E-Serging: Exploring the Use of Overlockers (Sergers) in Creating E-Textile Seams and Interactive Yarns for Garment Making, Embroidery, and Weaving

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ABSTRACT

Sergers, also known as overlockers, are common textile machines often found alongside sewing machines in homes and makerspaces. Despite this ubiquity, their application is underexplored in e-textile research. In this pictorial, we demonstrate the potential of sergers in seamlessly integrating interaction in garments and everyday home objects. After identifying the properties of various stitches and their utility for e-textiles, we demonstrate seven prototypes that implement our technique. Moreover, we present an innovative use for sergers to 'interlace' colorful conductive yarns that we call 'sperged threads'. Using a research through design approach, we explore potential applications in several hybrid crafts, including e-textile sensors, garment making, weaving, sewing, and embroidery. Through this work, we aim to inspire researchers, and empower the maker community, to explore e-textile serging, or 'e-serging'.

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Colourful conductive thread made with our new 'sperged yarn' technique.

Authors Keywords

serger; overlocker; serging; e-textiles; sensors; sewing; garment making; embroidery; weaving; hybrid crafts; wearables; interactive interiors

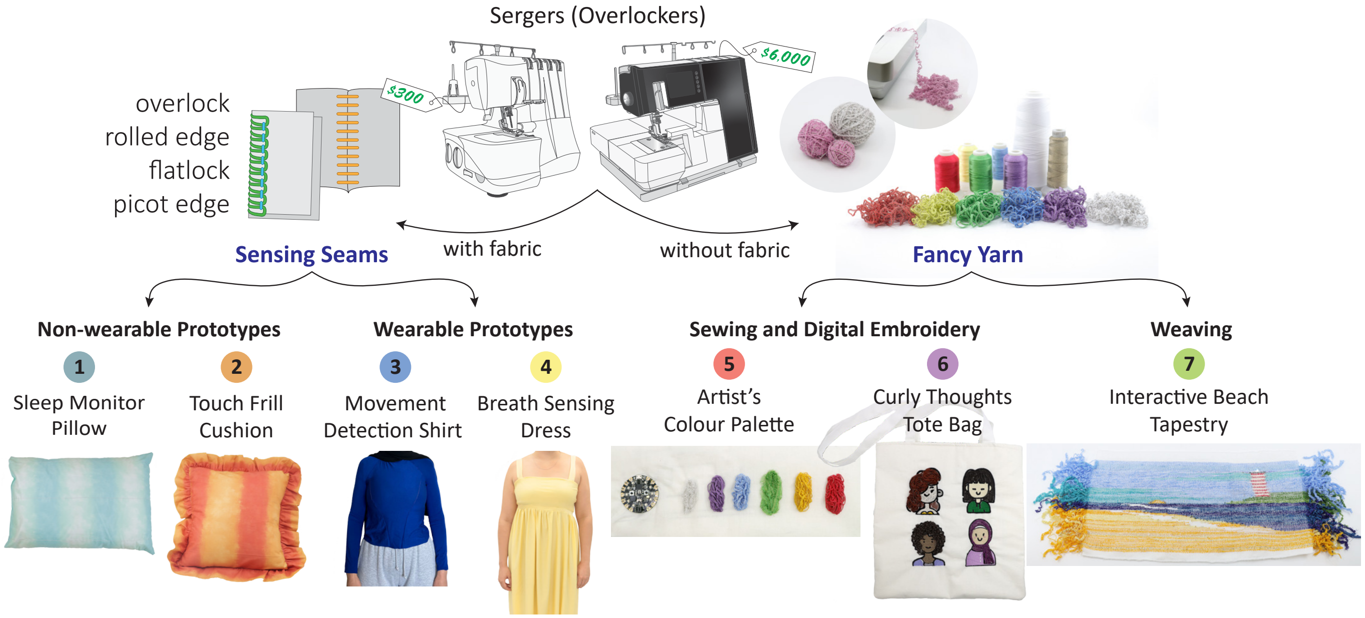
CSS Concepts

• Human-centered computing~Human computer interaction (HCI)

INTRODUCTION

In the field of e-textiles, novel fabrication methods increasingly intertwine with traditional crafting techniques. The scope now extends beyond conventional swatches [7,25,43], pieces [19,60], and samplers [29] to wearables [31,34] and non-wearable applications [44]. The increasing interest among the hybrid craft community to seamlessly integrate traditional craftsmanship with electronic capabilities promises an era of interactive everyday artifacts [1,30,71]. HCI researchers explored various e-textile hybrid crafts ranging from weaving [64], knitting [2,42], crocheting [52], and embroidery [14,38,47,69] to patchwork [4], goldwork [30], and punch-needling [23,32]. Hand-stitching is also extensively explored as practitioners and researchers delicately integrate conductive materials manually, with considerations like wider needles for fraying yarns and tighter connections around board pins [74]. Yet, the opportunity of using overlock (or serger) machines remains relatively underexplored [50,60].

Overlock machines, also known as sergers, are widely used by practitioners and hobbyists to 'finish' or 'sew and finish' garments, home furnishing, and fabric-based projects. This mechanized approach has the potential of, not only supporting the fabrication process beyond the realm of single instances of hand-stitched prototypes, but also democratizing access for individuals lacking sophisticated and expensive machinery. Sergers are, on average, significantly more accessible, familiar, and affordable than their embroidery counterparts. This can expand the design space for e-textile circuits from simple beginner kits [75] to a spectrum of applications including wearables [31], interiors [5], health [40], automotive [36], and beyond.



Though there is some inital research into machine-serged sensing sleeves [61], sergers can be involved in fabricating a broader range of interfaces. In this pictorial, we employ a 'Research through Design' [16] approach to explore the use of sergers and their creative interactive applications, beyond their traditional usage, in e-textile design.

We present three main research contributions, as follows.

- Investigating the properties of machine-serged stitches using conductive threads with varying factors (including stitch type and conductive thread placement) and their impact on conductivity and resistance.
- Introducing the technique of creating colourful conductive yarn for e-textiles using sergers, termed 'sperged threads'.
- Demonstrating the potential of e-serged applications through seven functional prototypes, where interactive elements are seamlessly integrated with garment making, sewing, embroidery, and weaving.

RELATED WORK

The increasing interest in e-textile circuits within the DIY community has fostered a wealth of educational resources, including books [9,35], web tutorials [76–78], and kits [6,8] primarily tailored for beginners. However, these resources often revolve around introductory light switch circuits, limiting options for users to delve deeper into more seamless sensing applications. Despite serving as accessible entry points, these resources predominantly rely on hand-sewing or alligator clips, hindering the production of robust applications, as well as automation, reproducibility, and scalability.

Researchers have explored various avenues to automate the design of e-textile circuits. Some have discussed making sensors from scratch [55] and interactive methods for embroidery [20] while others innovated hybrid tools for crafting such as Irene Posch's adapted measuring tape into a multimeter probe [57]. Prior work has also developed means to iron-on circuits [37], enable sewing-free wearable prototyping [31], and develop ThreadBoards [26] (as opposed to breadboards). These novel approaches help bring e-textile research closer to practical applications in collaboration with both practitioners [11,12,62] and industry [58].

Previous work on 'wearable' circuits include elements such as socket buttons [7], sequin [43], and beads [69] for integrating switches and sensors. Examples such as smart sleeves [54,67] and smart shoes [21,33,72] show potential and can be expanded further through machine serging. Likewise, digital embroidery has gained a lot of recent interest where it's used to add sensors and actuators [47,59], create circuits [36], or create dynamic visuals [38]. This research gap prompts exploration into the realm of digital fabrication using serger/overlock machines for e-textile circuits, aiming to advance the automation and scalability, as well as the empowerment of the maker community, of this evolving field. Sergers, or even overlock-style stitches made on a sewing machine, have been mentioned or used in previous e-textile research to study scalable e-textile manufacturing solutions [45], as part of a community-led maker space's toolset [24], and in various tangible e-textile applications [17,54,56,60,66]. Yet, none of the literature focuses on sergers as a digital fabrication tool in its own right, creating a missed opportunity to do more than finish fabric seams.

