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Cooperative Creativity Support Tools for Computational Crafting

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Abstract

The role of computers and software as tool, manufacturer, collaborator, and artist in relation to human crafters has been heavily debated philosophically and practically. A creativity support tool for a specific creative domain is interdisciplinary, crossing fields of computational creativity, creativity support tools, procedural content generation, human-computer interaction, and potentially many others. This work aims to consolidate applicable research to domains with physical craft execution, as well as present an instance of a proactive and cooperative creativity support tool for the domain of machine embroidery pattern digitization, or simply *digitizing*. Proprietary software tools exist for digitizers, but auto-digitizing features – features that claim to automatically convert an image to a pattern – are widely disparaged in the industry, and novices and intermediate digitizers face a steep learning curve. The primary directive of this work is to ease that learning curve by helping suggest and caution the user about both the digital and physical best practices of the craft. In order to accomplish this task, the creativity support tool must successfully model machine embroidery such that it can be executed by embroidery machines, including basic operations, expert rules-of-thumb, and physical constraints, as well as interface with the user in a helpful and productive manner.

Introduction

Software aimed at assisting the creativity of their users, usually in the context of a specific creative domain, are considered creativity support tools. A creator or designer makes some creative output, and the software helps with any stage of the process, such as brainstorming, communication, or production (Hewett et al. 2005). In the general domain of physical crafts for this proposal, there are often two stages of creation: a pattern and the result of executing the pattern, which commonly results in two creators. For example, a human can program a knitting machine to make a sweater without knowing how to knit, and disembodied software can make a knitting pattern for a human to knit. In the first case, machines as manufacturers are commonplace, but in the second case, machines as pattern designers or design aids is a scenario with countless unexplored domains of application.

Before splintering into domains, however, we should acknowledge the core common thread of creativity. If the goal is to support, increase, generate, or otherwise *make creativity happen*, the logical step would be to try and isolate and recognize creativity, at least to be able to evaluate our work. However, definitions of creativity and their practical applications to improve creativity support tools have been varied and elusive. The most common definition of creative output in any domain considers its *utility* – quality, usefulness – and its *uniqueness* – newness, innovation (Runco and Jaeger 2012).

In practice, however, the applicability, usefulness, and objectivity in measuring and comparing these creative properties is often domain-dependent, subjective, and overall neither conclusive nor an accurate representation of the research claims or goals. The challenge of evaluating the creative agent and its output are widely acknowledged issues in the computational creativity community (Jordanous 2011). The work in this paper considers the support tool as a proactive AI agent and co-creator. The system, with the permission of the user, acts on expert rules-of-thumb that improve the appearance and utility of the product in this domain.

The focus of this project is machine embroidery pattern digitization, previously known as *punching* (Nielsen 2010). This craft involves a designer placing and ordering needle positions and thus thread for an embroidery machine to follow, creating images and text sewn into shirts, caps, bags, towels, and many other surfaces. A professional designer attempts to balance many competing needs regarding material cost efficiency, client specifications, and the physicality of the medium. For example, using too dense of a stitch wastes thread and creates what is colloquially known as bulletproof embroidery: a result so thick that it loses all the flexibility and drape of the base fabric. Using too thin stitch coverage may leave gaps in the design, especially in fabrics that have any nap or texture to them such as terry cloth or velvet. The challenges of digitizing that relate to the physical properties of the materials are, in general, not made apparent in the current software, often resulting in many cycles of iteration between designing and stitching out a sample for hobby digitizers.

Contributions

This work presents a proactive creativity support tool for the creative domain of machine embroidery pattern digitization. As a minimum, embroidery software creates stitches that are able to be read and stitched by common household embroidery machines. However, embroidery designs can be made up of hundreds or thousands of stitches, even for the smallest home machines. There are many higher level functions within embroidery software that allow the user to, for example, fill an area while specifying stitch length, density, and style. Proprietary software ranges from a couple hundred to many thousands of dollars based on the flexibility, customization, and intelligence of these higher-level tools. Our goal is not to replace this software, but to offer different strengths and AI-enhanced features to a more casual audience.

