Techniques for Curved-Crease Fashion

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Abstract

This paper describes our process to create two different curved-crease dresses, one by means of heatsetting and another by using metal fabric. We developed a custom-fabricated soldering iron attachment for a Zünd digital cutter.

Introduction

While several artists and fashion designers have made fabric effectively fold into straight-crease origami designs [4, 5, 6], we are not aware of any examples of fabric folded like *curved-crease* origami; the rare examples of curved pleating (e.g., [3]) do not fold significantly. Our work translates curved-crease techniques from paper to fabric, making the result wearable over multiple uses. We created two dresses, one where the fabric was thermally treated to take on the folding pattern, and one where the fabric was cross-woven with metal threads that could be folded directly.

To efficiently utilize a large area of fabric, we chose a long crease pattern created from quarter circles instead of a closed circle, as shown in Figure 1. This crease pattern was adapted from the sculpture *Hanging Out* [1]. Mathematically, one way this pattern can fold is with the creases remaining planar, via vertical rule lines, an idea used in some of David Huffman's curved crease designs [2, Section 4.1].

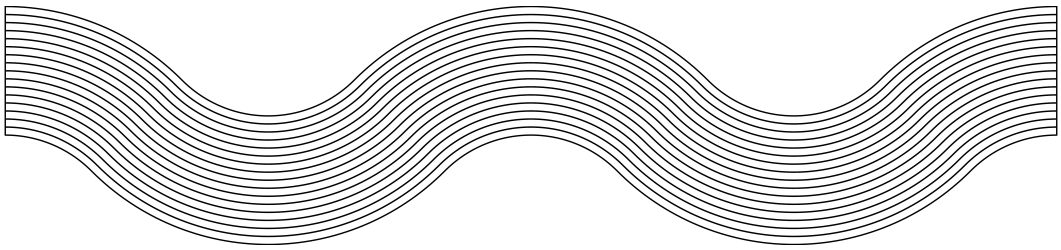
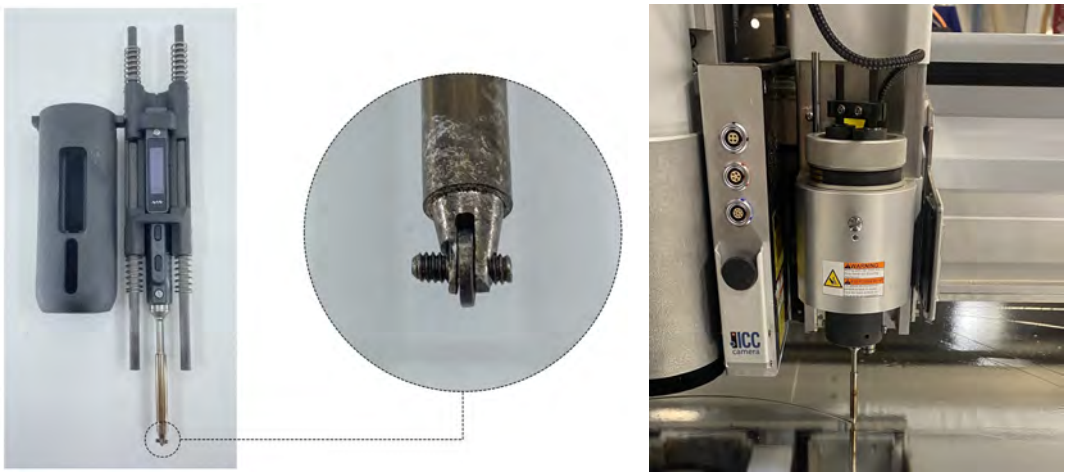


Figure 1: *Crease pattern used to cut and fold fabric pieces.*

The overall process consists of three stages: (1) cutting the fabric, (2) folding the fabric, and (3) draping the folded pieces on a dress form. We now describe each stage in turn. Figure 5 shows the final results.

Cutting the Fabric

Many fabrics, when cut (e.g., with a blade), eventually fray. To prevent fraying, the edge must be finished in some way, such as hemming. We wanted to avoid hemming because it adds thickness and hemming curves is difficult. Textiles made from synthetic fibers can be cut with a hot knife or similar tool that finishes the edge by heat-sealing it, essentially melting the fibers together along the cut edge, which prevents fraying. However, the crease pattern of Figure 1 has a curved boundary, which is difficult to cut precisely by hand. This motivates the use of a computer-controlled cutting tool.



