SHORT-PAPER

Multistable Leno Woven Textiles

MILOU VOORWINDEN, Delft University of Technology, Delft, Zuid-Holland, Netherlands

KRISTINA ANDERSEN, Eindhoven University of Technology, Eindhoven, Noord-Brabant, Netherlands

HOLLY MCQUILLAN, Delft University of Technology, Delft, Zuid-Holland, Netherlands

Open Access Support provided by:

Delft University of Technology

Eindhoven University of Technology

Published: 12 October 2025

Citation in BibTeX format

UbiComp '25:The 2025 ACM International Joint Conference on Pervasive and Ubiquitous Computing / ISWC ACM International Symposium on Wearable Computers
October 12 - 16, 2025
Espoo, Finland

Conference Sponsors:
SIGMOBILE
SIGCHI

UbiComp Companion '25: Companion of the 2025 ACM International Joint Conference on Pervasive and Ubiquitous Computing (October 2025)
https://doi.org/10.1145/3714394.3750710
ISBN: 9798400714771

Multistable Leno Woven Textiles

Milou Voorwinden
Delft University of Technology
Delft, Netherlands
M.Voorwinden@tudelft.nl

Kristina Andersen
Eindhoven University of Technology
Eindhoven, Netherlands
K.Andersen@tueindhoven.nl

Holly McQuillan
Delft University of Technology
Delft, Netherlands
H.L.Mcquillan@tudelft.nl

Figure 1: Three leno woven multistable textiles. Each repeat of the weave structure forms a column that can be moved by hand and will stay in place until it is manipulated again.

Abstract

This paper presents the development of a set of multistable textiles, emerging from a design exploration into leno weaving techniques. In this structure, two warps cross around a weft yarn, creating an open, yet strong textile. We propose that leno weaving offers unique affordances for creating lightweight textiles with multistable adaptive properties. Our work contributes to a growing discourse on intelligent materials, particularly those that embed interaction potential into their structure and behavior, rather than relying on electronics. The multistable textiles presented in this paper are particularly promising for interactive and wearable applications, where users can actively engage with and adjust the properties of the textile, such as support, flexibility, or breathability, through reversible mechanical state changes. In addition to technical contributions, we reflect on the design considerations and challenges of working with traditional textile craft techniques, highlighting the sustainable and creative potential that emerges from revisiting these practices through a design research lens.

CCS Concepts

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

Keywords

Weaving, Leno, HCI Textiles, Prototyping, Material Driven Design

UbiComp Companion '25, Espoo, Finland

ACM ISBN 979-8-4007-1477-1/2025/10
https://doi.org/10.1145/3714394.3750710

ACM Reference Format:
Milou Voorwinden, Kristina Andersen, and Holly McQuillan. 2025. Multistable Leno Woven Textiles. In *Companion of the the 2025 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp Companion '25), October 12–16, 2025, Espoo, Finland.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3714394.3750710

1 Introduction

Multistable structures are structures with two or more stable configurations under the same external conditions, without the need for continuous energy input to maintain these states [37]. Researchers have explored multi- and bi-stable structures with diverse materials and fabrication techniques to create metamaterial mechanisms [11], kirigami-based metastructures [33, 39], for compliant mechanisms [38], and adaptive wearable interfaces [18]. In soft robotics [7] and in textiles, origami folds and pleats can be used as a bistable structure [25, 35].

Leno weaving, also known as gauze weaving or cross weaving, involves twisting a pair of warp yarns around a weft yarn, resulting in a strong and open fabric structure. Using this technique, we developed a multilayer weave architecture that allows the textile to transition between multiple states, driven by the interaction of material properties and internal yarn movements within geometric constraints caused by the twisting of the leno structure. The samples can exhibit complex behavior, even though they can be constructed from a single material. Our approach aligns with larger goals in animated textiles [5], as these textiles have the potential to reduce dependence on power sources and complex assemblies [22].

Here, we present a fabrication process for, and examples of leno-woven multistable spacer textiles that were developed through an iterative design process. We then reflect on the outcomes and provide design considerations for future development of multistable woven textiles.

