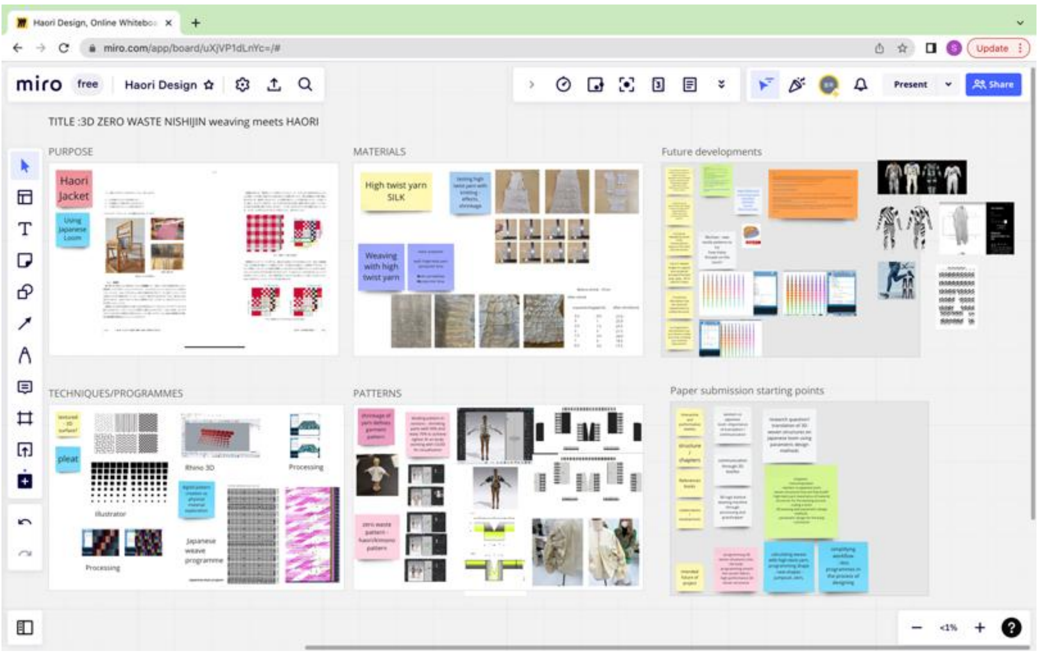

Figure 3: Digital collaboration process, documenting material development and sharing ideas – defining areas of research into purpose/material/pattern/techniques, screenshot taken by researcher, [https://miro.com/app/board/uXjVP1dLnYc=/], via Miro website, June 2023

With these two directions in mind, the material choice and the woven pattern implement the desired fabric qualities to dress a body based on the practical requirements of the garment pattern using digital programmes. As the design evolved, we tested and worked hand in hand with both physical and digital crafting processes.

Materials hold a unique position in the design process. Being involved in every output, materials are the core of storytelling and, finally, connecting people physically with the design. For this proposal, digital and physical created materials are the formal elements of this work and give meaning to the experience. As we are situated in different countries, the designing and sharing process happened via

Miro. We have developed four strands to allow for the material development to define the final design. Please note that this is still a work in progress.

This paper demonstrates their journey of creating complex 3D woven textiles – designing with a different 'toolset' using digital and physical fabrication methods. The focus is on the physical transformation and material supporting the design process for the (re)creation of the developed sensory materials has been focused on by Ueda. However, the digital transformation which have been enhanced through the application of technology to investigate different aesthetic effects of materials has been investigated by Roth. Each collaborator brings their own expertise. Roth has developed over the years a knowledge in digital fabrication of textiles and Ueda bringing her research into industrial assets to support Japan's kimono culture.

3.2. Materials

In this section, we discuss the materials utilised in our project and their impact on the final properties of the yarn and fabric. Specifically, we have focused on using high-twist yarn, which plays a crucial role in achieving desired texture and fit characteristics.

The twisting process applied to the yarn introduces stress, resulting in an unbalanced yarn with excess energy. 'This inherent instability can be harnessed by subjecting the yarn to hot water immersion, releasing stored energy' (Richards, 2021). The silk fibre further enhances this effect as it swells and intensifies the stress on the yarn, triggering a creeping reaction. This technique allows for the creation of contrasting textures and facilitates the fabric's ability to conform to the body. By employing high-twist wefts, more openly set areas provide sufficient space for the crepe effect and subsequent shrinkage to occur, thereby achieving a tailored fit around the body.

To enhance the textural characteristics of the fabric, we have incorporated squares or floats in the weaving structure. These floats create raised areas, while the threads between the floats form compacted regions that exhibit minimal shrinkage or movement. The density of the weave plays a crucial role in maintaining the stability of the yarn and ensuring its proper placement. Consequently, the shrinking effect induced by the creping process contributes to developing a garment pattern that conforms to the body's contours.

