Stitch: An Interactive Design System for Hand-Sewn Embroidery

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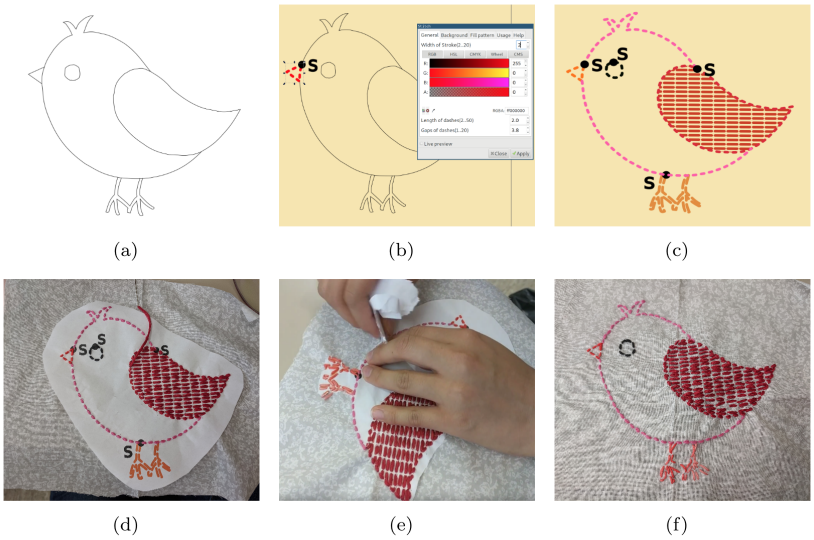

Figure 1: System overview. (a) The user draws an initial design path on the proposed system. (b) The user modifies the path, color, and dash-arrays to create original embroidery. (c) The system enables the user to fill the pattern and suggests the beginning position of sewing line. (d) The user prints on paper and stitches over it. (e) The user tears paper around the stitch, and (f) reveals his/her original embroidery.

ABSTRACT

This paper presents a system that aims to assist with the design of hand-sewn embroidery. With our system, a user can edit his/her design until he/she is satisfied with the simulated embroidery. We demonstrate the effectiveness of our approach, showing that visually pleasing results can be generated with minimal effort.

CCS CONCEPTS

• **Computing methodologies** → Graphics systems and interfaces;

KEYWORDS

Embroidery Design, Sketch Interface, and Fabrication

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1 INTRODUCTION

Recent commercial software for embroidery machines assists in producing elaborate embroidery designs. However, the equipment itself and CAD software are not cheap, and the primary audience is skilled professional designers. Because it is difficult for embroidery beginners to use and control this technology, they have to sew original embroidery by hand. For the creation of hand embroidery patterns, the user draws the embroidery design on paper and copies the design to the cloth with tailor's chalk or tracing paper. However, the impression of actual stitching is different from a rough sketch on paper, and embroidery design requires several pattern types of stitches, which may seem too challenging or perhaps laborious for hand embroidery beginners.

To solve this problem, we propose a sketch-based embroidery system and fabrication process. Our system is designed for a situation in which a user does not have a computerized sewing machine but wishes to create original hand embroidery. By using our system, users can design original free-form embroidery and check the quality of the design results easily and quickly. We ran pilot studies with eight subjects and confirmed that the proposed framework composes their original embroidery that serves as a concrete starting point for users.

2 USER INTERACTION

In this section, we describe how users interact with the proposed system to design embroidery that appears to be hand-sewn.

2.1 Design Step

Firstly, the user draws several free-formed strokes (parametric curves and primitive shapes) on the screen (Figure 1(a)) and designs stitch shape through trial and error. We provide three interactive mechanisms to control the shape of the hand-sewn embroidery: 1) the stitch template tool, 2) the filling tool, and 3) the image loading tool. The stitch template tool allows the user to convert the user-drawn strokes to a basic stitch pattern (e.g., "running stitch", "backstitch", "feather stitch"). The filling tool automatically fills the inside region of a silhouette stitch with different stitches such as "seed stitch" and "satin stitch" (Figure 1(b)). In our system, the user can add a new stitch pattern by drawing via two methods. By changing the stroke parameters (i.e., color, width, and type of stitch pattern), the user can control the embroidery result easily and quickly (Figure 1(c)). In addition, the system allows the user to add a new stitch pattern rule. As a representative work of a pre-existing image, the user can load a background image and draw strokes by referring to the reference shape of the loading image.

