Data Embroidery:
Exploring Alternative Mediums for Personal Physicalization

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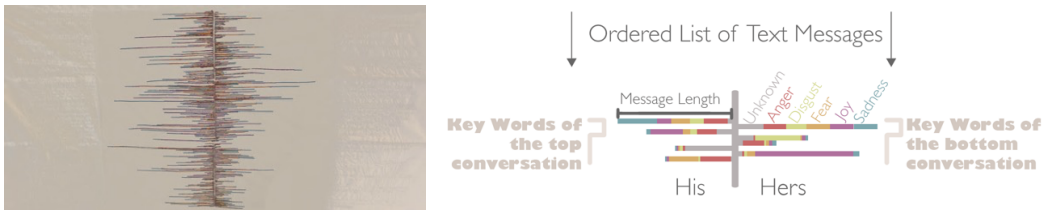

Figure 1. Left: Embroidered text message physicalization. Right: Embroidered physicalization mapping.

ABSTRACT

Our work explores the use of embroidery as a medium for personal data representation. Personal physicalization is at the intersection of personal visualization and physicalization. More precisely, personal physicalization uses tangible objects to represent data in a personal context. This unique design space inspired us to explore alternative mediums to integrate data with personal artifacts, as well as facilitate the exploration of a multi-sensory data encoding. We first developed a workflow for authoring embroidered physicalizations. Then, we used this process to create an embroidered blanket based on text message data.

Keywords: Visualization techniques, Visualization systems and tools.

1 INTRODUCTION

Physicalizations are physical artifacts whose geometry or material properties encode data. These properties can include weight, temperature, texture, or scent [3]. Personal physicalization affords the unique opportunity to embed a person's data into their personal artifacts. Physicalizations pose a unique set of challenges compared to their purely visual counterparts, since creating tangible objects based on data by hand can be time consuming, tedious, and prone to error [6]. For these reasons it is appealing to explore mediums where the fabrication process can be computer-numerically controlled (CNC). More recently, fabrication spaces have had access to CNC embroidery machines, which can create ornamental designs on fabric with needle and thread. Embroidered physicalizations could allow for both traditional visual encodings of data as well as new mappings that utilize material property or physical texture. We envision embroidery as a seamless approach for embedding data into household artifacts such as tablecloths, clothing, and blankets.

We explored the available workflows for creating CNC embroidery and found that they lack support for data-driven designs. In response, we outlined and implemented critical features for the creation of embroidered physicalizations. Finally, we created a personal physicalization, *Thread* (see Figure 1), to test the process and explore embroidery a medium for physicalizations.

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2 RELATED WORK

Researchers in physicalization and visualization have examined the benefits of different types of data representations. Embroidery as a medium could uniquely utilize and combine many of these data representations' key attributes. For example, Tanahahi et al. found that less-conventional visualizations encourage users to explore their personal data more, and as a result are more successful at prompting personal insights [7]. Additionally, Pousman et al. found that ambient visualizations in the home prompt interesting conversations with curious visitors [4]. Finally, Stustak et al. found that generating modular personal artifacts encouraged people to achieve their goals [5]. Embroidery is an unconventional medium for data that lends itself to be an ambient physicalization in the home, and can be created modularly. Furthermore, Stustak et al. noted environmental concern when creating their plastic modular trophies [5] but because embroidery can be integrated into existing objects there is less waste.

We focus on one challenge for data physicalization identified by Jansen et al.: *Developing techniques to actualize physicalizations that have a collective sensory experience* [3]. We focused on developing a technique to actualize embroidered physicalizations and we developed a prototype that allowed us to explore the multi-sensory design space. Past HCI research has used existing workflows to create interactive and data-generated embroidery installations. *Threadsteading* explores interactions with the creation of embroidered physicalization through a simple game [1]. Meanwhile, Pale Grey Labs[1] have used Mathematica to algorithmically generate designs for CNC embroidery with applications in embroidered animation, as well as quilt-plotter visualizations of pi, prime numbers, and the Fibonacci sequence.

3 CONTRIBUTIONS

Embroidery is a unique medium for personal physicalization that may have benefits over traditional visualization and physicalization media. In order to explore these benefits, we first need a way of generating data-driven embroidery patterns and initial examples of these techniques in use. We outline our initial progress below.

