

DressUp: A 3D Interface for Clothing Design with a Physical Mannequin

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ABSTRACT

This paper introduces DressUp, a computerized system for designing dresses with 3D input using the form of the human body as a guide. It consists of a body-sized physical mannequin, a screen, and tangible prop tools for drawing in 3D on and around the mannequin. As the user draws, he/she modifies or creates pieces of digital cloth, which are displayed on a model of the mannequin on the screen. We explore the capacity of our 3D input tools to create a variety of dresses. We also describe observations gained from users designing actual physical garments with the system.

Author Keywords

Clothing design, DIY, craft, tangible interaction, 3D drawing

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation: User Interfaces—*Interaction styles*.

General Terms

Design, Human Factors

INTRODUCTION

Clothes are very personal and worn on our bodies, yet for the most part are mass produced. The skills involved in designing clothes (e.g. pattern-making and tailoring) take years to acquire and present an obstacle to those who might be interested in designing and making their own personalized garments. The goal of this paper is to introduce a system for even casual users to be able to do exactly that.

Professionals who design and make clothes usually do so by first sketching garment concepts on paper. Next, they translate their designs into 3D by draping fabric onto a mannequin to get an idea of the 3D shape of the clothes and how the clothes fit on a body. Creating patterns for constructing the garment is a non-trivial task since the fabric is flat but when assembled, must fit the curves of a human body. A

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Figure 1. Overview of the system. User with mannequin and display (left), model of dress (center), and dress (right)

pattern maker will cut the pieces of cloth in a way that best approximates the curved design.

Computers now aid fashion designers in a variety of ways—for example, to design a 2D pattern and view it in 3D, or obtain a 2D pattern from 3D garment design [6]. Recently, innovative systems have been developed that allow users to sketch simple clothing in 2D, automatically converting the sketch to a simulated cloth model and a developable pattern [9] and also systems that allow changing the pattern shape while running a physical simulation [11]. However, designing with these tools is done entirely virtually with 2D input devices on a 2D screen, making it difficult for novice computer users to control the 3D shape of the garment.

With the novice user in mind, we developed a system that lets users design clothing with tangible tools and a full body-sized mannequin as a guide in the real world 3D space (Fig. 1). We believe that the process of working with a mannequin in 3D is an easy and natural form of interaction, encouraging designs that are interesting in all three dimensions and that fit the body well. Our initial prototype was received favorably by fashion industry professionals, who stated the idea was very new to them and were enthusiastic to explore it further, as well as novices, who used it to successfully design interesting dresses. We hope our system encourages people to take a more interactive role in the clothes they wear on their bodies, replacing a purely consumerist role in fashion.

RELATED WORK

Several types of 2D interfaces have been proposed for designing clothes. Some commercial software [7] allows casual users to put together clothing from templates of ready-made parts: collars, sleeves, skirts, etc., but we prefer to encourage creation of entirely new designs. Turquin et al. [3] developed a system that allows users to sketch the front and back designs of a garment over a 2D image of a person, to design clothing for digital characters. Decaudin et al. [9] use that system [3] as their interface for creating developable garments for dolls. This system, however, does not give users control of the garment design in any view besides the front and back. Wang et al. [4] created a system, intended for those working in the fashion industry, for specifying a garment with contour curves and cross-section curves, which allow users to very precisely specify a garment. Plushie [1] and Sensitive Couture [11] apply physical simulation to a resulting plush toy and garment model, respectively, to predict the final shape while the user is editing the pattern. All these systems use standard 2D input methods and none take advantage of 3D input or a body shape as a guide to create clothing.