Stitch Simulation and Validation

Most features in proprietary embroidery software come as options for stitches, such as laying a zig-zag along a path or around corners. It is the digitizer's job to correct problems such as the zig-zag getting spread thin in the outside of the corner or over-dense on the inside. Some software offers *pull compensation*, which extends stitches to correct for the tension of thread pulling in and appearing to shorten areas of the design, although this is often not the best-looking solution. These are two of many common issues that professional digitizers learn through trial and error. Novice digitizers may or may not have the professional software features to help with these issues, understand why their stitch out is unsatisfactory, or know how to fix it.

Our system's approach is more holistic, examining the effects of the whole pattern and identifying not only areas of trouble, but suggesting and automatically creating – with the user's permission – a more professional solution where useful. For example, catching sharp directional turns while using wide stitches and filling/thinning where necessary, flagging when the same position or area is punched too many times by the needle, or creating an underlay to counteract pull compensation rather than making the stitches bigger. Because the lowest level of representation in the software is the needle puncture, theoretically accurate to .01 mm with no fabric distortions, we can attempt to predict *and help fix* glaring problems before the user tries to sew their design.

Stitch Generation and Improvisation

The basic operations of embroidery software involve laying down stitches, usually along a line or to fill an area of arbitrary shape. While these operations technically generate needle punch positions that the user has not hand-placed individually, the simplest versions of these tools are common. In an effort to make not just a verification and correction tool, but a tool that aids in users exploring the creative domain of embroidery, we aim to bring the power of procedural content generation to the user. Beyond tweaking needle positions or patterns to stitch, covered in the last section, we aim to model different embroidery styles that can be applied to a user's loose design forms. Common embroidery styles, such as sketchy lines, echoed lines, bold/thin lines, solid fills, or layered gradients offer different character to the stitched piece, such as those seen in the Style section of some embroidery design shops [1].

Following a rough outline of the desired form, we can generate needle positions around, following, or filling between those lines to express various styles without the user having to plan or place a fraction of the stitches. This rough outline can be specified by the user directly, or even interpreted from a user's uploaded image using image processing techniques such as edge detection. Unlike auto-digitization tools found in expensive proprietary software that attempts a most-accurate stitch-out, we use the user's image as an outline for procedural generation techniques to interpret and build from (Goldman 2012). The style, algorithms, depth of interpretive freedom, and options for all these steps would be customized by the user, allowing the system's AI to create in near-full-autonomy or not at all.

Evaluation and Broader Consequences

In the field of academic research for creativity support tools, the domain of machine embroidery digitization has remained untouched, while simultaneously many proprietary tools exist for comparison and inspiration. There are communities of digitizers of all skill levels with different software to test and compare to our tool, and many more novices that may find our work more usable. The validity of stitch examples is easy enough to evaluate on a practical level: finding different machines and different users to sew out the generated designs and evaluating them for appropriate qualities such as registry and readability of the design, even coverage, and appropriate drape of the finished piece.

Of more importance to us and the broader research community is our approach to, presentation to, and evaluation of novice users. Our creativity tool will by no means be inherently simpler nor less customizable than proprietary software. Our system's agency in detecting, generating, and even editing work laid out by the user will be confusing or frustrating if the user isn't expecting or does not understand the purpose behind the AI's choices. We plan to take inspiration from game design's approach to player modeling in order to fit the capabilities of our system with the experience of our user (Smith et al. 2011).

Conclusion

To the general public and embroidery communities, this project offers a free and open-source means of viewing and performing basic editing operations, as well as offering a suite of AI-enhanced generation techniques and validation support explicitly for digitizing novices. There already exists a range of proprietary software, professional digitizers, expert domain knowledge, home embroidery machines for executing designs, pools of novice users, and, in general, digitizing communities where this software would be practically useful. We can leverage this community to help isolate and tackle research challenges regarding creativity support tools, user-centric design, and computational creativity, such as separating product and process evaluation and exploring ways to create a proactive and non-obtrusive AI collaborator.

[1] http://www.urbanthreads.com/categories.aspx?category=Art+Styles

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