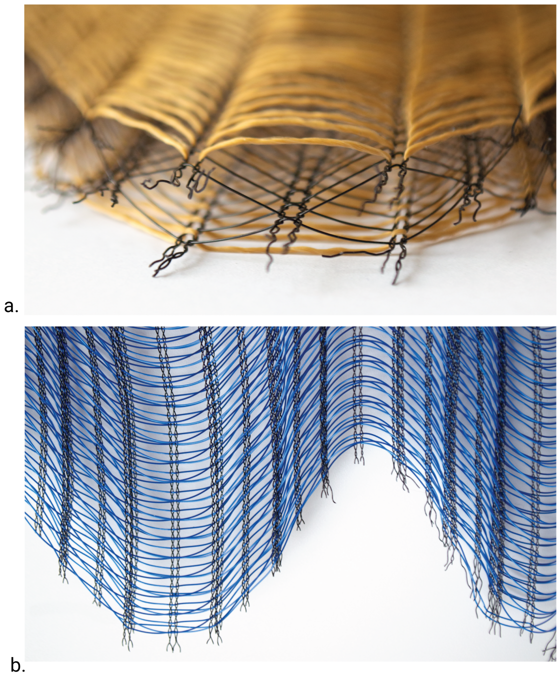

Figure 2: (a) Close-up of the cross-section (b) Top view, showing weft thread movement as columns shift between different states.

2 Related Work

Textiles are of interest to the HCI community for their ability to be programmed at a structural level, enabling interactive (wearable) interfaces that are soft, responsive, and seamlessly integrated into everyday life [5, 9, 26]. Diverse textile techniques are used to create animated textiles such as weaving, [2], felting [17], embroidery [12], lace [13], and 3D printing on textiles [35]. In the context of weaving, designing textiles that can shape change are often achieved through the use of active yarns that shrink [6, 24, 28, 29], or dissolve [4, 16], both of which result in irreversible changes.

Textiles with reversible shape change often rely on specialized yarns such as Shape Memory Alloys [3, 15]. Researchers have developed shape-changing and actuated fibers [8, 14], embedded artificial muscles [20], or achieved through creating auxetic textiles [32] (Z. Wang and Hu 2014; Glazko et al. 2024). Reversible shape change in textiles has also been researched in the context of textile-form [21] to direct the change [23]. Recently, the use of cellulose-based yarns to create a reversible change in textiles [30] has also been explored.

However, multi- or bi-stable textiles, where the textiles have two (or more) passive states embedded in the structure, remain rare. Through knitting, curved shells are developed that present snap-through behaviour [19]. Although not explicitly designed as multistable, some macro-form examples can be found in woven textile-forms. For example, a twisting box that can lie flat or fully expand into 3D form [31], or a textile interface where each end of the textile can be pulled but will remain in that state until pulled further or returned to its previous state [6]. Furthermore, a participant in the same study identified the bistability of a pleated textile as an interesting property for textile interfaces, as they were able to 'lock' the sample and suggested that it could act as a switch.

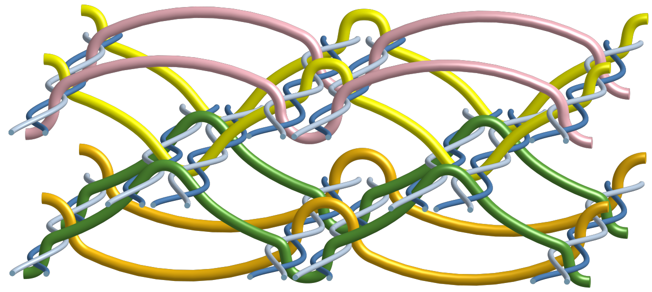

Figure 3: 3D Visualisation of the weave architecture.

In leno weaving, two (or more) warp yarns are paired together (one 'standard' and the other 'doup' or 'crossing'), which are twisted around the weft yarn by hand or using special leno heddles, locking the weft yarn in place [1]. This locking effect makes leno weaving suitable for preventing the edges of shuttle-less woven fabrics from fraying and for creating mesh-like textiles that are breathable, transparent, and strong. Although leno weaving has a long history and is used in many traditional weaving practices [34], today, the knowledge of the technique is disappearing [10]. Researchers are also exploring the development of digital tools to preserve this heritage [36]. While digital tools can help preserve and recreate traditional weaving techniques, we believe these techniques should also be actively engaged with and combined with new materials and techniques to keep this craft in motion. Therefore, this paper presents a material-driven, exploratory approach that aims to investigate the potential this technique can offer for future materials and applications.