Since 2D input methods require expert skill to create non-standard model shapes, there has been exploration of various types of 3D input for creating 3D models. Surface Drawing [2] explores generating 3D surfaces by sweeping the hand and other tangible tools. Spatial Sketch [5] explores freeform drawing in 3D space in order to create a physical 3D object (lampshade). Its authors discuss the challenge of drawing in 3D-space without the ability to press against a surface. Thus many 3D input tools are concerned with artistic expression and not precise output. Our system avoids completely freeform drawing by involving a life size mannequin as a drawing surface/guide. Yee et al. [12] implemented a 3D freeform drawing program using augmented reality to give the user a real world context for the objects being created, but no study has implemented a 3D input system tailored for clothing design to the best of our knowledge.

USER INTERFACE

The user interface consists of physical props that serve as input devices (mannequin, cutting tool, surface tool), and a large display with a virtual representation of the mannequin and clothes. (Fig. 1 left). The user designs 3D clothes in the environment (Fig. 1 center) and the final result is given as a flattened pattern from which the user can create a real garment (Fig. 1 right). In this work we focus on the dress, the single clothing item that allows the most variation of shapes. We also focus on just one mannequin size, though in the future a user could pick from several mannequins of a range of sizes, or even given a shape-changing mannequin [8].

Our tools (Fig. 2 left, center) allow for 2 distinct input modes: on body (cutting) and off body (surface generation). The motivation for these two modes is as follows. Many dresses can be fully described by sections that are *contoured to the body* and sections that are *not*. When the clothing shape follows that of the body, only the boundaries need to be indicated. In these cases, the cutting tool is used, and the user's strokes indicate boundaries such as armholes, neckline, and



Figure 2. Cutting tool (left) and surface tool (center), mannequin with string, wire, and tape as drawing guides (right)

seams. To indicate areas of clothing that extend off the body, such as a full skirt, the user can use the surface tool to draw surfaces directly by sweeping. We chose to use two different tools because of the affordances given by their shapes (a pointer for cutting and a rake-like T shape for sweeping).

The virtual model of the mannequin starts clothed with a simple form-fitting dress. Any seams are indicated on the virtual dress as thick lines. The GUI also features a few function buttons accessible by mouse: Clear, Undo, Make Seam, Cut, Symmetry Toggle, and Make Pattern.

The physical mannequin (Fig. 2 left) is a standard sewing mannequin: a female torso attached to a pole (for free rotation about the vertical axis) with wheels (for easy translation). It provides a tangible way to interact with the virtual model of the mannequin. The manipulations that the user performs on the physical mannequin (rotation, translation) are applied to the virtual model in the display in real time. For example, if the user wants to modify the back of a dress, he/she can grasp the mannequin and rotate it 180°, and the digital, clothed mannequin will rotate along with it, showing the back of the dress. After making a cut, the user can check how that change affects all angles of the dress by rotating the mannequin slowly 360°. The physical mannequin can serve as a guide for designing the dress both conceptually, as a reminder of the dimensions and shape of the human form and practically, which we discuss later, addressing the problem of a missing reference in 3D drawing methods [5].

The cutting tool (Fig. 2 left) is used to draw lines on the mannequin to indicate holes (neckline, sleeve-lines, cutouts) and seams, which immediately appear on the digital mannequin. Symmetry about the vertical axis can be turned on and off for this tool. The cut can either be a loop or an unconnected line, in which case the system will extend the cut to the nearest cloth borders. The user can choose whether a cut removes a whole section of fabric or just inserts a seam.

To create parts of a dress that extend away from the body, e.g. a skirt, the user can drag the surface tool (Fig. 2 center) through the space around the mannequin to form a surface, similar to Surface Drawing [2]. The user can drag multiple times, and the new surface section can connect smoothly to the previous section (Fig. 3). If close enough to the man-



Figure 3. Forming a skirt by adding multiple sections



Figure 4. Mini-dresses created with system

nequin, the surface can snap to the nearest points. Surfaces can be mirrored across the symmetry plane of the mannequin. Fig. 5 show various skirts designed using the tool.