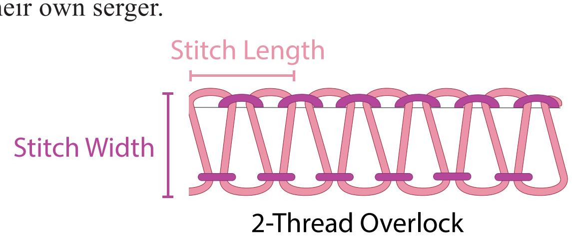
Aside from the conventional way of using sergers to finish seams, we also explore 'fancy yarns' [10,18] and spinning as a traditional textile craft [28]. Fancy yarns, or novelty yarns, are those that are unusual and inconsistent in shape, form, texture, or colour – as opposed to regular yarns, which are deliberately manufactured to be an even, uniform, and consistent as possible [18]. Previous research has already studied traditional techniques for spinning yarns and its implications on spinning interactive yarns in the field of HCI [28]. Researchers have also recently looked into Biofibers [39] and EcoThreads [73] in sustainable efforts to explore custom-made interactive yarns. In this pictorial, we explore another form of custom-made conductive fancy yarn and a new, unconventional technique for making them.

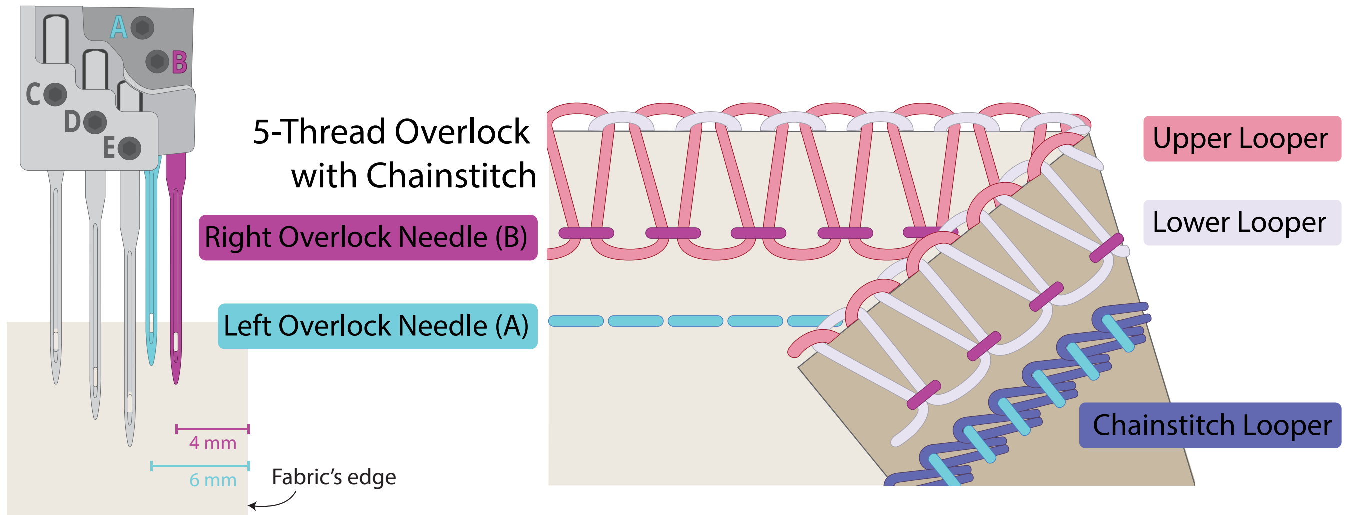
SERGER BASICS AND TERMINOLOGY

Sergers, also known as overlockers, are specialized sewing machines designed to finish, protect, and seal fabric edges, resulting in neat and durable seams that prevent fraying. Unlike traditional sewing machines, which use two threads (spool for needle and bobbin underneath), sergers can use anywhere between two and five threads (spools for needles and loopers underneath). This affords sergers the versatility to perform various stitches, such as overlock, flatlock, and rolled edge, for different fabric needs.

Some overlock machines (like our PFAFF admire™ air 7000) offer five needle positions and three loopers. Different combinations of these various needles and loopers play distinct roles in creating different stitches and finishes. The left and right overlock needles (A and B, respectively) create the stitches into the fabric that hold overlocks in place. They can be used together like twin needles, or individually for wider (A) or narrower (B) stitches. The optional left, middle, and right coverstitch needles (C, D, and E, respectively) can allow the serger to operate like a sewing machine and may be used in different combinations to create triple, wide, or narrow coverstitches. The middle coverstitch needle (D) also acts as a chainstitch needle when used on its own.

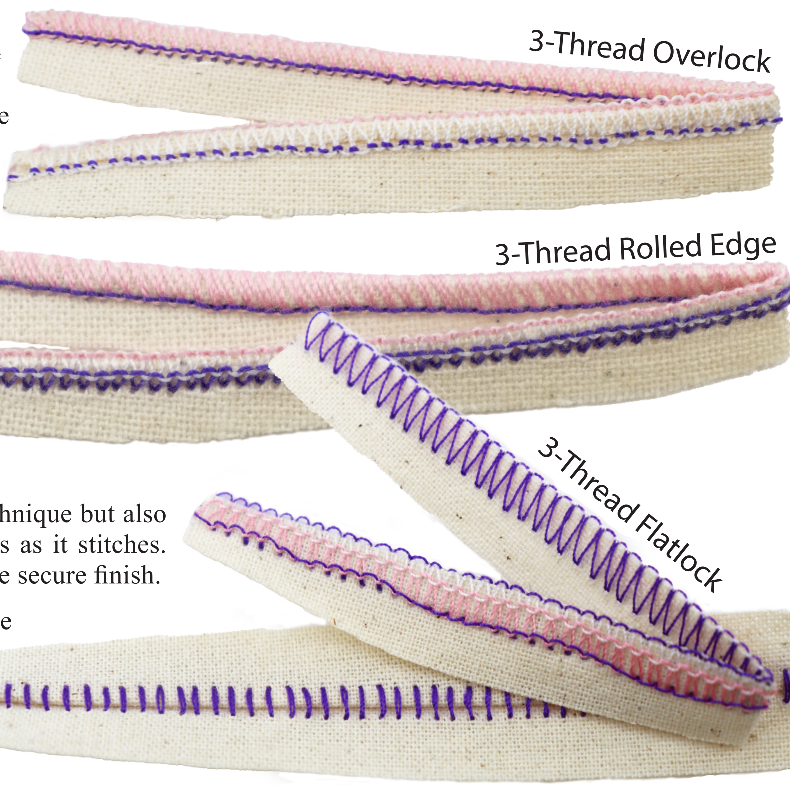
The upper looper works by grabbing the upper thread and pulling it around the edge of the fabric, while the lower looper complements this by grabbing the lower thread around the fabric's edge on the other side, interlacing them as the needle stitches. In the case of a chainstitch, the chainstitch looper forms continuous loops in the back of the fabric. Some sergers offer customization controls for thread tension, differential feed adjustment, and stitch length. Changes in these settings are typically made based on fabric and thread type. Users need to refer to their owner's manual to understand these settings on their own serger.





SERGER STITCHES

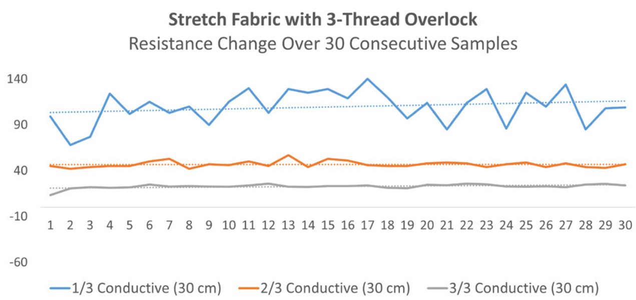
Three stitch types are of particular interest for the applications in this pictorial: 3-thread overlock, 3-thread rolled edge, and 3-thread flatlock. All three stitches use the right or left overlock needle, the upper looper, and the lower looper.



1. The **3-thread overlock** stitch exemplifies the simplest application of the serger and is the most widely used stitch for garment seams. The overlock needle pierces through the fabric while the loopers loop the threads around the fabric's edge.
2. The **3-thread rolled edge** applies a similar technique but also rolls over the edge of the fabric into the loops as it stitches. This creates a thicker and, simultaneously, more secure finish.
3. Finally, the **3-thread flatlock** creates a decorative stitch when two fabrics are serged together and pulled apart. By making shorter and looser loops with the lower looper between the overlock needle and the upper looper, the serger leaves a space tolerance that makes room for the threads to stretch and sit tighter when pulled, creating a decorative effect on the flatlock side.