3 Multistable Leno Woven Textiles

The samples (Figure 2) and weave architecture (Figure 3) presented in this paper emerged from a design research project exploring the potential of leno weaving to create spacer fabrics. When first working with leno, we observed the tendency of the weft yarns to bend at the leno interlacement, caused by the twisting of the warp yarns. We aimed to leverage this property to create 3D spacer fabrics and developed a multilayer leno structure that forces the weft yarn to be pushed upward or downward by the leno process through the crossing of the warp yarns.

3.1 Fabrication of the structure

For this project, we used a CCI sampling loom with leno heddles. In the leno heddles, two warp ends are paired together, creating a set of leno yarns labeled A, B, and C (Figure 4). Because leno weaving uses one (or more) standard ends and one (or more) doup ends, these yarns have different consumption rates. Therefore, we installed three warp beams to allow the yarn consumption to vary between the standard and doup end of the leno. The warp, a black monofilament (PES 0.22), was selected for its stiffness, which we anticipated would support the bending effect of the weft yarns. The weave architecture was designed to leverage the twist of the leno

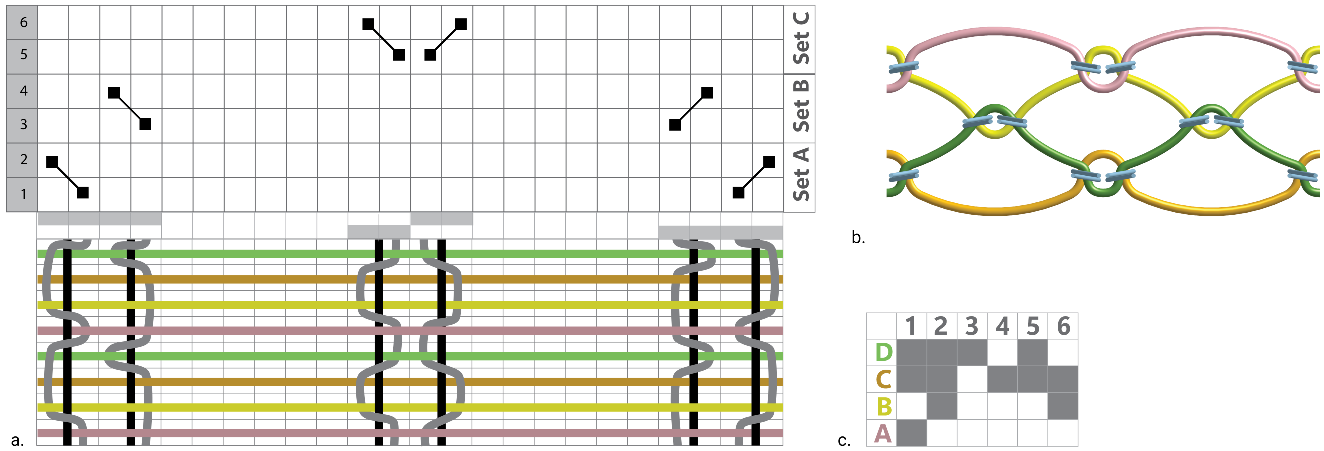

Figure 4: (a)The loom draw-in with three sets of leno, and below a view from above. To align sets A and B of the leno vertically, these warp yarns are threaded through the same reed opening. To create the space between the middle and top/bottom leno's, empty reed openings are left between set B and C of leno. (b) cross-section and (c) Machine diagram for lifting the shafts

ends to bend the weft yarns in alternating upward and downward directions. The structure, as depicted in Figure 4, was woven in 2.5 layers, where leno set A creates alternating directions of weft A (up) and B (down), leno set B alternates weft C (down) and D (up), and leno set C alternates weft B (up) and D (down). When woven with a monofilament, these yarns, due to their smooth surface, can slide at different angles within the structure, but the locking effect of the leno keeps the weft in place once the external force is removed. With this weave architecture, we tested various monofilament weft yarns and observed the different behaviors based on their material composition and diameter. For example, a 0.2 mm non-elastic monofilament produced a 'snap through' effect between states (Figure 5a and b) and behaved as a planar multistable structure. In contrast, a 0.3 mm elastic monofilament allowed the textile to transition more fluidly between states, and it is therefore possible to 'mould' it into a form (Figure 5c and d).