3.1 Embroidery Tools

Machine embroidery has existed since the 1980's, but unlike other CNC fabrication machines such as CNC mills or 3D printers which

communicate using a common programming language (GCode), each embroidery machine manufacturer (Pfaff, Brother, Tajima, Melco) has created a proprietary ecosystem with independent file systems and formats. As such, official authoring tools are costly and while many can import common vector graphics formats like SVG, they do not provide lower-level control over SVG rendering. This is important for data-driven designs, especially when mapping attributes to texture. The open source software community has attempted to create universal approaches for generating platform-independent embroidery files: Embroidermodder[2] and Stitchcode[3]. Stitchcode is a simple set of scripts capable of generating embroidery files from a list of Cartesian coordinates. We built an extension of Stitchcode that adds the additional features we needed for generating data-driven designs.

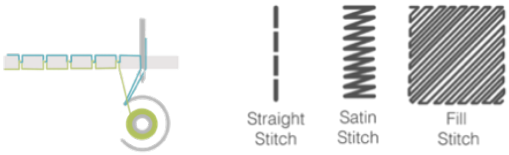

Figure 2. Left: Embroidery Machine interlocking stitch illustration, from [2]. Right: Three stitch techniques for embroidery machines.

While hand embroidery techniques include a plethora of knots and stitches, machine embroidery is limited to a single stitch type, known as the *interlocking stitch*. Fortunately, there are a variety of possible textures that can be achieved using different stitching techniques, including *straight stitch*, *satin stitch*, and *fill stitch* (Figure 2) [2]. Our extension of Stitchcode utilizes these techniques. We aimed to balance the simplicity of listing Cartesian coordinates with the complexities of customization for features such as penetration distance, density, width, and slope. Additionally, we added the ability to indicate colour change and embroider text with most fonts. These improvements significantly reduce the scripting time for new designs and allow texture to be easily encoded. All of these improvements are open source and can be found at https://github.com/kawannam/stitchcode.

3.2 Thread: An Embroidered Text Message Blanket

To test the data physicalization workflow and begin exploring the multi-sensory design space, we created an embroidered blanket using text message data (see Figure 1).

3.2.1 The Data

The underlying data for the blanket was a set of text messages between one of the researchers and her partner, exchanged between 6 November 2016 and 15 September 2017, amounting to 1576 data points. Each text message data point included both its contents and its metadata (date, time, and sender). We ran each individual message through IBM Watson's[4] emotional analysis which returned a percentage certainty for each of the following attributes: anger, disgust, fear, joy, and sadness. Finally, we had the authors of the text messages generate keywords for all of the conversations.

3.2.2 Visual Mapping

Each bar in the blanket represents a single text message arranged in chronological order. Messages from one partner extend left from the center line while messages from the other extend to the right. The length of each bar shows the length of the message and the colour of the line is the percentage of certainty for Watson's emotional analysis for each emotion: red is anger, green is disgust, orange is fear, purple is joy, blue is sadness, and grey is unassigned based on low certainty from Watson. Keywords from conversations appear in white thread on white fabric to the left or right of the corresponding bars. We include keywords rather than raw text to keep font sizes large and legible.

3.2.3 Design Rationale

We tried to keep the design simple while highlighting some of the unique advantages of embroidery. The thin embroidered bars are aesthetically quite different than if they had been printed or displayed on a computer screen. The white text on white fabric is something unique to embroidery and helps convey the more private nature of the messages. The information is present, but the viewer has to move in close to read what the conversations were about.

4 Discussion and Future Work

Embroidery has the potential to connect people with their data as it can seamlessly integrate information into their personal artifacts and homes. We have begun to explore embroidery as a medium for personal physicalization, and invite other researchers to build on our scripts, available on GitHub. Future research areas include: *Developing the underlying library* — Simplifying the control of texture requires complicated underlying algorithms to render the stitch techniques. Future exploration on this topic could reduce the rendering time and extend the types of texture possible. *Streamlining authoring tools*. Simple and robust authoring tools could make designing these types of physicalizations much easier. *Design space exploration.* We hope that our tools will lead to a diverse range of new embroidered physicalization designs that illustrate the potential of the medium and support future research.

5 Acknowledgements

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