(a) **(b)**

Figure 2: *Custom thermocutter: (a) components of the end effector, (b) thermocutter as a Zünd module.*

For this project, we used the Digital Cutter Zünd G3 2500. It has a large working area (2500 by 1800 mm) and vacuum table, allowing us to secure the fabric to the table without any additional fixtures. Figure 2 illustrates the design and fabrication of the custom thermocutter end effector. This device comprises an off-the-shelf digital PID-controlled PINE64 soldering iron, encased in a 3D-printed housing we designed. The housing is fixed in the x and y axes but incorporates a spring-loaded mechanism in the z axis, providing pre-tension against the fabric. Given that the Zünd cutter operates as a 3-axis gantry, moving in x and y, and rotating around the z axis to maintain tangency with the spline being cut, we minimize friction with the fabric by integrating a wheel at the end effector's tip. To accomplish this, we precisely milled the tip of the soldering iron to accommodate a wheel, consisting of an M2 washer and an M2 screw as the washer rotational axis. The tool is powered by 20V through an external source. To protect the machine bed from the hot end, which can reach up to 400°C, we used a 1/4-inch MDF (Medium-Density Fiberboard) sacrificial underlay, which gets damaged by the cuts. The porosity of the MDF preserves vacuum-hold functionality by transmitting suction from the machine bed to the fabric.

Folding the Fabric

Each dress used a different method to crease the fabric along curves. For our dress titled *All Curves are Beautiful*, we used heatsetting to crease a double-faced acetate taffeta fabric. For our dress titled *Safe Space*, we used a polymetal taffeta fabric woven with metal threads that plastically deform when folded directly.

Heatsetting is a thermal process used to permanently pleat fabric, similar to using an iron, but it treats an entire piece of fabric at once instead of one crease at a time. We created a Kraft paper mold for the fabric by folding two identical copies of the desired crease pattern (Figure 1), as shown in Figure 3a. Then we unfolded the paper, placed our fabric between them, and refolded them while holding the fabric (in the folded configuration) between both sheets of paper using metal clips, as shown in Figure 3b. Once secured, we placed this folded contraption into the oven at 150°C (300°F) for 45 minutes to heatset the folds. We included a tray of water in the oven to create steam. Once removed from the oven and cooled down, the fabric can be removed from the mold and is ready for draping.

Fabric made from metal threads does not need to be heatset, as the metal can hold a fold by undergoing plastic deformation. The fabric we worked with was made from polyester and metal threads, with the polyester strands running horizontally and the metal strands woven vertically, relative to the orientation of the crease

(a) **(b)**

Figure 3: *Preparations for heatsetting: (a) folding the paper mold, (b) the fabric folded inside the mold.*

pattern in Figure 1. The metal threads are able to hold a crease so long as the folds are not parallel to the metal threads, which our crease pattern avoids (forming at most a 45° angle to vertical lines). We used the Zünd tool to mark the crease pattern directly on the fabric without fully cutting through it. We then folded the fabric directly by hand, as we would with paper, and it was able to hold a crease well.

Draping the Fabric

After cutting and folding the fabric, we draped it onto a dress form to assemble the final dress (Figure 4). We started by making a normal (uncreased) dress from mesh fabric to serve as a base for holding the creased fabric. Then we draped the folded fabric pieces onto the dress form, and pinned them in place once we liked how they looked. Multiple evenly spaced curved creases (pleats) can give rise to regions of negative curvature or remain planar depending on twist: vertical rule lines in Figure 1 induce a (nearly) planar form, and twisting that form around the horizontal axis gives a variety of negative-curvature forms. We pinned each piece to the mesh dress, then replaced the pins with sewn stitches to permanently secure the folded fabric to the mesh garment.

Figure 4: *Draping the dresses from (left) the heatset fabric and (right) the metal fabric.*

Results

Despite using the same crease pattern and same amount of fabric (six copies of the crease pattern shown in Figure 1 for each dress), the results are aesthetically different due to the material used and the choices we made in draping. Figure 5 show our final dresses.

(a) *"All Curves are Beautiful" modeled by Abena Koomson-Davis (she/her). The two colors come from alternate sides of the fabric. The inspiration behind this work is to promote body positivity by showcasing a curved dress on a curved model who is confident and proud in her body.*

(b) *"Safe Space" modeled by Obi Taswell (they/them). The inspiration behind this work is to create a garment that honors the identity of the wearer and makes them feel safe, reclaiming dresses from the societal expectation that they only belong on women. We added plastic fish to allude to coral, a safe space for ocean life.*

Figure 5: *Our two finished dresses.*

Future Work

In the future, we plan to continue our collaboration and make more garments using this technique. We want to try using a different paper for the mold that is less likely to form kinks when curled tightly, as this will help the curved creases to be sharper and smoother.

References

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