We observed that the combination and placement of various yarns within the weave architecture also significantly influenced the multistable properties of the material. Specifically, positions B and D require a yarn that is both smooth and stiff, as these yarns mainly facilitate movement within the structure. However, positions A and C do not require this stiffness, and can therefore accommodate more flexible materials, such as polyester multifilament yarns, as long as they do not introduce significant levels of friction. Yarns with excessive texture, such as paper or wool, disrupt smooth state transitions and prevent the material from transitioning between different states.

3.2 Designing Multistability

The weave architecture in different yarn combinations presented in this paper opens up possibilities for programmable mechanical properties. The mechanisms contributing to the sample's multistability can be broken down into the microarchitecture, geometry, and material composition. By varying these elements, the potential for programmable mechanical properties with leno weaving is explored.

The micro (or weave) architecture presented in this paper can be altered by changing the interlacement and arrangement. With leno weaving, multiple wefts can be woven in the same shed, allowing them to move closer together. In other sections, each thread can be woven in a separate interlacement, creating more distance between the wefts. The arrangement of threads can also affect the microarchitecture. When there is a greater distance between the sets of leno, the height of the spacer structure is increased, as the threads have more space to move up or down. This could influence the maximum angle at which the fabric can move, as there will be fewer warp threads restricting movement.

While these samples have a uniform geometry, we see opportunities in exploring how leno weaving can be combined with jacquard shedding, to allow for variations in structures in different zones of the textile, particularly when combined with 3D and textile-form weaving, complex textile geometries can be created [27, 29]. For example, we can envision using such structures to be embedded in future 3D woven garments, creating states of wear, guiding movement, or changing in response to external input or manual deformations by the wearer.

Changing the material composition can be leveraged to change the properties of the textile. Varying the weft selection down the length of the textile could already allow multiple behaviors and properties to emerge within one textile, for example, changing the range of motion, height of the spacer structure, and elasticity of the textile. Furthermore, the use of active materials, such as paper, can also elicit other types of animated behavior, as shown in Figure 6. In the context of wearables, we envision that such structures might enable future wearables and garments with complex behaviors based on material properties, movement, and manipulation, resulting in possibilities for both dramatic expressive changes and gradual evolutions of wear and fit.

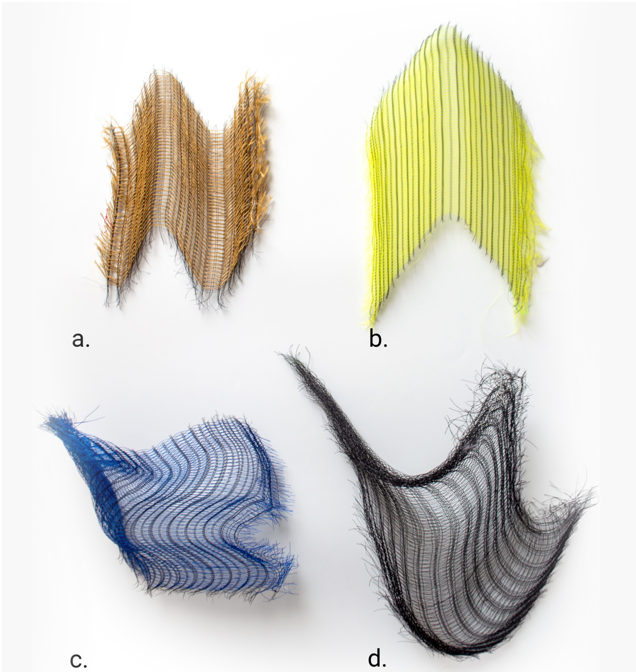

Figure 5: Four samples woven with the same warp yarn (PES 0.22mm monofil), but using different weft yarns, impacting sample behaviour. a. PES 1100CS 150/s , b.PA 0.2mm monofil, c. PES elastic 0.3mm monofil, d. PES 0.22mm monofil.