It is important to note that the final results are only partially predictable based solely on known fibre characteristics and measurements. Therefore, extensive sampling has been a fundamental aspect of our methodology. While measurements provide a general indication of the expected outcome, the design process for a double cloth fabric has yielded a more predictable shrinkage calculation, consequently aiding in the creation of accurate garment patterns.

By carefully selecting and manipulating the materials, we have achieved innovative fabric textures and tailored fit characteristics. Using high-twist yarn, coupled with the crepe reaction induced by silk fibre and hot water treatment, has enabled us to explore novel design possibilities. However, the iterative sampling process remains essential in fine-tuning the final outcomes, ensuring the successful integration of materials, weaving techniques, and garment patterns. The subsequent sections will delve into the experimental procedures and results obtained, shedding light on the intricacies of our material-driven approach to Japanese textile innovation.


Figure 4 -5 Measuring shrinkage with simple structure, Images taken by researcher January 2023

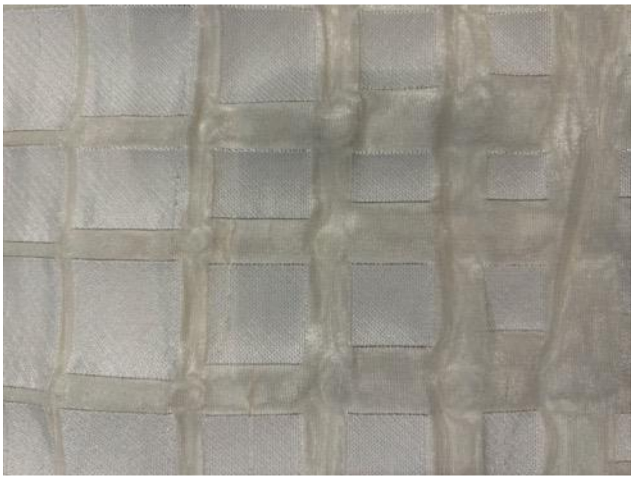

Figure 6 Using evaluation of digital material developments to create 3D woven structures, designs made researcher, woven structures created by Morisan, Images taken by researcher February 2023

Figure 7 Using evaluation of digital material developments to create 3D woven structures, designs made by researcher, woven structures created by Morisan, Images taken by researcher February 2023

3.3. Techniques and crafting technologies

An intriguing question often arises when contemplating the intersection of craft and technology: Can computing, as an advanced technological tool, be considered a form of craft? Specifically, we explore this question in the context of weaving, a traditional craft, and digital programs, which serve as tools for generating new materials.

It is important to note that the final results are only partially predictable based solely on known fibre characteristics and measurements.

Dormer (1997) asserts that although rooted in craft, technology differs from craft itself. As Japanese weavers approach their craft differently, influenced by factors such as loom setup, different pattern notation methods, available materials, and software accessibility, we find similarities between weaving structures and parametric design and coding. Johnston (2015) sees this as a revolution embedding technology into the crafting process, which allows one to see the skills and vision of the artisans using new technologies to free that process from the confines of mass production and move towards means of on-demand manufacturing and individual expression. This opens new avenues for experimentation and creativity in surface design while showcasing the distinct approaches within the conventions of parametric design.

By comparing craft and design methodologies, we can gain insights into the role of design as a tool for generating new materials. Design tools have the potential to support the dissemination of craft knowledge by documenting emergent processes. We consider both human-led and machine-led weaving processes in our exploration.

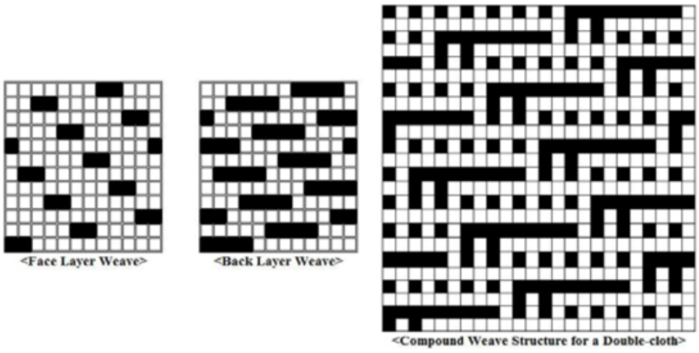

Figure 8 Kim, Ken Ri (2018): Weave structure and image pattern exploration for modern double-cloth design development by deploying digital technology. Loughborough University. Journal contributions

Parametric design, a form of design that involves creating dataflows between parameterised operations to generate new outputs, plays a significant role in our approach to woven design. By manipulating the parameters and elements within the data flow, we can directly influence the resulting weave drafts. We aim to create woven forms that exhibit multidimensional or shape-changing cloth structures.