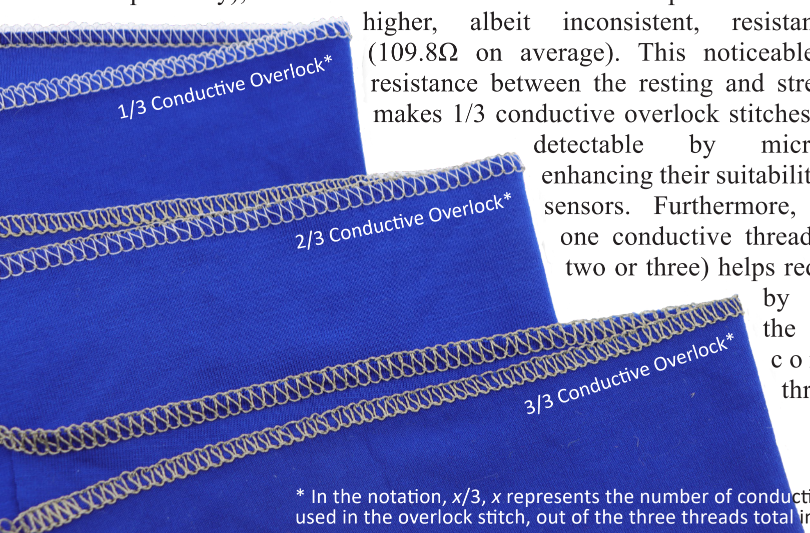
SERGING WITH CONDUCTIVE THREAD

Previous work has explored the use of sewing with conductive thread [8,61], but the effects of serger stitches made using conductive thread focused mainly on sleeve seams [60]. In this section, we characterize the effects of using conductive threads in overlock stitches on measurable resistance changes and illustrate applications of this method through four serged prototypes. For this characterization and these prototypes, we used Madeira HC-40 for the conductive thread, exhibiting <300 Ω/m in its resting state (100% Polyamide/ Silver-plated).



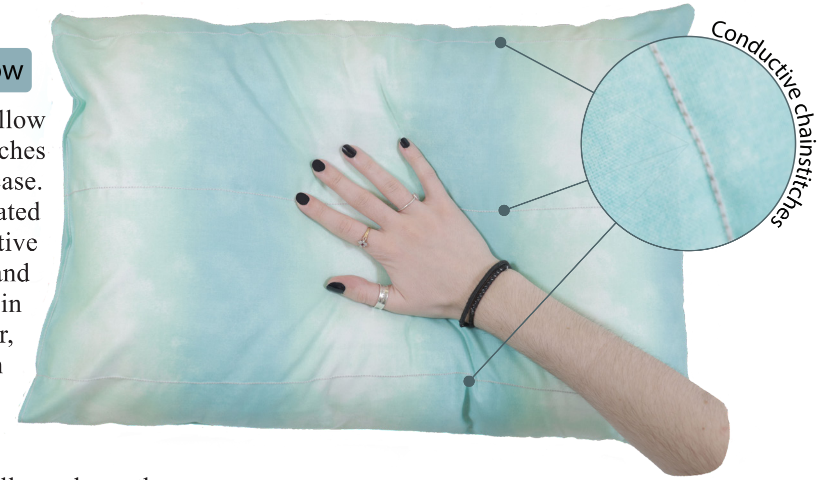
The number of threads used for overlock stitches can range from two to five threads, with 3-thread and 4-thread overlocks being the most widely used in garment seams. We chose to experiment with 3-thread overlocks because they are standard stitches that are available on all sergers and utilize only one of the two available needles. We serged the edges of a stretchy knit fabric (95% tencel, 5% spandex) with one, two, and three conductive threads and captured the change in electric resistance. The procedure involved documenting the resistance measurements using a multimeter before and while stretching the 30 cm of fabric (i.e. resting and stretched seam resistance).

Although 2/3 and 3/3 conductive overlock stitches result in a steady and consistent resistance change overtime (46.9Ω and 22.88Ω on average, respectively), 1/3 conductive overlock stitches provided a significantly higher, albeit inconsistent, resistance change (109.8Ω on average). This noticeable change in resistance between the resting and stretched states makes 1/3 conductive overlock stitches more easily detectable by microcontrollers, enhancing their suitability as variable sensors. Furthermore, using only one conductive thread (instead of two or three) helps reduce e-waste by minimizing the amount of conductive thread needed.

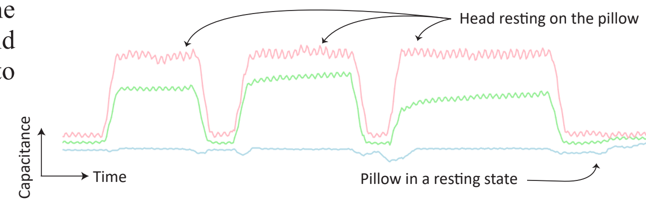


* In the notation, *x*/3, *x* represents the number of conductive threads used in the overlock stitch, out of the three threads total in the stitch.