2.2 Fabrication Step

Our system can export the embroidery design in image format (SVG, PNG) which will be printed on paper. The user places the paper on the cloth (or garment) and embroiders it over the paper. He/she tears this paper after completing the stitching process (Figure 1(d)(e)(f)).

3 IMPLEMENTATION

We implement the prototype system as a plugin for Inkscape [Ink 2018], which is an open-source vector graphics editor, and our system ran interactively on a laptop. Our system uses SVG (Scalable Vector Graphics) vector representation format because it has advantages in modifying and changing the stroke parameters compared to raster representations such as bitmap formats.

4 PILOT USER STUDY

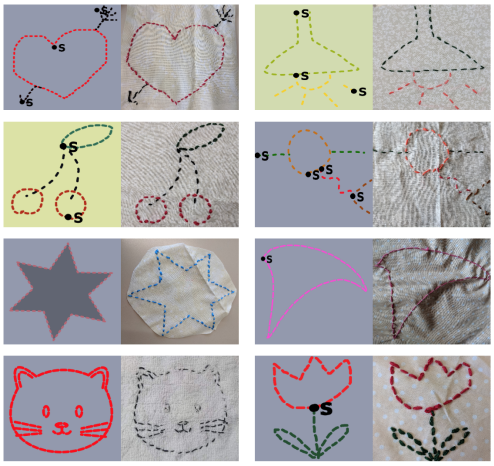
We invited eight amateur people (A, B, ..., H) in this experiment. Three people had no embroidery experience and five people had few embroidery experiences. Participants were provided only needles, cloth, and strings. We asked participants to keep designing until they are satisfied. The overall experiment took an hour on average.

Task 1: Draw an embroidery design on real paper with pen and stitch cloth over the paper.
Task 2: Design an embroidery with the proposed system, print simulated design on paper and stitch cloth over it.

Half of the participants were asked to perform Task 1 first and Task 2 second, and the others were required to perform the tasks in the opposite order. All participants were asked five questions after completing these tasks. **Q1:** Which did you find was easier to design? Hand-design or with the software. **Q2:** Which did you think was faster to design? Hand-design or with the software. **Q3:** Which embroidery were you more satisfied? Hand-design or with the software. **Q4:** Evaluate the overall usability of hand-design. **Q5:** Evaluate the overall usability of the software.

5 RESULTS

The result of the pilot study can be seen in Figure 2 and Table 1. "S" and "H" in Table 1 stand for Software and Hand-design. The



(a) (b) (c) (d)

Figure 2: User study participants' (a)(c) design and (b)(d) embroidery resulting from Task 2.

Table 1: Result of user studies.

Questions	A	B	C	D	E	F	G	H
Q1: Simplicity (S vs H)	S	S	S	S	S	H	S	S
Q2: Design speed (S vs H)	S	S	S	S	H	S	S	S
Q3: Satisfaction (S vs H)	S	S	S	S	S	S	S	Both
Q4: Score for hand-design	3	3	3	4	5	3	3	2
Q5: Score for the software	5	4	4	5	4	4	4	5

average score for usability of hand-design was 3.25 (1 for poor and 5 for excellent), and usability of the proposed software was 4.375. We analyzed Q4 and Q5 score with Mann-Whitney U Test. The U-value is 9, which is significant at 0.05 significance level in two-tailed hypothesis.

In participants' free comments, two participants commented that the software was not easy to use until they become familiar with it. Our future improvement will be to make the software more intuitive so that novice users can use them before familiarizing themselves.

6 CONCLUSIONS AND FUTURE WORKS

In this paper, we presented an interactive system for designing hand-sewn embroidery. Our key ideas are based on (1) designing embroidery with the help of the proposed software, and on (2) a fabricating framework (i.e., printing a paper and embroidering over it), which allows novice users to design original embroidery. Currently, our system mainly focuses on 2D vector graphics design. The extension of the proposed fabrication process (e.g., 3D puff embroidery or combination with other designing tools such as [Igarashi 2011; Igarashi and Mitani 2015]) may present interesting research opportunities, which we plan to explore in the future. We believe that our technique will open up a new venue for hand-sewn embroidery design and democratize hand-stitching for manufacturing.

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