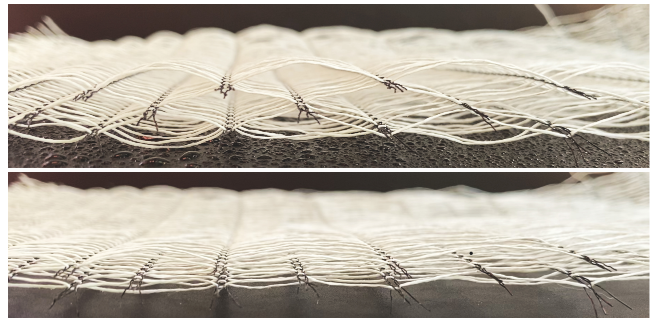

Figure 6: A photo of a sample created using the weave architecture, with paper yarns. When wet, the sample's cross-section expands, then flattens again as it dries.

4 Discussion and Conclusion

In this paper, we present a fabrication technique, material samples, and design considerations for creating multistable leno woven textiles for the HCI and design community. By sharing this fabrication technique, we hope to inspire more explorations in leno weaving and multistable textiles. We believe that by working towards multistable mono-materials, we can create animated textiles via their inherent material potential for movement and active behaviour. This, in turn, enables us to envision new kinds of unobtrusive wearables that can be viewed as devices in their own right.

Leveraging material properties: Although textiles animated through their inherent material properties are beneficial for sustainability goals due to their reduced use of critical resources for electronics and subsequent ease of recycling, they may also improve user acceptance. In informal interactions with the samples, users do not hesitate to interact with these seemingly ordinary textiles, and are then delighted by the surprising multistable behavior. Such novel and unexpected interactions may improve engagement and extend the time it takes materials to be kept in use.

Learning from history and craft: While this paper is grounded in a specific textile structure and technique, our motivation is broader: to open up new material and interaction possibilities using traditional weaving techniques. These traditional techniques, when examined through a design research lens, can reveal overlooked affordances and lead to novel material behaviours. By working with and reinterpreting these techniques, we aim to expand the tools and material library available to designers of wearable and interactive systems.

Limitations: So far, only a limited range of yarns has been applied uniformly throughout one weave architecture. Future research could explore the variables that contribute to this multistable behaviour, including microarchitecture, geometry, and material composition. Furthermore, there are challenges in working with leno. The technique requires a specialised loom setup, and significant weaving expertise, making it less accessible to inexperienced weavers. However, the design considerations we describe can be applied to more widely available methods, such as jacquard weaving. The multistable effects are observed in origami-like pleated textiles, in some multilayer and unbalanced simple weaves. Although we have personally observed and experienced the delight of interacting with these multistable textiles, systematic user studies have not been conducted. Future materials experience studies would help to better understand how users respond to the novel textiles. By articulating how multistability can emerge from the material and structural interactions in woven textiles, we aim to stimulate future explorations of multistable woven textiles.

Conclusion: This paper explores leno weaving as a technique with potential for creating multistable, animated textiles. By developing a set of multilayer woven samples, we show how the structural properties of leno, particularly its twisting and locking behaviour, can be leveraged to enable reversible, passive shape changes without electronics. The fabrication process and material exploration presented here lay the groundwork for future explorations that embed programmable mechanical responses into wearable and interactive systems, offering new directions for sustainable and expressive textile design.