Our decision to adopt a parametric approach to woven design stems from our desire to create intricate structures and 3D textiles. An underlying algebraic logic exists in the weaving process, which serves as the foundation for constructing a piece of cloth. Considering the continued interest in weaving and other craft-based approaches to interaction design, both within and beyond the field of Human-Computer Interaction (HCI), we recognise parametric design as a tool within the crafting process. It empowers us to leverage unique capabilities made possible by computational processing, expanding the boundaries of textile craftsmanship into digital spheres.

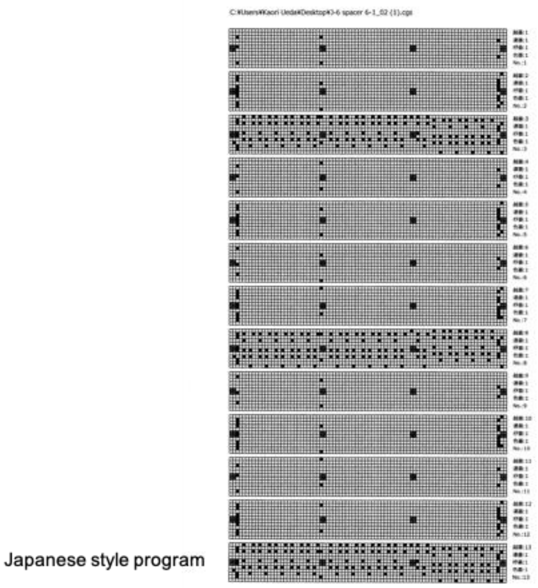

Figure 9 Digital design development by Kaori Ueda, Japanese Jacquard programme, Screenshot taken by researcher February 2023

3.4. Garment pattern development: Loom – to – body patterns

The *kimono* and *haori* patterns exemplify a form of clothing known as 'loom-to-body', wherein the garments are shaped solely through the draping of rectangular pieces of cloth. In this project, we explore the possibilities of shaping woven clothing on the loom by utilising high-twist yarn and incorporating shrinkage calculations. By leveraging the inherent structure of the yarn, we aim to shape the fabric directly on the loom rather than relying on conventional cutting techniques. The focus is on developing techniques that enable the creation of 'loom-to-body' garments, emphasising the shaping process itself.

The transformation of woven rectangles occurs through the interplay of yarns and the weave structure, allowing the fabric to undergo shape-shifting properties. To explore the potential variations in shaping woven rectangles, we employ digital tools such as Clo3D, Processing, and Grasshopper, which enable us to manipulate the coordinates and visualise the outcomes. By combining different materials, variations in yarn twists, and manipulating weave structures, we aim to achieve contrasting effects in the shaping process.

It is important to note that the properties of the yarn, particularly the stress it undergoes during wet finishing, play a crucial role in causing the rectangular pieces of cloth to change shape. While these structural transformations are typically more readily achievable in knitted processes, where increasing and decreasing stitches yield distinct characteristics, we aim to harness similar principles in woven textiles. These techniques have proven highly effective in creating three-dimensional shapes and fostering an interactive relationship between the material and its underlying structure.

3.4 Table 1: Shrinkage of yarn and evaluation

Table 1: Shrinkage of yarn

square(cm)	gap(cm)	After wet treatment (cm)	Definition
3.5	0.5	27.0	Big squares allow for less shrinkage
3	1	25.0	
2.5	1.5	23.5	Gradually shrinking
2	2	21.5	
1.5	2.5	20.0	
1	3	18.5	
0.5	3.5	17.5	Small squares should be places around waste for body fit pattern

3.5. Textile design tools: Interplay of material and structure

In this proposal, we have directed our attention towards integrating computational or structural components to enhance the smartness of textiles. These textiles exhibit active properties during the design and production phases but do not possess active functionalities during their usage. Developing such smart textiles necessitates the utilisation of digital components, employing parametric design as a fundamental tool.

Designing through the process of making offers practical advantages by enabling designers to observe and respond to the behaviour of materials and structures, allowing for the gradual evolution of the design. The designer's responsiveness to feedback from digital prototypes may contrast with their preconceived physical ideas, highlighting the need for a flexible and adaptive approach to design.

The accessibility of computer-aided drafting has facilitated our engagement in more intricate manipulations of textile structures, utilising software programs such as Clo3D, Processing, and Rhino to generate intricate patterns. The visual representations illustrate the evolution of designs from two-dimensional to three-dimensional forms. This prompts whether these digital programs can be seamlessly integrated into the making process and evaluated as successful, even if the resulting outputs are not physical textiles.