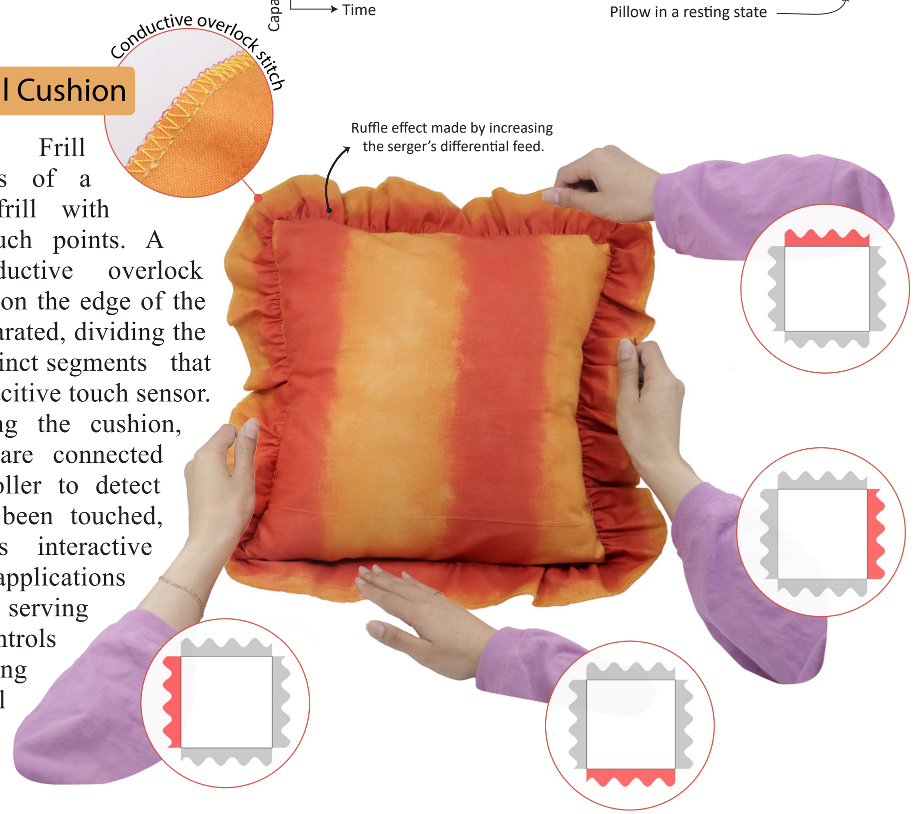
1 Sleep Monitor Pillow



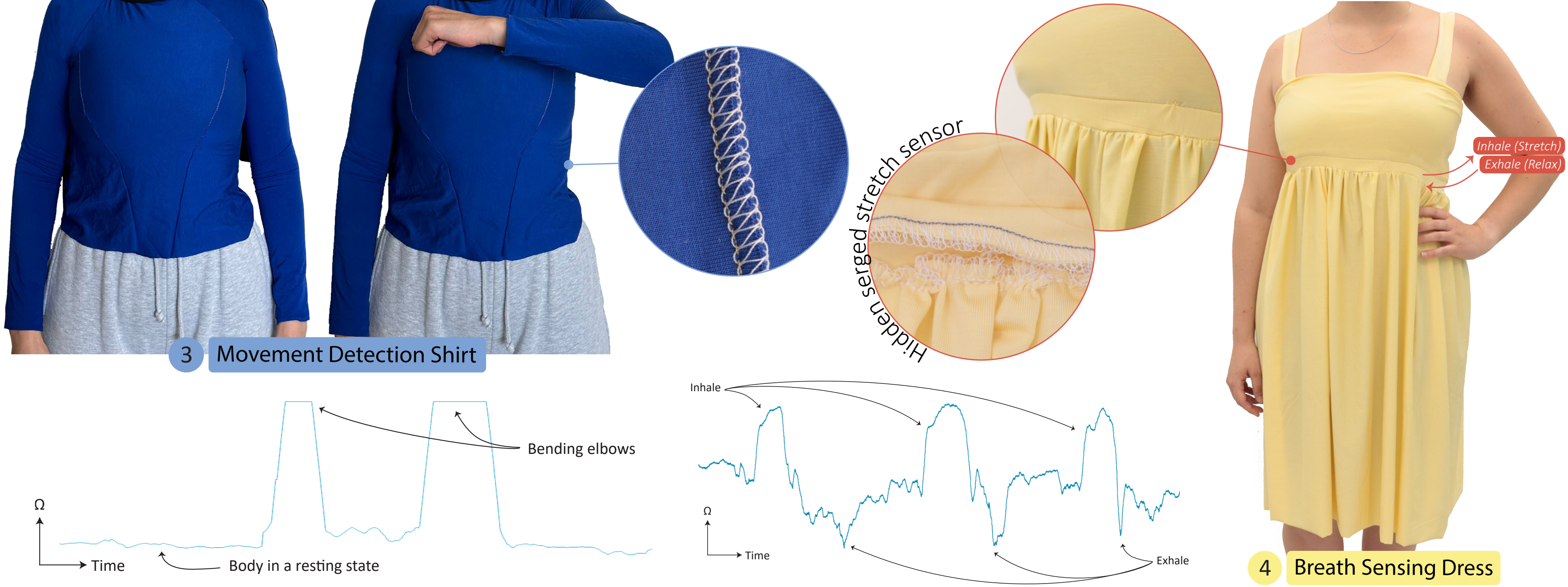
The Sleep Monitor pillow features three chainstitches running down the pillowcase. Each chainstitch, created using a serger with conductive thread in the needle and non-conductive thread in the chainstitch looper, acts as a capacitive touch sensor when connected to a microcontroller. By monitoring detectable signal changes, the pillow has the potential to identify sleeping patterns and durations, providing valuable insights into sleep quality. The three signals can also give clues on the pillow orientation while sleeping.



2 Touch Frill Cushion



The Touch Frill Cushion consists of a touch-sensitive frill with four distinct touch points. A decorative conductive overlock stitch was added on the edge of the frill and then separated, dividing the frill into four distinct segments that each act as a capacitive touch sensor. After constructing the cushion, the frill edges are connected to a microcontroller to detect which side has been touched, enabling various interactive interior design applications [46,48,49], like serving as intuitive controls for triggering environmental changes in smart living spaces.



For our third serged prototype, we present the Movement Detection Shirt. Previous works in HCI have used sleeves as a medium for capturing a variety of information and data from the human body [41,54,67]. Most recently, SeamSleeve [60] uses the seam of a sleeve as a means of gathering body movement data. Inspired by this approach and informed by our experiments on conductive serged stitches, we extend the technique to construct a fully wearable garment.

For the construction of this shirt, we used a 1/3 conductive overlock stitch. Materials included a stretchy knit fabric (95% tencel, 5% spandex), spools of white serger thread for the upper and lower loopers, and one spool of Madeira HC-40 conductive thread for the needle. We used a standard shirt sewing pattern that came with several panels for the front and back for a contrasting effect. Instead of sewing the panels, we serged them together. The conductive seam runs continuously from the wrist to the bottom hem through the underarms. This long, uninterrupted seam results in better readings than a shorter seam that ends at the edge of the sleeve.

Finally, we connected our seams to an Adafruit Circuit Playground Express, wrote accompanying Arduino and Processing code to visualize the readings while wearing the shirt. In a resting state, the readings are steady and relatively consistent. Arm movements, such as bending the elbow, result in spikes in these resistance readings because the seams are being stretched as the wearer moves.

The Breath Sensing Dress detects subtle movements in the wearer's diaphragm when taking deep breaths and is designed to monitor and visualize respiratory patterns. Building upon the Body Movement Shirt, the dress utilizes a similar technique (with the same materials used) of hidden stretch sensors in the seams to capture these subtle breathing changes.

The dress consists of four main components: the shirt, waistband, top, and straps. During the assembly process, the top and skirt pieces were sewn onto the waistband, integrating a hidden serged stretch sensor within the waistband on the inside of the dress. As with all our serged prototypes, we used a 1/3 conductive overlock stitch for the inner waistband. The waistband serves as the primary sensing area, capturing the expansion and contraction of the wearer's diaphragm during breathing. After completing the main body of the dress, we added the finishing touches by attaching the straps and closing the back of the dress.

To bring the dress to life, the hidden sensing seam is connected to an Adafruit Circuit Playground Express, programmed to detect changes in the sensor's resistance and visualize the breathing patterns in real-time. While the garment is worn, the readings remain steady when the wearer is at rest (sensor is relaxed). As a deep breath is inhaled, the sensor is stretched with the expansion of the chest, resulting in noticeable spikes on the resistance value graph.

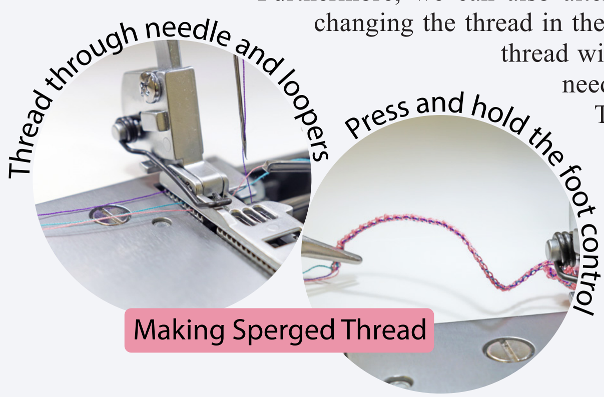
This real-time feedback can be invaluable for various health and wellness applications. For example, it can serve as a tool for individuals managing anxiety or stress to practice relaxing deep breathing exercises to reduce anxiety levels. Similarly, individuals undergoing respiratory therapy can use the garment to aid in training proper breathing techniques or used as a biofeedback device during mindfulness and meditation sessions.

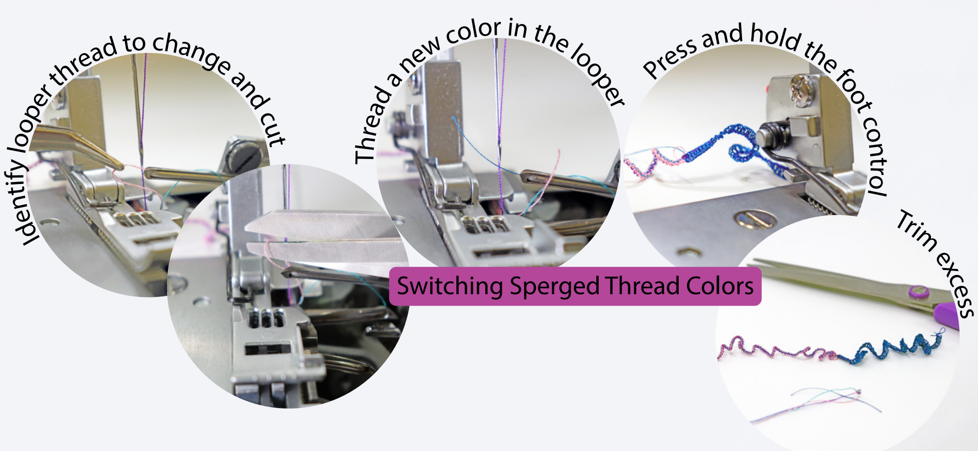
SPERGED THREADS

Looking beyond the traditional usage of a serger, we can also take advantage of its thread looping and interlacing qualities to create colourful yarns. Thus, we introduce a novel fabrication technique that can be used for a variety of applications. We use the term **'sperging' (spinning, or interlacing, on a serger)** to refer to the act of pressing the foot control on a threaded serger without a piece of fabric between the presser foot and the stitch plate. This causes the loopers to loop and chain around the needle thread, resulting in beautiful **'sperged' threads**, consisting of two or more threads. These threads are visually similar to fancy yarns made with the traditional methods of spinning and twisting [10]. However, they differ in structure and their complex interlacement cannot be replicated on a spinning wheel or spindle.

Two factors affect the apparent density and texture of sperged threads: thread tension and stitch type. Some stitches create looser or tighter chains than others, and an increase in thread tension results in tighter yarns. Through experimentation with 22 different stitch settings, we have found that the 3-thread rolled edge stitch produces the most secure and compact sperged thread, suitable for a variety of crafting applications.