Acknowledgments

We thank the Eurecat Functional Textiles Unit and Virginia Garcia Candel for their valuable collaboration. Special thanks to Francesc Mañosa for his expertise in leno weaving, which was essential to our work. We also acknowledge the Worth Partnership Program for partial funding, which supported this design research. Finally, we thank Thimo Voorwinden for the detailed CAD drawing of the leno structure

References

[1] Amany M. Shaker. 2017. Utilizing the Leno Weave Aesthetic Values in Teaching Weaving for Art Education Students. 7, 1 (2017), 189–200. doi:10.12816/0049418

[2] Joanna Berzowska. 2004. Very Slowly Animating Textiles: Shimmering Flower. In *ACM SIGGRAPH 2004 Sketches on - SIGGRAPH '04* (Los Angeles, California, 2004). ACM Press, 34. doi:10.1145/1186223.1186266

[3] J. Berzowska and M. Coelho. 2005. Kukkia and Vilkas: Kinetic Electronic Garments. In *Ninth IEEE International Symposium on Wearable Computers (ISWC'05)* (Osaka, Japan, 2005). IEEE. doi:10.1109/iswc.2005.29

[4] Alice Buso, Holly McQuillan, Kaspar Jansen, and Elvin Karana. 2024. AnimaTo: Designing a Multimorphic Textile Artefact for Performativity. In *DIS* (Copenhagen, Denmark, 2024). doi:10.1145/3643834.3660738

[5] Alice Buso, Holly McQuillan, Kaspar Jansen, and Elvin Karana. 2022. The Unfolding of Textileness in Animated Textiles: An Exploration of Woven Textile-Forms. In *DRS2022: Bilbao* (2022-06). doi:10.21606/drs.2022.612

[6] Alice Buso, Holly McQuillan, Milou Voorwinden, and Elvin Karana. 2023. Towards Performative Woven Textile-Form Interfaces. In *Textile Intersections 2023* (2023-09). Design Research Society. doi:10.21606/TI-2023/106

[7] Yinding Chi, Yanbin Li, Yao Zhao, Yaoye Hong, Yichao Tang, and Jie Yin. 2022. Bistable and Multistable Actuators for Soft Robots: Structures, Materials, and Functionalities. 34, 19 (2022), 2110384. doi:10.1002/adma.202110384

[8] Jack Forman, Ozgun Kilic Afsar, Sarah Nicita, Rosalie Hsin-Ju Lin, Liu Yang, Megan Hofmann, Akshay Kothakonda, Zachary Gordon, Cedric Honnet, Kristen Dorsey, Neil Gershenfeld, and Hiroshi Ishii. 2023. FibeRobo: Fabricating 4D Fiber Interfaces by Continuous Drawing of Temperature Tunable Liquid Crystal Elastomers. In *Proceedings of the 36th Annual ACM Symposium on User Interface Software and Technology* (San Francisco CA USA, 2023-10). ACM, 1–17. doi:10.1145/3586183.3606732

[9] Maas Goudswaard, Abel Abraham, Bruna Goveia Da Rocha, Kristina Andersen, and Rong-Hao Liang. 2020. FabriClick: Interweaving Pushbuttons into Fabrics Using 3D Printing and Digital Embroidery. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven Netherlands, 2020-07-03). ACM, 379–393. doi:10.1145/3357236.3395569

[10] Brooks Hagan. 2020. Looking Back to Look Forward: Reanimating Textiles for Novel Design and Manufacturing. 8, 2 (2020), 126–142. doi:10.1080/20511787.2020.1731238

[11] Alexandra Ion, Johannes Frohnhofen, Ludwig Wall, Robert Kovacs, Mirela Alistar, Jack Lindsay, Pedro Lopes, Hsiang-Ting Chen, and Patrick Baudisch. 2016. Metamaterial Mechanisms. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology* (Tokyo Japan, 2016-10-16). ACM, 529–539. doi:10.1145/2984511.2984540

[12] Yu Jiang, Alice C Haynes, Narjes Pourjafarian, Jan Borchers, and Jürgen Steimle. 2024. Embrogami: Shape-changing Textiles with Machine Embroidery. In *Proceedings of the 37th Annual ACM Symposium on User Interface Software and Technology* (Pittsburgh PA USA, 2024-10). ACM, 1–15. doi:10.1145/3654777.3676431