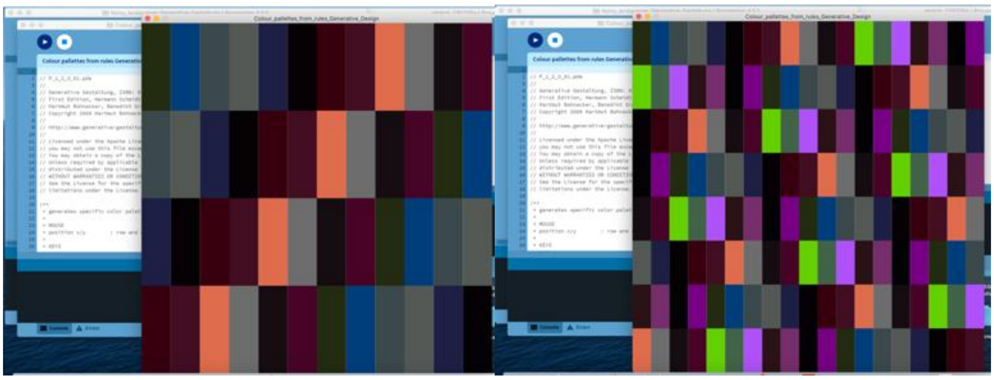

Figure 10-11 Generating patterns and materials using Processing

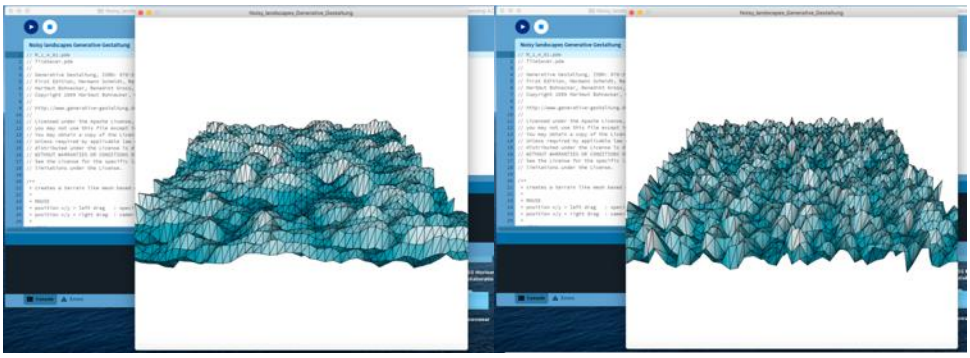

Figure 12-13 Generating patterns and materials using Processing

While visualising designs on paper or screen may possess inherent success, the ultimate evaluation of success or failure lies in creating the textiles and observing their interaction with the material. The quality of the textiles varies based on factors such as the texture and stiffness of the fibre, the characteristics of the yarn, and the pattern employed.

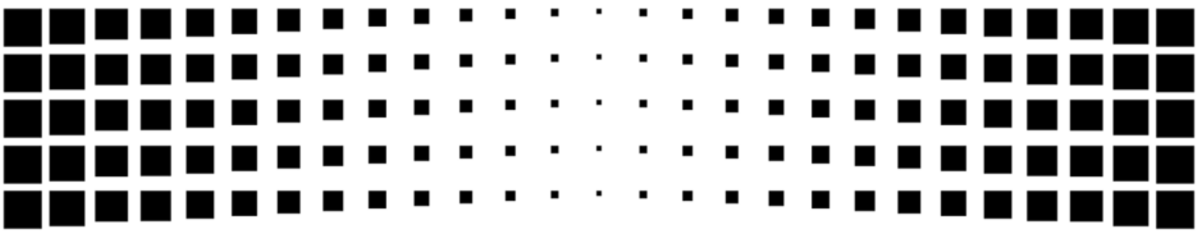

Figure 14 Pattern development: Using evaluation of digital material developments to create 3D woven structures that shrink to fit. Generating a square pattern to allow for different shrinkage within a double cloth. Image created by researcher