Furthermore, we can also alternate the dominant thread colour by changing the thread in the loopers, creating a strand of sperged thread with multiple colours. The thread in the needle forms the foundation of the thread. Therefore, it is recommended that this thread remains consistent in a single strand to maintain the structural integrity of the sperged thread. Once the colours are switched in the loopers, we can continue to sperge the thread again and trim the excess thread when we are satisfied with the length of the strand.





CONDUCTIVE SPERGED THREADS

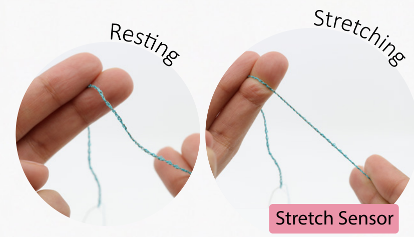
By threading a spool of conductive thread in the needle, we can begin to introduce elements of interactivity in the applications of our sperged thread. Previous works have explored altering the resistive, textural, and aesthetic properties of conductive thread using dye, polymerization, or coating techniques [13,14,27,50,53]. These exhaustive methods, however, still impose a barrier to makers and artists who wish to incorporate interactivity in their pieces. Commercially available conductive threads and yarns are often limited to metallic and rusty colours. Furthermore, not all conductive threads are created equal – some yarns can be dyed [79], and others cannot because they are already coated with the resistive material or their performance degrades after the washing or dyeing process [63]. Nevertheless, dyeing is often inaccessible to many makers and can pose health and safety hazards. Thus, we present an alternative for creating colourful conductive yarns in our sperging technique.

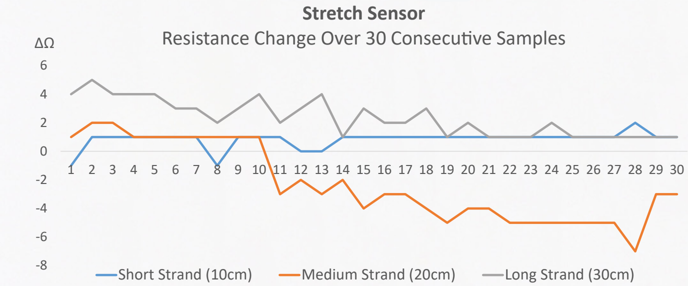
Using the conductive thread in the overlock needle ensures that a strand of sperged thread has a consistent connection throughout. This is because we never cut the thread in the needle; we only cut the looper threads when we desire a colour switch in the same strand of sperged thread. A strand of conductive sperged thread has measurable changes in resistance when stretched. Thus, this strand can be used as a two-dimensional stretch sensor. Making longer strands and winding it into a ball of yarn creates a three-dimensional squeeze sensor. We used these two sensor types to begin characterizing our conductive sperged thread in terms of its measurable resistance changes. Throughout our experiments, we used a spool of Madeira HC-12 in the needle of our serger with a rolled edge stitch.

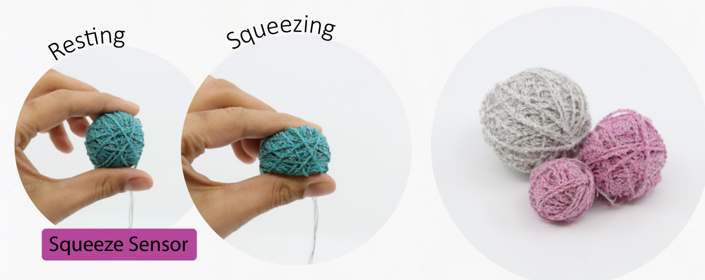
We observed measurable changes in resistance for three samples of the stretch sensor with varying lengths (10 cm, 20 cm, and 30 cm). Over the 30 consecutive measurements, the change in resistance from the strand's resting state to its pulled state (by hand) decreases.

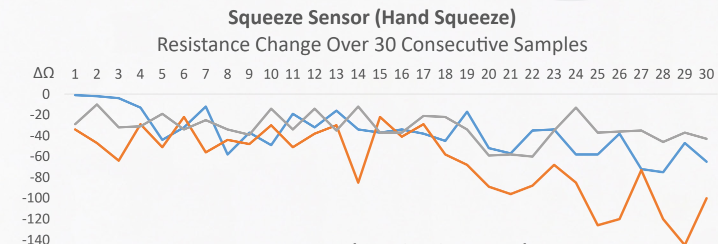
Similarly, three squeeze sensors were used to observe resistance changes of three-dimensional sperged thread sensors (18 mm, 26 mm, and 34 mm in diameter). We used two methods to measure the change in resistance. The weighted squeeze method involved placing a 1 kg weight on the ball and measuring the resistance observed pre-squeeze, squeezed, and post-squeeze. This represents a standard and controlled method for measuring resistance changes, resulting in a decrease in the average resistance change as the size of the sensor decreases. For a more realistic view of the sensor's usage, we used the hand squeeze method. This method allows us to represent the variability of day-to-day use of the sensor. As expected, we observed much less consistent results with the hand squeeze method than with the weighted method due to the natural inconsistency of hand-applied pressure, as well as differences in sensor geometries when they were wrapped. Ultimately, both methods demonstrate that the sperging technique with conductive thread can successfully produce functional sensors, resulting in an overall decrease in resistance change over the consecutive measurements.

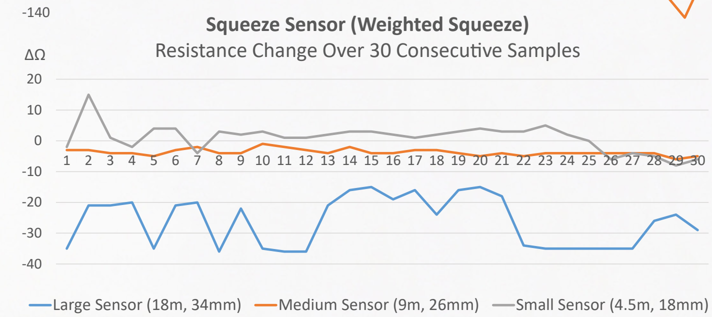
Most notably, this technique affords us the flexibility to change the colour of our conductive yarn for all kinds of sensor applications, including woven and embroidered sensors. With sperged threads, we can achieve coloured conductive yarns without the need for exhaustive dyeing or coating processes. Furthermore, we can integrate sperged colourful conductive yarns in various hand and machine-assisted crafts such as machine sewing, digital embroidery, and weaving. We present the following prototypes to demonstrate applications that blur the boundary between functional and non-functional elements in interactive e-textile pieces.





