Threadsteading: Playful Interaction for Textile Fabrication Devices

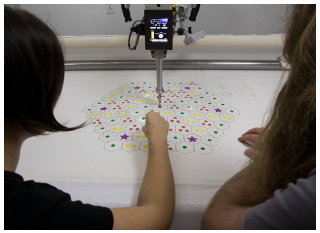

Figure 1: Players consider a game of *Threadsteading*.

Figure 2: The winner of a round of *Threadsteading*, wrapped in their victory quilt.

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Abstract
Our interaction – *Threadsteading* – combines game design practices, traditional crafting techniques of quilting and embroidery, and existing fabrication technologies to produce an innovative game experience that results in a tangible artifact at the end of play. *Threadsteading* offers a glimpse at a future in which humans can engage in realtime, playful interaction with fabrication machines.

Author Keywords
game design; computational craft; manufacturing; quilting

Introduction
The advent of programmable manufacturing technologies has the potential to enable a variety of recreational and product-focused activities. However, most work with these technologies has focused on manufacturing needs. Just as user interface design has transitioned to include values such as enjoyment, aesthetics, and strategy, so too is there room for manufacturing technologies to explore these values, thus enabling new user experiences.

One domain that embodies these values is game design, making it a promising domain for investigating innovation in the use of manufacturing technologies. Alternative input controllers, like the Kinect, allow physical objects to be used for game *input*; manufacturing technologies can make game

Figure 3: Proposed hardware for the CHI version of Threadsteading. The game is played on a pre-printed board, and players enter their moves using a custom hexagonal button panel.

Figure 4: An example of an exquisite corpse. Photo ©Erica Parrott, drawing by Erica Parrott and Noah Ryan.

output physical in a dynamic and permanent way, offering a new kind of game experience that cannot exist without these technologies. However, supporting playful experiences requires adapting machines that typically take a single piece of input and produce a single artifact into ones that can support interactive control and progressively refine an artifact.

This project examines the use of textile manufacturing technologies, specifically a computerized long-arm quilting machine and a computer-controllable consumer embroidery machine, for innovative play experiences. We explore manufactured, situated play in the context of two-player quilting and embroidery games. Our work extends prior work in innovative game design by combining situated input on the manufacturing device with physical output produced by the manufacturing device to produce a durable, aesthetically pleasing artifact. This domain is challenging from a game design perspective because interaction is constrained to a device that can only draw a single, continuous line. The game is also constrained by requirements and common aesthetic properties of the final tangible artifact produced during play – in this case, we want a roughly even density of quilting across the game board, with few, if any, lines sewn over more than once.

Our interactive installation allows CHI participants to play *Threadsteading*, the first ever game made for a sewing machine (to our knowledge). The version of the game we will present at CHI is played on a consumer-level Singer CE-200 embroidery machine, augmented with a custom control panel (Figure 3). Players will be able to take home the embroidered game board that results from their play experience. The display in the booth also includes a projector showing what the game would look like if it were played atop a larger quilt.

Background

Our work builds on a rich and long history of games that are physically-based either in their use of input, output or both. In reviewing this body of work we pay special attention to games for which the gameplay is designed for the constraints of input to and output from the gaming platform.

Games with innovative output mechanisms

Since at least 1875 [9], blindfolded children have happily added tails to a donkey's ass, while the tradition of beating papier-mâché creations harks back centuries [4]. A more modern take on the piñata demonstrates the ongoing appeal of situated and embodied gameplay as New Yorkers took to the streets to compete in teams for the most Pigeon Piñatas Pummeled [3]. In contrast to the destructive focus of the piñata, and the temporary nature of Pin the Tail on the Donkey, in the early 1900s the surrealist art movement developed a game – the Exquisite Corpse [2] – that constructs a picture in pieces (Figure 4).

More recent innovations in output include an interactive fiction story which outputs 3D printable objects, commissioned by 3D printer manufacturer MakerBot [7]. In a very different approach to interactive fiction, *San Tilapian Studies* engages a group of 30-40 people in constructing a physical archaeological text based on game materials [8].

Innovative Input for Fabrication Devices and Games

Recent years have seen a growth of new interfaces for games, such as the Oculus Rift or Leap Motion. However, there is also a long history of designing games for unique platforms and machines, including arguably the first computer game: Tennis for Two [5]. Recently, the games industry has also seen a growth of custom-built controllers, as showcased at venues such as the Alt.Ctrl.GDC exhibit at the Game Developers Conference.

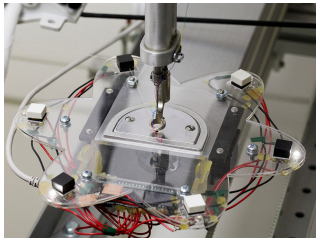

Figure 5: The quilting-machine version of our game is controlled with a ring of buttons around the sewing head (top), while the embroidery machine version uses a custom on-machine button panel (mockup, bottom).

Figure 6: As a game of threadsteading progresses, board hexes are quilted (and over-quilted) with players' motifs.