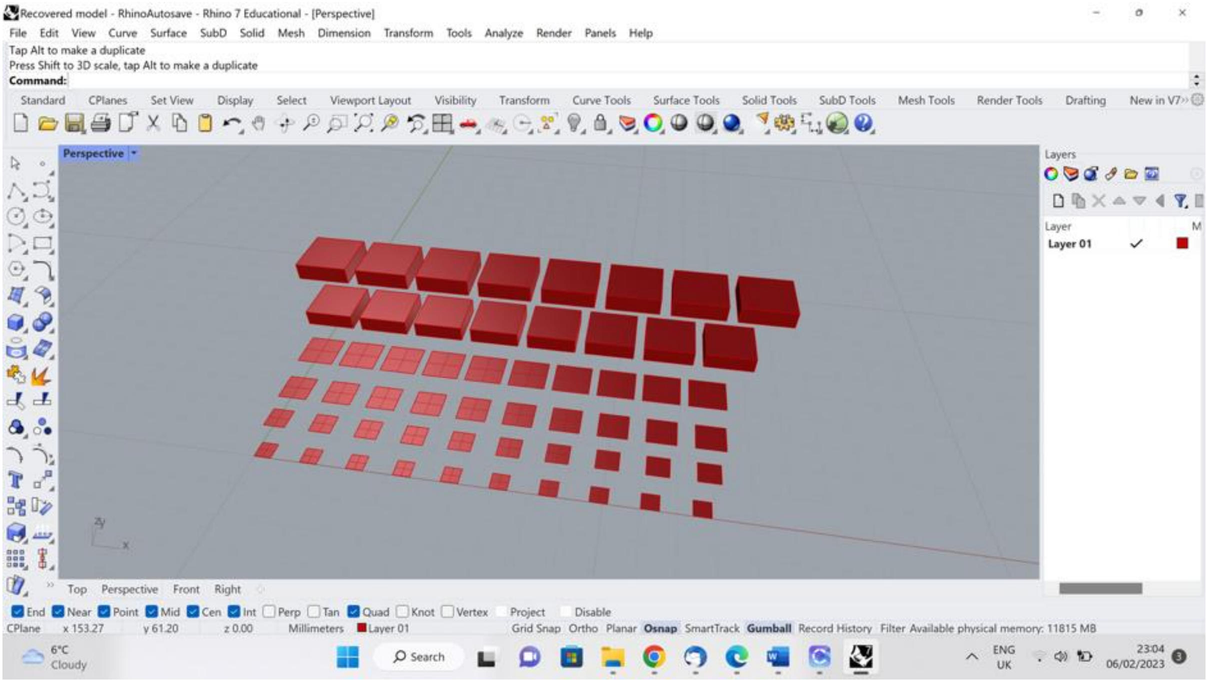

Figure 15 Pattern development: Using evaluation of digital material developments to create 3D structures within woven textiles – generating structures in Rhino to demonstrate 3D output. Image created by researcher

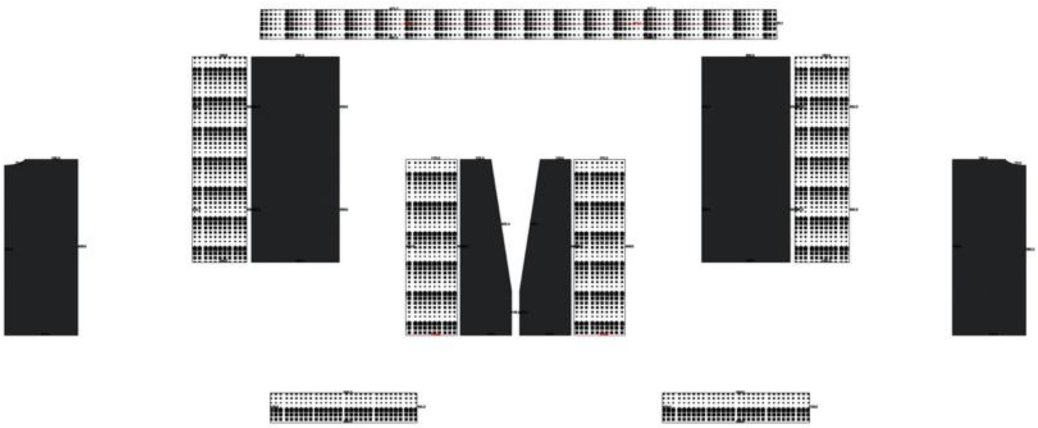

Figure 11 Pattern development: Using evaluation of digital material developments to create 3D woven structures that shrink to fit. Using Clo3D pattern making to calculate shrinkage in various parts of the body using Haori garment pattern design. Screenshot taken by researcher