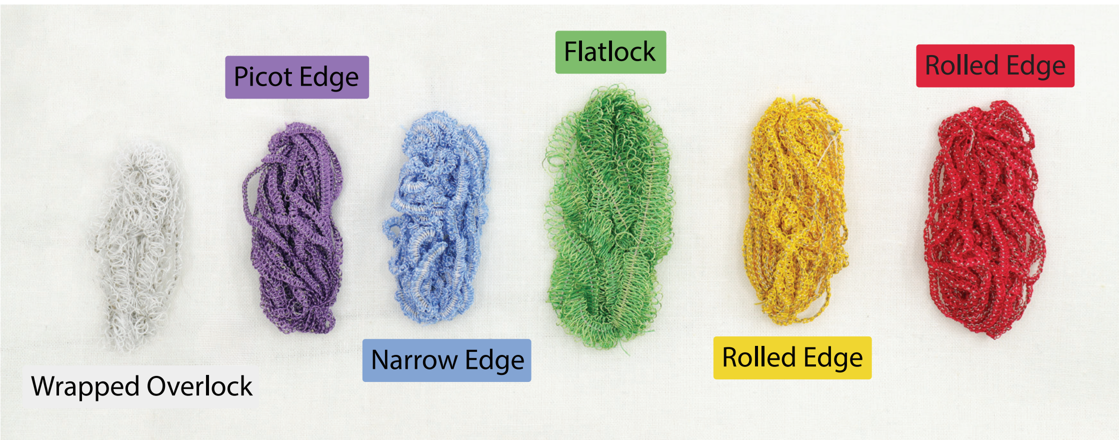


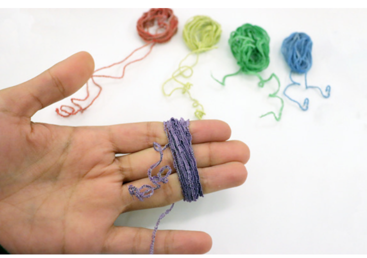


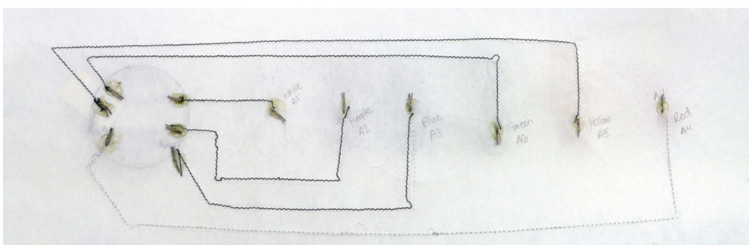


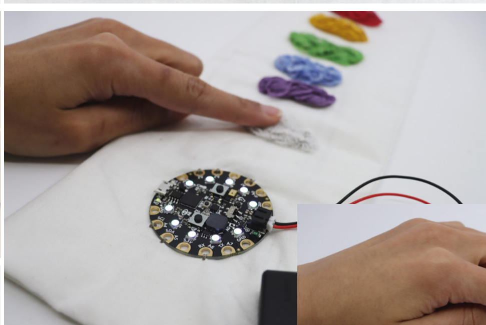
PROTOTYPES OF SPERGED THREAD SENSORS

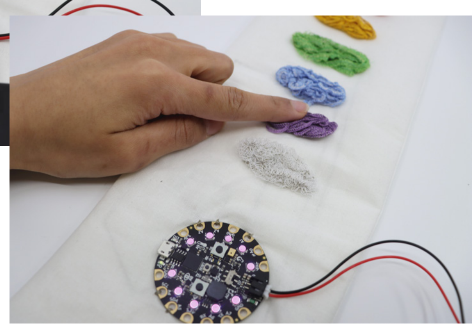
To illustrate the applicability of sperged threads in practice, we present two sewing prototypes that use colourful, conductive sperged threads in different ways: the Artist's Colour Palette and the Curly Thoughts Tote Bag. These pieces illustrate the diverse aesthetic capabilities that sperged threads can offer in terms of colour and texture. Throughout this exploration of the use of conductive sperged threads as sensors, we vary colour combinations in the loopers and the type of serger stitch used to sperge the thread to achieve various colours and textures for the desired application. Meanwhile, the serger's needle consistently held the same spool of conductive thread: Madeira HC-12, which exhibits <100 Ω/m in its resting state (100% Polyamide/Silver-plated).

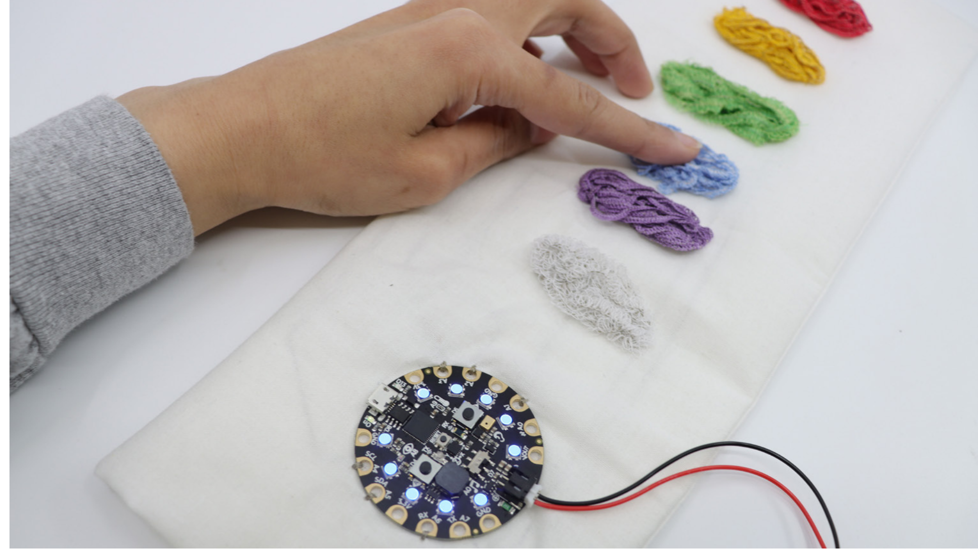












5 Artist's Colour Palette

This piece consists of conductive sperged thread swatches, each distinct in colour and texture, and serves as a sampler that demonstrates the vast possibilities enabled by the sperging technique. The Artist's Colour Palette is both a tactile and visual compilation that showcases the technique's versatility and highlights its capacity to produce a diverse array of aesthetic qualities in yarns. It also provides a tangible reference for observing the effects of different stitches and colour pairings.

To craft this piece, we created sperged threads with specific texture and colour combinations. These threads were then wrapped and couched onto a piece of fabric in a chosen layout. The thread ends were threaded to the fabric's back and connected to hidden conductive paths linked to an Adafruit Circuit Playground Express. Once all the connections were secured, the fabric's edges were finished with an overlock stitch, concealing all electronic connections. The microcontroller was programmed to detect capacitive touch on the connected electrodes, enabling the NeoPixels to illuminate in the touched thread's colour accompanied by auditory feedback, thereby creating an interactive textile display.

6 Curly Thoughts Tote Bag

Inspired by the naturally curly and textured appearance of sperged threads, the Curly Thoughts Tote Bag merges embroidery and textile art with storytelling. In this piece, embroidery and personal narratives fuse to create an interactive prototype. Each character embroidered on the tote symbolizes a unique story, resonating with the diverse experiences of the volunteers who voiced them.

Conductive sperged threads are sewn and couched atop the digitally embroidered artwork, connecting to a Bare Conductive Touch Board concealed within the tote bag's lining. We programmed the Touch Board to play MP3 files when the electrodes (characters) are touched. These audio files contain the voices of volunteers who felt drawn to a particular character, each sharing personal anecdotes and reflections in brief audio snippets. As one interacts with the tactile surface by touching the textured sperged threads, the corresponding character's story is audibly unveiled, breathing life into the embroidered figures. Both the Curly Thoughts Tote Bag and the Artist's Colour Palette are examples of the many ways conductive sperged threads can be utilized in e-textile arts.

1 Digitally embroider artwork

Artwork designed using Adobe Illustrator.

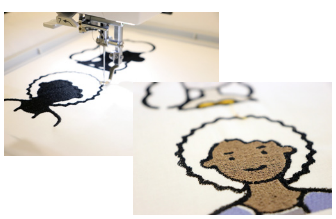
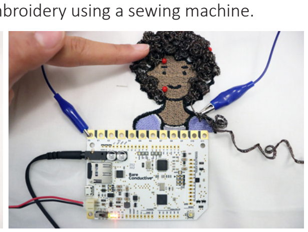


Illustration converted to embroidery file compatible with JANOME Memory Craft 550E and digitally embroidered.

2 Sperged threads placement

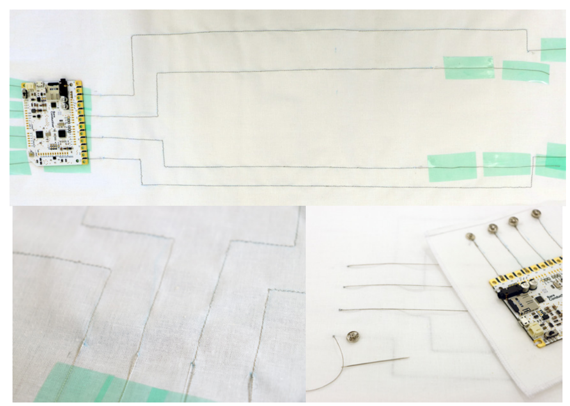
Sperged threads are placed in the desired configuration and couched onto the embroidery using a sewing machine.

Tail ends of the sperged thread are pulled through the back.



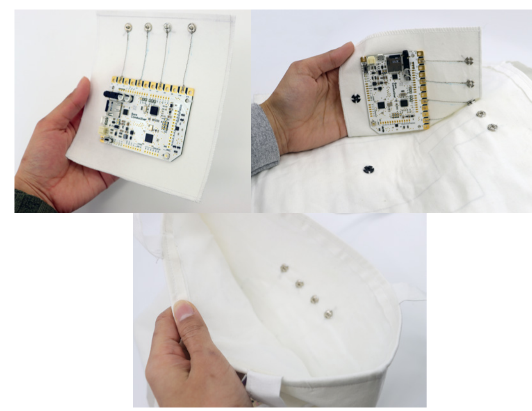
Capacitive touch sensing is tested with the Bare Conductive Touch Board.