[13] Lee Jones, Molly Stewart, Sydney Alana Shereck, Joelle Lintag, Dallas Doherty, Bianca Bucchino, and Sara Nabil. 2025. Interactive Bobbin Lace: Metal Thread History, Interviews with Lacemakers, and Material Explorations with E-textiles. In *Proceedings of the Nineteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '25)*. Association for Computing Machinery, New York, NY, USA, Article 31, 18 pages. doi:10.1145/3689050.3704957

[14] Ozgun Kilic Afsar, Ali Shtarbanov, Hila Mor, Ken Nakagaki, Jack Forman, Karen Modrei, Seung Hee Jeong, Klas Hjort, Kristina Höök, and Hiroshi Ishii. 2021. OmniFiber: Integrated Fluidic Fiber Actuators for Weaving Movement Based Interactions into the 'fabric of Everyday Life'. In *The 34th Annual ACM Symposium on User Interface Software and Technology* (Virtual Event USA, 2021-10). ACM, 1010–1026. doi:10.1145/3472749.3474802

[15] Pin-Sung Ku, Kunpeng Huang, and Cindy Hsin-Liu Kao. 2022. Patch-o: Deformable Woven Patches for on-Body Actuation. In *CHI Conference on Human Factors in Computing Systems* (New Orleans LA USA, 2022-04). ACM, 1–12. doi:10.1145/3491102.3517633

[16] Eldy S. Lazaro Vasquez, Lily M Gabriel, Mikhaila Friske, Shanel Wu, Sasha De Koninck, Laura Devendorf, and Mirela Alistar. 2023. Designing Dissolving Wearables. In *Adjunct Proceedings of the 2023 ACM International Joint Conference on Pervasive and Ubiquitous Computing & the 2023 ACM International Symposium on Wearable Computing* (Cancun, Quintana Roo Mexico, 2023-10-08). ACM, 286–290. doi:10.1145/3594739.3610781

[17] Young Suk Lee. 2015. Spiky Starfish: Exploring 'felt Technology' through a Shape Changing Wearable Bag. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction* (Stanford California USA, 2015-01). ACM, 419–420. doi:10.1145/2677199.2690878

[18] Yuyu Lin, Hatice Gokcen Guner, Jianzhe Gu, Sonia Prashant, and Alexandra Ion. 2025. Wearable Material Properties: Passive Wearable Microstructures as Adaptable Interfaces for the Physical Environment. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (Yokohama Japan, 2025-04-26). ACM, 1–16. doi:10.1145/3706598.3714215

[19] Kausalya Mahadevan, Michelle C. Yuen, Vanessa Sanchez, Robert J. Wood, and Katia Bertoldi. 2024. *Knitting Multistability.* arXiv:2410.14810 [cond-mat] doi:10.48550/arXiv.2410.14810

[20] Ali Maziz, Alessandro Concas, Alexandre Khaldi, Jonas Stålhand, Nils-Krister Persson, and Edwin W. H. Jager. 2017. Knitting and Weaving Artificial Muscles. 3, 1 (2017), e1600327. doi:10.1126/sciadv.1600327

[21] Holly McQuillan. 2020. Zero Waste Systems Thinking: Multimorphic Textile-Forms.

[22] Holly McQuillan and Elvin Karana. 2023. Conformal, Seamless, Sustainable: Multimorphic Textile-Forms as a Material-Driven Design Approach for HCI. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg Germany, 2023-04). ACM, 1–19. doi:10.1145/3544548.3581156

[23] Elizabeth Meiklejohn, Laura Devendorf, and Irene Posch. 2024. Design Bookkeeping: Making Practice Intelligible through a Managerial Lens. In *Designing Interactive Systems Conference* (IT University of Copenhagen Denmark, 2024-07). ACM, 35–49. doi:10.1145/3643834.3660754

[24] Elizabeth Meiklejohn, Felicita Devlin, John Dunnigan, Patricia Johnson, Joy Xiaoji Zhang, Steve Marschner, Brooks Hagan, and Joy Ko. 2022. Woven Behavior and Ornamentation: Simulation-assisted Design and Application of Self-Shaping Woven Textiles. 5, 4 (2022), 1–12. doi:10.1145/3533682