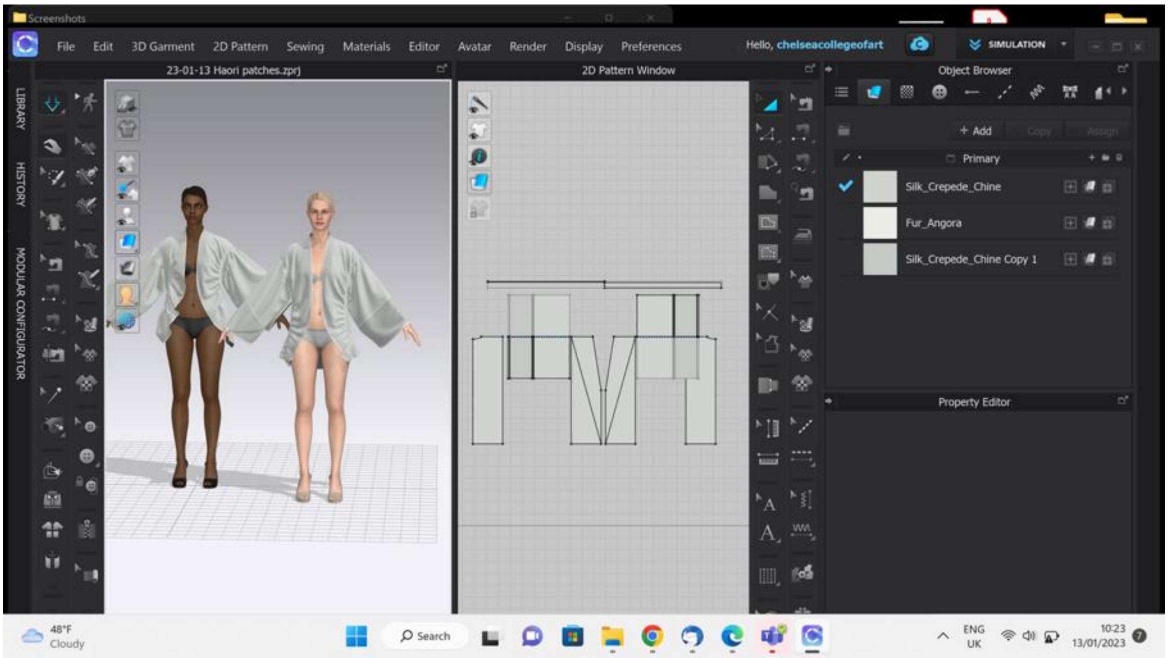

Figure 12 Pattern development: Using evaluation of digital material developments to create 3D woven structures that shrink to fit. Using Clo3D pattern making to calculate shrinkage in various parts of the body using Haori garment pattern design Screenshot taken by researcher

Figure 13 Pattern development: Using evaluation of digital material developments to create 3D woven structures that shrink to fit. Using Clo3D pattern making to calculate shrinkage in various parts of the body using Haori garment pattern design – final rendering by researcher

Figure 15-16 Physical pattern development: Using Clo3 developed patterns applied to toile to test potential shrinkage