3 Sew hidden connections and metal snaps



Conductive paths are sewn from the sensors (front), down the face of the bag, and up the back of the bag. The paths are sandwiched between layers of fabric to protect the stitches on all sides and create an inner lining for the bag. Metal snaps are used to form a connection between the sensors and the Touch Board.

4 Tote bag construction and assembly



An overlock stitch is used to serge the seams of the bag and the detachable Touch Board. A chainstitch is used to create a hem at the opening of the bag, as well as for the attached bag handles.

WEAVING WITH SPERGED THREAD

The weaving process involves creating fabrics with threads that are interlaced with each other in a certain pattern. The most standard of these patterns is the plain weave. A plain weave pattern calls for the weaver to lift alternating vertical threads, the warp, across the loom and send another thread horizontally, the weft, in the space created by the separation of the warp.

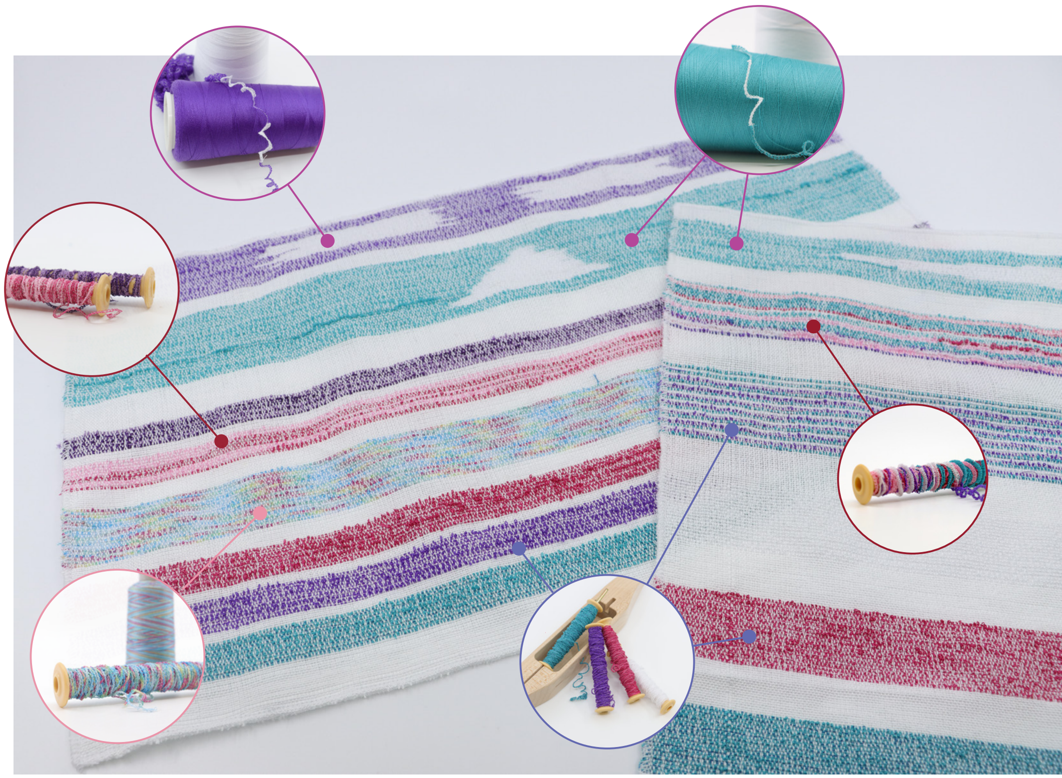
We have determined that a 3-thread rolled edge stitch offers the tightest and most secure stitch for applications of sperging. A loose sperged thread stitch would result in different textures when used as the weft for the woven fabric. Although the chosen stitch for the sperged thread changes the textural qualities of the fabric, there are two main factors that affect the visual qualities: color composition of the weft and weaving technique.

Effects of Color Composition

Sperging threads on a serger means that makers have an elevated level of freedom of creativity to mix and match different thread colors and types to essentially create new thread altogether. We have identified three techniques of color composition that form the basis of visual qualities of weaving with sperged thread. First, we can sperge threads that consist of a set number of colors, without switching out any color in the loopers. This is called **single-color sperged thread**. Although the threads that are sperged do not necessarily have to consist of only one color, the term is used to refer to threads that remain intact throughout the strand, no matter the length. Weaving with single-color sperged thread results in fabric that is consistent and varies only based on the choice of threads used in the serger for the same stitch type. A variation of single-color sperged thread is **multicolor sperged thread**, which uses the same sperging technique but dictates that the dominant thread uses a spool of multicolor thread. This results in fabric that has distinct variations in color throughout. Finally, we can also weave with **alternating color sperged thread**, which is made by switching thread colours in either (or both) of the serger loopers while sperging. This concept visually mirrors the multicolor sperged thread application, but threads can be cut and switched out at any point in the length of the sperged thread. This adds an element of randomness to the fabric that is created and may enable the maker to take control of the combinations of colours used in their weft.

Weaving Techniques

We have identified three color composition methods all of which use the same traditional weaving technique of sending a weft across the separated warp. We will refer to this technique as the **continuous strand weaving method**. This is because the weft uses one (typically long) continuous strand of sperged thread to form the fabric, as is done in traditional weaving. To extend the possibilities of sperged thread applications, we will also introduce a weaving technique which we will refer to as the **strips weaving method**. This method involves sperging threads to a length that is beyond the width of the loom's warp. We refer to these shorter strands of sperged thread as 'strips'.



Each strip is taken as its own weft and sent across the warp, leaving the edges to dangle over the salvage. This method gives us flexibility in the exact placement of the weft, while allowing us to take advantage of the sperged thread's natural curl as added decorative embellishments in the dangling edges of the salvage.

Applications of the strips weaving method can range from simple shapes and patterns to intricate art and designs. By using the alternating color sperged thread with strategically placed colors in tandem with this technique, we can manipulate color placement and gradually build patterns, strip by strip.

We can also vary our control of the length of the strategically placed color. If we control the pressure placed on the foot control, we can get somewhat random and inconsistent length of the dominant color. Otherwise, we can aim for a more precise length by turning the handwheel and counting the number of stitches made by the movement of the needle. Although it varies based on the stitch selected and the type of thread being used, we have found that for a 3-thread rolled edge sperged thread using Sergin' General "poly wrapped poly" thread (TEX 30), 1 cm of woven fabric can be made with approximately 6 stitches, on average.

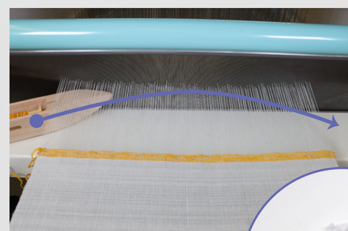
7 Interactive Beach Tapestry

We can extend these techniques to incorporate elements of interactivity in woven pieces by using sperged conductive thread. We demonstrate the possibilities of this application with by developing a woven prototype, the Interactive Beach Tapestry. This piece utilizes a combination of our proposed color composition and weaving techniques using sperged thread and woven on the Tronrud TC2 Digital Jacquard loom.

We created a beach landscape scene using the strips weaving method and alternating color sperged threads that are strategically sperged to build the landscape. We also closed off the landscape's vertical ends in the sand and sky using continuous strand weaving to protect the salvage.

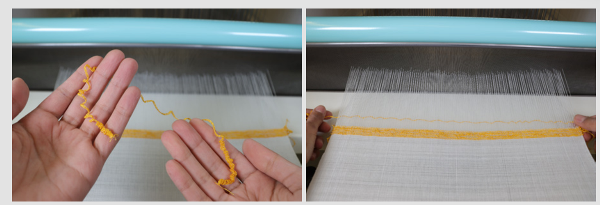
The lighthouse in the background of the scene comprises a simple circuit that can be switched on and off to activate the lighthouse. The strips that compose the lighthouse alternate colours in only the upper looper until the colours of the lighthouse are achieved, where both the upper and lower looper are switched for the dominant thread color and conductive thread, respectively. Typically, excess thread is trimmed down when a strip has been completed. In this case, we maintained the length of the excess conductive thread and pulled it to the back of the fabric while weaving. This mimics the inlay method of creating patterns and designs in fabric but has the added advantage of concealing the conductive thread color under the dominant thread. Once the weaving process was complete, we added the components of the circuit to the back of the fabric, pushing the switch through to reveal it at the bottom of the lighthouse.

