Computational Tailor-Making for Personalized, Shape-changing, and Sustainable Fabrics

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Abstract

Fabrics are fundamental elements of our daily lives, which are woven, knitted, or embroidered into diverse products like clothing and furniture. Recent advances in materials science and digital fabrication have enabled us to fabricate personalized and responsive fabric products computationally and interactively, which we call "computational tailor-making." In this workshop, we will build an interdisciplinary network of researchers on computational tailor-making and discuss (1) computational fabric design, (2) novel fabric fabrication tools, (3) shape-changing fabrics, and (4) sustainable fabric production, from the viewpoint of HCI. The workshop session will help attendees build a shared vision, recognize potential challenges, find unexpected solutions and ideas, collaborate beyond disciplines, and explore the possible connection to industries.

CCS Concepts

• **Human-centered computing** → **Interaction devices**; *Interactive systems and tools*; • **Applied computing** → *Computer-aided design.*

Keywords

Fabrics, Textiles, Sustainable Fashion, Shape-changing Interfaces, Computational Design and Fabrication

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1 Introduction

Fabrics are woven, knitted, and embroidered into our everyday lives, appearing as clothing, furniture, and a wide range of other daily products. Thanks to advancements in materials science and digital fabrication, researchers in HCI and CG have recently been exploring ways to make the traditional fabric manufacturing process more computational and interactive. Such "computational tailor-making" could lead to revolutionizing the fashion and fabric industries by introducing innovative tools and methods that enhance creativity, efficiency, individuality, and sustainability. Here are some examples:

1. Interactive fabric CAD tools that allow designers to easily switch between 2D textile patterns and 3D draped garments, providing immediate and accurate feedback [20, 29, 35];
2. Novel fabric fabrication tools (e.g., custom 3D printers) accessible and useful for both non-traditional and traditional fashion designers, allowing for rapid prototyping and functional materials/structures [9, 30, 33];
3. Shape-changing fabrics in response to various stimuli and situations (e.g., temperature, pneumatics, user's manipulation) [2, 10, 16];
4. Sustainable fabric production by reducing wastes with constrained pattern design and biodegradable materials [42, 43], or by upcycling and repurposing waste [23, 24, 31].

In the past, the HCI community has offered multiple workshops and SIGs for e-textiles [6, 13, 14]. However, the recent interest in fabrics is not limited to e-textiles. Rather, wider aspects like fabrication, geometry, and materials are gaining attention [34]. In this workshop, we will build an interdisciplinary network of researchers on computational tailor-making, to learn from each other's perspectives and work, identify open research spaces in the computational

design of personalized, shape-changing, and sustainable fabrics, and provoke discussions on the tools and techniques for potential design and solutions. We believe that the workshop will help researchers with similar interests build a shared vision, recognize potential challenges, collaborate beyond disciplines, and explore the possible connection to industries.

2 Workshop Procedure

Our workshop will include:

- Fabric-related lectures by HCI researchers;
- Hands-on activities. The audience will experience (1) weaving with a toy jacquard loom, (2) handmade solid knitting, and (3) other fabric fabrication methods;
- Discussion within small groups regarding the fabric-related topics detailed in the next section. We will identify potential research directions and collaborations;
- Presentation of the discussion results from each group.

The main goal of this workshop is to bring together researchers who are interested in exploring how HCI can contribute to computational tailor-making or how computational tailor-making can contribute to HCI. We will provide an opportunity where people from different fields, such as computer graphics, digital fabrication, materials science, robotics, and electrical engineering, can share ideas, methods, and findings.

3 Topics

3.1 How Can We Design Fabrics for Personal Demands?

The introduction of the interactive fabric CAD tools marked a significant shift. Especially, recent projects often focus on how people can interactively switch from 2D to 3D and vice versa. For example, users can simulate how 2D sewing patterns fit 3D human models [8, 35]. Inversely, various methods can generate 2D patterns that meet individual demands. For example, patterns are tailored from garment 3D models [29], individual body shapes and movements [39], and required kinesthetic force feedback [36, 37]. Recently, AI-powered CAD tool [25] generates 2D sewing patterns of garments even from a single photo of a person wearing it, with the help of a large data set including images and corresponding sewing patterns. Other than the pattern shape, there are many prior works on computational fabric design, such as a parametric textile design system [5] and compilers for machine and manual knitting [12, 26].

We will map existing systems and discuss the remaining possibilities of fabric design systems.

3.2 What are the Potential Applications of Fabric Fabrication Tools?

In HCI, people have proposed multiple fabrication methods to achieve hairy [22, 27, 38], woven [9, 33], and non-woven [28, 30] structures mainly using 3D printers. Among others, 3D Printed Fabric [33] and DefeXtiles [9] achieved quasi-woven structures by connecting pillars and the under-extruded filaments of FDM 3D printers, respectively. The current benefits of 3D printed fabric are a combination of functional filaments (e.g., conductivity, color change, shape memory effect) and design freedom of the structure not necessarily restricted to weaving or knitting. As a typical example, our workshop will explore the potential benefits and applications of 3D printed fabric. Along with quasi-fabric structures, we will also investigate how we can design, fabricate, and leverage 3D printed garments [7, 11, 32], shoes [1, 3, 41], and other products in the context of HCI.

3.3 How can Shape-Changing Fabrics Contribute to Interactive Fashion?

In the last decade, researchers in HCI have explored different ways of shape-changing fabrics and garments for multiple applications. For example, a small rover holding the fabric with magnetic force [4, 15] was used as a movable I/O unit. Also, McKibben pneumatic actuators were embedded in knitted or woven fabrics to achieve a movable wrist band [18] or a posture correction garment [16]. Another popular shape-changing approach is the use of thermally shrinkable threads such as shape memory alloys (SMA) [17, 19, 21] and liquid crystal elastomers (LCAs) [10], which are knitted or woven inside fabrics. More simply, a tendon embedded inside a machine-knitted structure can actuate soft objects [2].

However, the actual use of shape-changing fabrics is still quite limited (except for, for example, Steam Stretch fabric by ISSEY MIYAKE [40]). We hope to discuss how they can contribute to user interaction.

3.4 How can HCI Help Reduce Wastes and Create from Wastes?

The fashion industry has been under increasing pressure to adopt more sustainable practices. The computational tailor-making process enhances environmental sustainability mainly by (1) low-waste fabric production which creates the fabrics with minimum fabric wastes during production process [42] and (2) fabric waste upcycle which repurposes fabric scraps from garment production process and discarded clothing for sewing practice [24] and patchwork [23, 31].

Along with the use of biodegradable materials [43], we will discuss how the HCI community can contribute to the development of innovative tools and technologies that support these sustainable practices, enabling designers and manufacturers to efficiently implement low-waste or zero-waste fabric design and fabric waste upcycling in their workflows.

4 Outcomes and Next Steps

One of the major outcomes of this workshop will be a research network for successive collaboration. To maximize the outcome, we plan to invite or send researchers to work on the problems and ideas found in the workshop session. An important next step would be to repeatedly have the gathering at least annually in HCI conferences to update our topics and involve more people to work together. Also, inviting people from the fashion industry to our community will help specify the practical issues and scale future outcomes in the wild.

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