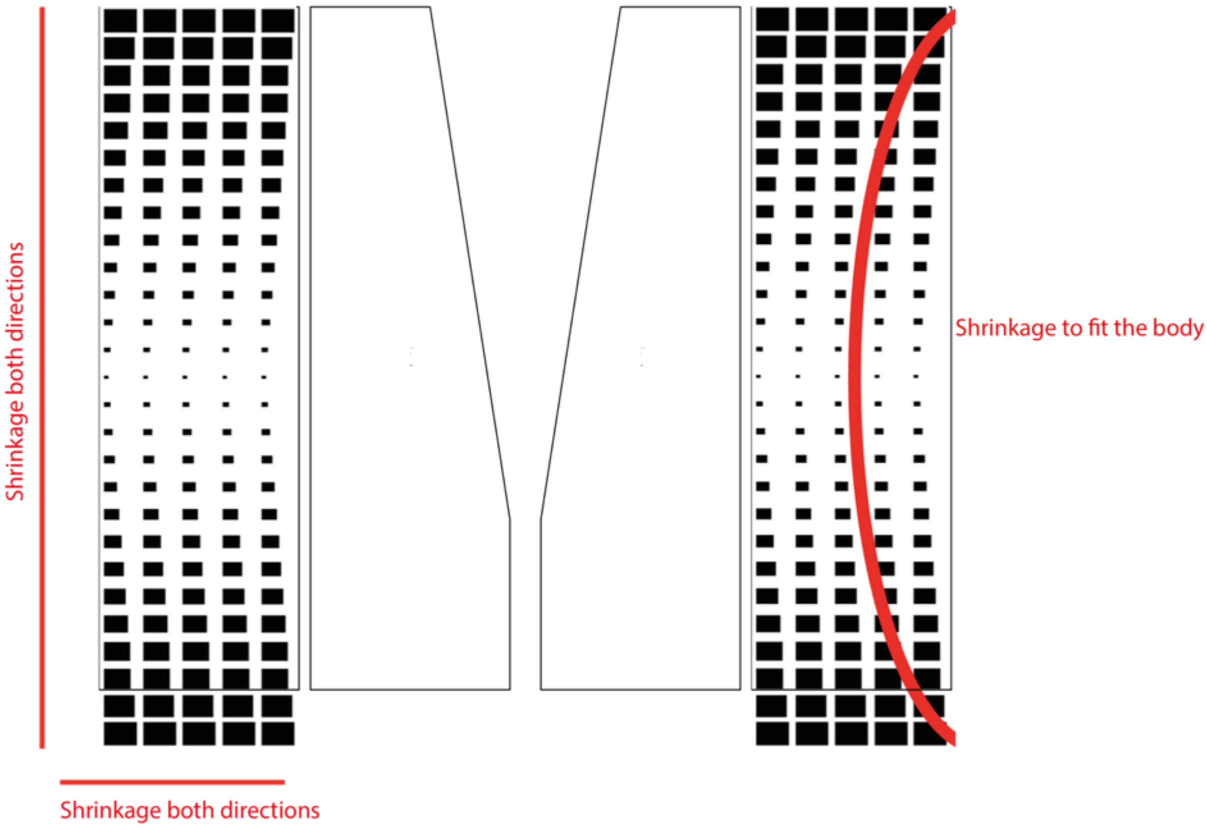

Figure 17 Pattern development: Using square pattern to generate shrinkage and body-fit materials

4. Conclusion and research findings

Through the implementation of three-dimensional prototyping, two *haori* jacket patterns were created, sewn, soaked in hot water, and stretched. The utilisation of high-twist yarn imparted a slight elasticity to the fabric, resulting in unexpected comfort and several potential advantages:

(i) The incorporation of three-dimensionality introduced a sense of luxury to the garments.
(ii) The adjustability of the yarn's elasticity enables the development of different sizes.
(iii) Weaving can be executed according to precise dimensions, minimising excess fabric production.
(iv) The fabric can be cut along planes without the need for traditional patterns, relying solely on graphical representations as guides.

While computer simulations were employed, certain realisations deviated from the assumptions made during the digital modelling stage in Clo3D and Processing. The final prototypes underwent modifications not accurately represented in the computer simulations. A comparative analysis between computer-based and analogue designs revealed the strengths and advantages of both approaches. A comprehensive examination of the advantages and disadvantages of computer-based design methods compared to traditional analogue design processes is as followed explored:
The computer-based methods such as Clo3D and Processing allowed us to explore quick 3D illustrations and build on more complex structures in contrast to the time-consuming nature of analogue design. The digital tools allowed for easy alterations, quick mock-ups, and iterations within the design process, offering greater flexibility during the creative process compared to traditional methods, where changes might require starting from scratch. The digital trials have been explored in the UK in conversation with the Japanese partner. However, referring to the analogue process which has been executed in Japan using Japanese looms, the accuracy of the digital tools was not fully in line with the crafted textiles. The use of Japanese craftsmanship however, enhanced the digital outlook and the precision of tools and weaving allowed for accurate testing and exploration in the physical.

These will be further explored in the following item creations (*Sarouel* trousers and jumpsuit).

Figure 18 – 21 Demonstrating dyeing and shrinkage process for garments after sewing. Image taken by researcher

Figure 22 Development of physical material, developing zero-waste pattern and calculating shrinkage, jacket before dyeing process not shrunk yet, Image created by researcher

Figure 23 Developing haori jacket design, image taken by researcher after dying process which supports the shrinking process of high-twist yarns and allows for fit-to-body structure, Image created by researcher

Figure 24 Final design haori jacket Credit: Kaori Ueda

Figure 25 Second final design haori jacket design using digital and physical material creation, Credit: Kaori Ueda)

4.1. Future challenges and prospects

This research has opened up new possibilities for Nishijin textiles. Moving forward, our focus will be on developing (1) software and (2) materials to enhance the outcomes of our investigations.

(i) The software tools used in this study, namely Processing and Clo3D, proved effective in establishing the relationship between the body and the basic fabric structure. They also facilitated remote communication between Japan and the UK. However, they exhibited limitations in handling complex calculations involving high-twist yarns, weave structures, and graphic patterns. To simulate intricate weave structures and their corresponding complex models, integrating software capable of accommodating various conditions, such as Grasshopper, becomes necessary.

(ii) Exploring and generating pattern designs using body data to allow for 3D structures designed with and for the body.

(iii) Furthermore, the exploration of recycled polyester high-twist yarn, which was not utilised in this project, holds potential. This material possesses shape memory and can be heat-cut, suggesting its applicability beyond clothing-related contexts.

(iv) Analysing computer-based versus analogue design processes in the context of design to create active digital materials to enhance physical material developments

(v) Software tools like Houdini and AI generated patterns are explored to gain more accuracy in the digital and physical material development.

Incorporating these advancements in software and materials is expected to yield higher-level and more accurate research outcomes steering towards more sustainable production.