Continuous Weaving

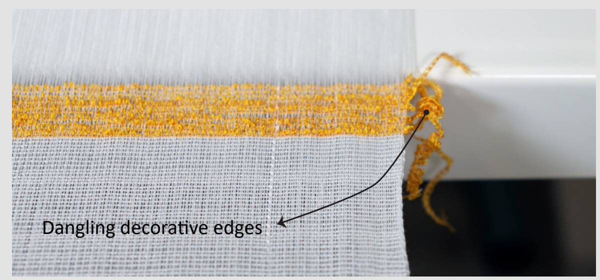


Wrap the sperged thread onto a bobbin and place into a boat shuttle (weft). Send the weft across the warp back and forth continuously.

Strips Weaving

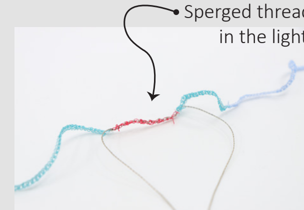


Place a strip of sperged thread in between the separated warp. Grab both ends of the strip and adjust its position.



By strategically switching colors in the serger's loopers, we can create shapes, designs, and dictate where conductive threads are placed.

Sperged thread strip used in the lighthouse.



UNTANGLING INSIGHTS

Through this exploration of e-serging, we uncovered key insights, which we endeavour to discuss and untangle, that can transform the use of traditional tools, encouraging innovation beyond the instruction manual, and informing future work in e-textile hybrid crafts.

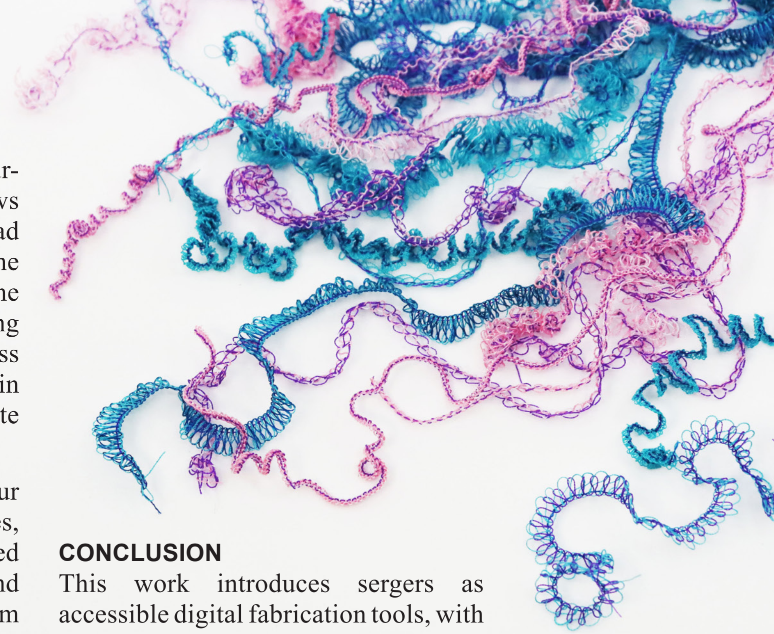
Design for DIY and accessibility. Sergers and the materials used in our exploration are easily accessible and available in local stores or online, making them a practical choice for a wide range of crafters. Unlike dyeing and polymerization methods used in previous work [14,27,53], the sperged threads technique requires no intensive resources or exhaustive processes. This uniquely situates machine-serged yarns as a technique that can be easily replicated and seamlessly integrated into traditional crafts. Furthermore, we encourage crafters to seek inspiration from this unconventional use of sergers to build upon previous work [2,42,52] and experiment with crochet and knitting using sperged threads, potentially adding an element of tactile sensing.

Design with material as a coproduction [15]. HCI researchers often take a material-led approach in exploring hybrid crafts [1,70]. Zheng et al. [70] embody this in their study on interactive ceramics, where they allowed their material and its traditional design practices to shape their incorporation of physical computing. Rather than imposing expectations of machine-serged fabrics and yarns, we use the serger as a fabrication tool with its established settings and embrace a collaborative approach with the material it extrudes. Embracing the range of colour and textural properties demonstrated in the Artist's Colour Palette, like the coiling texture of sperged 3-thread rolled edge stitches, inspired the Curly Thoughts Tote Bag.This approach resonates with reflections on "designing interactions" with a material [3] and working with the material [51] rather than against it. We also envision sergers becoming an active player in HCI labs, similar to how prior work embraced traditional tools in interaction design to do more [57,68].

Design that is resourceful. Our approach emphasizes resourcefulness by transforming 'waste' from the serging process into a useful material and valuable resource for various hybrid crafts. We also developed a colour-switching technique for sperged threads, which allows us to maintain a continuous strand of conductive thread (and, therefore, a continuous electrical connection) in the needle and change the colour of our yarn. This saves the time and effort of connecting separate pieces, resulting in more robust e-textiles. The element of resourcefulness in our technique contributes to sustainable practices in e-textile hybrid crafts [28,39,73] and repurposing waste from traditional crafts in an ecofriendly manner [32].

Design for real-world use. We showcase our technique in various functional, deployable prototypes, demonstrating how serged textiles can be integrated into everyday life. Our Movement Detection Shirt and Breath Sensing Dress advance previous work on seam sensing sleeves [60] by creating complete garments that sense their respective upper body movements while showcasing the flexibility of serging in personalizing garments for individual preferences and gender expression. Similarly, our Sleep Monitor Pillow and Touch-Sensitive Frill Cushion expand on existing research [22,65], providing practical home applications and extending the body of literature on e-textile interfaces and fabric-based sensors [7,43,69].

Design limitations and future work. Not all conductive threads are suitable for use in sewing, embroidery, or overlock machines. Some may be too thick or abrasive, potentially causing damage over time due to the metallic fibers. Further research is needed to assess the long-term impact on machine health. Additionally, sperged threads cannot be used directly in sewing or embroidery machines due to their thickness and inconsistent texture. For this reason, we recommend couching the sensors on top of the fabric rather than embroidering them. The behaviour of conductive seams, while promising, is also influenced by the properties of the stretchy fabric, as well as the orientation of the overlock relative to the fabric's stretch direction. Future work will involve a deeper quantitative evaluation of sensor performance, as well as user studies with practitioners to explore the creation of prototypes using these techniques and long-term end-user studies to assess wearability, durability, and user interactions.



CONCLUSION

This work introduces sergers as accessible digital fabrication tools, with the potential to expand the material palette for makers, designers, and HCI researchers. We explore their traditional uses and capabilities, incorporating interactivity through conductive thread in stitches and experimenting with various settings. We developed a new technique for producing coloured spun-like conductive yarns, termed sperged thread, demonstrating their value and experimenting with their properties and behaviour. Moreover, we showcase the potential of our approach through seven prototypes spanning multiple crafting practices. Our DIY approach is detailed to encourage creativity, resourcefulness, and co-making with materials and tools. We envision this work to open a new design space that can inspire future work to rethink the expected uses of traditional fabrication tools, giving us the ability to expand our material palette and empower makers and e-textile practitioners to use their tools and materials in novel, unconventional ways.

ACKNOWLEDGMENTS

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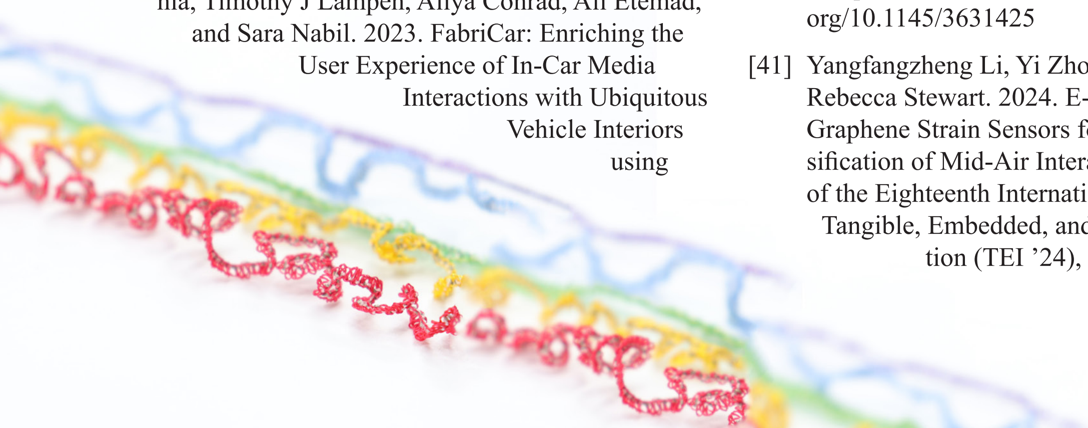

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