Realtime, situated interaction methods are less common for fabrication machines, which typically take as input static 2D or 3D models. An exception is Mueller et al.'s *Constructable*, which permits interactive control over a laser cutter through the evocative use of a laser pointer [6].

Threadsteading

Threadsteading is a two-player territory control game played on computer-controlled quilting or embroidery machine, Figure 1. Input to the game is provided through custom on-machine buttons, Figure 5, and output is quilted onto a fabric map loaded into the machine, Figure 2. The design of the game is heavily influenced by constraints imposed by the use of quilting as a medium and the fabrication process followed by the machines.

Game Description

In *Threadsteading*, players take on the roles of rival military officers jointly responsible for scouting territory. Each officer wants to have credit for scouting as much territory as possible, yet they are forced to cooperate to give the appearance of efficient exploration of the space.

The game is played on a hexagonal map with a radius of six tiles. Each hexagon is marked with a terrain difficulty from one to three, corresponding to how many movement points it costs to move into that piece of territory. In addition, six of the difficulty-one tiles are designated "towns", and are worth more points.

The officers take turns deciding which direction their joint corps of scouts should move. The scouts start with four movement points, and march in the selected direction – subtracting the movement cost of each tile they encounter from this total – until they run out, at which point it falls to the other officer to pick a direction to scout in.

Direction of movement is indicated using a hexagonal arrangement of buttons on the gaming machine (Figure 5). Army movement is recorded by the machine in the form of a sewn path of player-specific motifs, as shown in Figure 6.

Once all six towns are scouted, the machine stitches a scoreboard (Figure 7) showing which officer received the most prestige from the scouting expedition. Prestige is assigned to each officer by adding one point for every regular tile and three points for every town that was scouted under that officer's command. Officers don't receive any prestige from tiles that they both scouted, because retracing their steps makes them both look bad. The officer with the most prestige is considered the winner.

Sewing Constraints for Innovating Game Design

The introduction of constraints into the design process is widely held to produce innovative ideas [1]. There were three main constraints imposed by our use of a quilting machine: the need to sew in a single line, a desire to discourage players from sewing over the same space multiple times, and a goal of producing an aesthetically-pleasing, recognizable quilt. Each constraint has resulted in a deliberate game design decision that, combined, resulted in an innovative game tailored to the platform of a quilting or embroidery machine.

Quilting and embroidery machines are best suited to sewing along continuous paths. Moving the needle without sewing either requires cumbersome manual intervention to knot and cut the thread, or makes tangling very likely. Thus, our game is single-path. Each player must start their move where the previous player ended theirs.

Repeatedly sewing over the same area can weaken fabric, produce unpleasant visual artifacts, and lead to broken threads or needles. Thus, we must encourage players not to

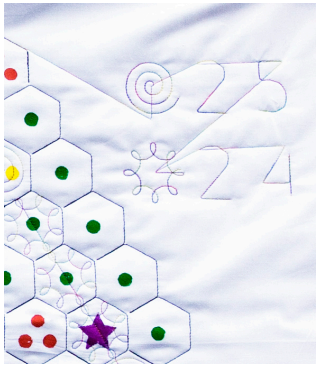

Figure 7: When the game concludes, the final score is quilted next to the board.

Figure 8: A traditional hexagon-quilt. Photo ©Elisabeth Augusta Borchgrevink.

go over ground that has already been covered, which led to the interesting theme of internally competing for territory while externally keeping up appearances.

Finally, *Threadsteading* adopts the traditional aesthetic of a hexagon-quilt (Figure 8). This both determines our board shape, and required us to come up with a goal – exploration – that encouraged adding many motifs to the board.

Implementation

Threadsteading runs on either an Innova 32" longarm quilting machine or a Singer SE-200 embroidery machine, both of which use proprietary communication interfaces to receive pattern files. Thus, part of developing the game involved reverse engineering these protocols to be able to send paths from our software.

We also developed custom input controllers (instead of requiring use of an on-computer GUI interface) to support situated input on the machine itself and improve the directness of interaction. On the quilting machine, this interface is mounted underneath the quilt surface, surrounding the throat plate. This allows players to push down on the quilt itself to guide the motion of the needle. On the embroidery machine, the controls are mounted to the side of the sewing area, due to space constraints; however, this control panel still supports players directly interacting on the machine.

Conclusions

As an experimental game, *Threadsteading* explores a novel combination of aesthetic, tangible game output and situated input in a highly constrained domain. Its value is to an audience of game design scholars and practitioners, as well as those who do experimental work in the independent games community. We also expect *Threadsteading* to appeal to scholars and practitioners involved in digital fabrication, as it raises questions around interactive fabrication technologies. Finally, with its focus on producing tangible artifacts and adopting traditional craft practices, the game is intended to appeal to those in the computation and crafting communities. *Threadsteading* merges all three of these areas – game design, digital fabrication, and traditional craft – to produce what is simultaneously an innovative game experience and a provocation for the future of interfaces to digital fabrication.

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