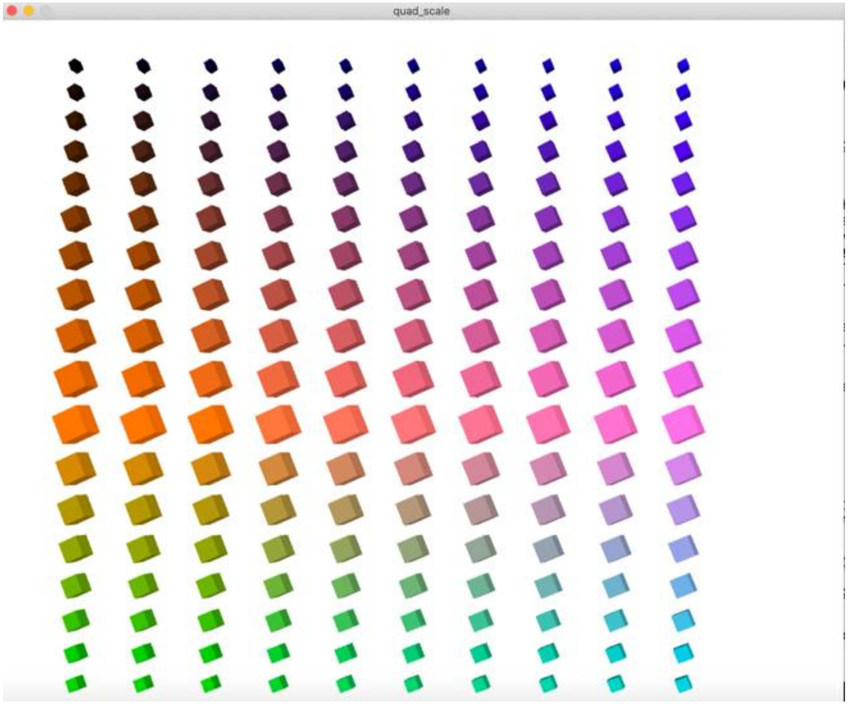

Figure 26 Creation of new patterns using Processing - to allow the development of more 3D structures we will embed Grasshopper in the future

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Images:
Figure 1 Japanese gold brocade, applications are used in temples, taken by researchers, 2021

Figure 2 Japanese loom structure demonstrating the different systems, taken by researchers, 2021

Figure 3 Digital collaboration process, documenting material development and sharing ideas – defining areas of research into purpose/material/pattern/techniques, screenshot taken by researcher, [https://miro.com/app/board/uXjVP1dLnYc=/], via Miro website, June 2023

Figure 4 & 5 Measuring shrinkage with simple structure, Images taken by researcher January 2023

Figure 6 Using evaluation of digital material developments to create 3D woven structures, designs made researcher, woven structures created by Morisan, Images taken by researcher February 2023

Figure 7 Using evaluation of digital material developments to create 3D woven structures, designs made by researcher, woven structures created by Morisan, Images taken by researcher February 2023

Figure 8 Kim, Ken Ri (2018): Weave structure and image pattern exploration for modern double-cloth design development by deploying digital technology. Loughborough University. Journal contributions

Figure 9 Digital design development by Kaori Ueda, Japanese Jacquard programme, Screenshot taken by researcher February 2023

Figure 10-13 Generating patterns and materials using Processing

Figure 15-16 Physical pattern development: Using Clo3 developed patterns applied to toile to test potential shrinkage

Figure 17 Pattern development: Using square pattern to generate shrinkage and body-fit materials, Illustration made by *researcher 2023*

Figure 18 – 21 Demonstrating dyeing and shrinkage process for garments after sewing. Image taken by researcher, 2023

Figure 22 Development of physical material, developing zero-waste pattern and calculating shrinkage, jacket before dyeing process not shrunk yet, Image created by researcher 2023

Figure 23 Developing haori jacket design, image taken by researcher after dying process which supports the shrinking process of high-twist yarns and allows for fit-to-body structure, Image created by researcher 2023

Tables:

About the Authors:

Bine Roth: Her main focus is exploring how the human body and technology connect, leading to the development of new materials, textiles, and artefacts using digital and customised manufacturing techniques. Bine is actively involved in projects using Virtual Reality (VR) and Augmented Reality (AR) and takes part in global community and public engagement initiatives, reflecting her commitment to broader societal interests.

Dr Kaori Ueda: Her research approach is hands-on rather than theoretical, involving practical design methods rooted in historical sources and materials. Notably, during her PhD, she has skillfully recreated antique *chirimen* fabric to compare its quality against contemporary textiles. Another area of her interest lies in the history of looms, particularly the distinctions between the European Jacquard loom and the ones traditionally used in Japan for clothing.

Acknowledgement: We acknowledge the support of Morisan: Hideaki Mori and Yoshi Yamada (https://www.mori-san.com/) for weaving and technical support. We would like to thank Dr Julia Cassim and the Textile Summer School 2022, Kyoto Saga University, for their support (https://fabcafe.com/events/kyoto/tss2022_lecture/). For further development within Grasshopper and Houdini we would like to acknowledge the support of Junichiro Horikawa and the Kyoto Institute of Technology.