[25] David Melancon, Antonio Elia Forte, Leon M. Kamp, Benjamin Gorissen, and Katia Bertoldi. 2022. Inflatable Origami: Multimodal Deformation via Multistability. 32, 35 (2022), 2201891. doi:10.1002/adfm.202201891

[26] Emmi Pouta, Jussi Ville Mikkonen, and Antti Salovaara. 2024. Opportunities with Multi-Layer Weave Structures in Woven e-Textile Design. 31, 5 (2024), 1–38. doi:10.1145/3689039

[27] Yuyuan Shi, Lindsey Waterton Taylor, Vien Cheung, and Abu Sadat Muhammad Sayem. 2022. Biomimetic Approach for the Production of 3D Woven Spherical Composite Applied in Apparel Protection and Performance. 29, 1 (2022), 159–171. doi:10.1007/s10443-021-09936-5

[28] Riikka Talman. 2018. Designing for Multiple Expressions: Questioning Permanence as a Sign of Quality in Textiles. 6, 2 (2018), 201–221. doi:10.1080/20511787.2018.1514697

[29] Milou Voorwinden, Alice Buso, Elvin Karana, and Holly McQuillan. 2025. A Design Space for Animated Textile-forms through Shuttle Weaving: A Case of 3D Woven Trousers. In *DIS '25, Madeira, Portugal* (Madeira, Portugal, 2025). doi:10.1145/3715336.3735741

[30] Kathryn Walters, Laura Devendorf, and Karin Landahl. 2024. Animated Linen: Using High-Twist Hygromorphic Yarn to Produce Interactive Woven Textiles. In *Dis '24* (Denmark, 2024). ACM. doi:10.1145/3643834.3662146

[31] Kathryn Walters and Veronika Kapsali. 2023. From Boxfish to Twistbox: Developing a Woven Textile Hinge through Bio-Inspired Design. In *Textile Intersections 2023* (2023-09). Design Research Society. doi:10.21606/TI-2023/108

[32] Zhengyue Wang and Hong Hu. 2014. Auxetic materials and their potential applications in textiles. *Textile Research Journal* 84, 15 (2014), 1600–1611. arXiv:https://doi.org/10.1177/0040517512449051 doi:10.1177/0040517512449051

[33] Yi Yang, Marcelo A. Dias, and Douglas P. Holmes. 2018. Multistable Kirigami for Tunable Architected Materials. 2, 11 (2018), 110601. doi:10.1103/PhysRevMaterials.2.110601

[34] Mei Yu Yao and Li Li. 2025. Revival of Cultural Textile Arts: Creation of Innovative Weaving Technology for Fabricating Traditional Chinese Non-Fixed Four-Warp Leno. 116, 6 (2025), 1071–1077. doi:10.1080/00405000.2024.2366027

[35] Jiakun Yu, Supun Kuruppu, Biyon Fernando, Praneeth Bimsara Perera, Yuta Sugiura, Sriram Subramanian, and Anusha Withana. 2024. IrOnTex: Using Ironable 3D Printed Objects to Fabricate and Prototype Customizable Interactive Textiles. 8, 3 (2024), 1–26. doi:10.1145/3678543

[36] Lan Yu. 2023. Digital Sustainability of Intangible Cultural Heritage: The Example of the "Wu Leno" Weaving Technique in Suzhou, China. 15, 12 (2023), 9803. doi:10.3390/su15129803

[37] Hang Zhang, Jun Wu, Daining Fang, and Yihui Zhang. 2021. Hierarchical Mechanical Metamaterials Built with Scalable Tristable Elements for Ternary Logic Operation and Amplitude Modulation. 7, 9 (2021), eabf1966. doi:10.1126/sciadv.abf1966

[38] Ran Zhang, Thomas Auzinger, and Bernd Bickel. 2021. Computational Design of Planar Multistable Compliant Structures. 40, 5 (2021), 1–16. doi:10.1145/3453477

[39] Xiao Zhang, Jiayao Ma, Mengyue Li, Zhong You, Xiaoyan Wang, Yu Luo, Kaixue Ma, and Yan Chen. 2022. Kirigami-Based Metastructures with Programmable Multistability. 119, 11 (2022), e2117649119. doi:10.1073/pnas.2117649119