Because the mannequin is a physical object, physical guides can be placed on it to help with drawing a design (Fig. 1 left, Fig. 2 right). For instance, the user can pin string to the cloth-covered mannequin in the shape of a neckline, or can arrange wires in the shape of a skirt, to trace with the tools. Since drawing in the air is ephemeral, these guides are a visual reminder of what was drawn, and can help in the placement of the next seams and holes. We place tape on the mannequin to indicate the default seam lines of the garment. Note that these physical guides are not recognized by the system. They purely serve as a guide for the user.

The pattern window (Fig. 7 left) displays each piece of the flattened version of the clothing. There is a scale marker at the top left corner, which can be adjusted by zooming to be 3.5 cm long, in order to create a pattern of size wearable by a person. The user can print this pattern, cut each piece from cloth with a 2 cm seam allowance, and sew the seam edges together to create a wearable garment.

IMPLEMENTATION

A vision-based EVaRT motion capture system with 6 Hawk-Eye cameras is used to connect the mannequin and the physical tools to their virtual counterparts. Reflective marker dots are placed on the tools to track their positions and orientation. Tracking could be done instead by inexpensive devices such as Wii remotes [5].

In cutting/seam mode, the user's input as recorded by the motion capture system is projected onto the surface of the digital mannequin model (a mesh created from photos) with a projection vector equal to the inverse of the average normal of the closest faces. This line is smoothed to remove noise from unsteady drawing.



Figure 5. Variety of skirts designed with surface tool: bubble (left), longer in back (center), flared (right)

The surface tool creates surfaces by Bezier spline. Each time the T-shaped tool is dragged, the midpoint of the top of the T indicates the control line being drawn. The endpoints of the top of the T control the tangent of the final surface at each point on the line. When the next line is drawn, the two lines are connected by a surface using the tangents to calculate the Bezier control points between them. Fig. 3 shows examples of skirts created this way, with the control lines indicated.

Given a polyhedron and border edges that divide the polyhedron into distinct pieces (topological planes), the algorithm flattens the pieces by calculating an as-rigid-as-possible transform on the pieces to a 2D plane [10]. This method directly flattens the mannequin's surface without ease and assumes stretchable fabric only, so the result is not 100% accurate if applied to woven fabrics. However, we found that the result is good enough for initial prototyping in garment design process. Fig. 4 and Fig. 1 right show small doll-sized prototypes and a human-sized garment created from the patterns produced by the system.

USER STUDY AND RESULTS

We performed two rounds of tests with 5 users total: three with little sewing experience, one a hobbyist, and one with experience running a clothing line. In the first round, the users with little experience found it difficult to draw in free-hand, prompting more line smoothing to the lines and the idea of using string or wires as drawing guides.

In the second round, the users were given a brief demo of the system and then shown example screenshots of dresses to create. Finally, each user designed a dress of their own (see Fig. 7) and gave feedback on the process. To give insight into the helpfulness of the mannequin and other physical guides, the users were asked to draw example dresses with and without: 1) the physical mannequin, 2) rotating the mannequin, 3) wires to guide the drawing of the skirt, and 4) string to guide the drawing of cut-outs and seams.

Results

When drawing without a mannequin, the user could still watch the screen to see their drawing projected onto the digital model of the mannequin. Even so, all users agreed that it was very difficult to draw in 3D without the physical mannequin as a guide, and the designs drawn without the mannequin reflect that (see Fig. 6). Users liked being able to rotate the mannequin in order to draw on the back or review



Figure 6. Example dress (left); drawn without (center), and with (right) physical mannequin



Figure 7. User's inspiration photo of Audrey Hepburn's dress², user-created dress and pattern

their dress design, but the designs drawn without rotation did not suffer much in quality.

Users were divided about the use of wires and strings as drawing guides. Users with little sewing/design experience felt more confident with physical guides such as string and wires, while users with more experience preferred designing without them. One novice to sewing said that working directly with a mannequin and pinning strings to the mannequin as guides made her “feel like a designer.” Even for the experienced designers, it was typical for the first attempt at drawing a full skirt to be exaggerated and cartoonishly puffy. Users with design experience learned quickly and reduced their motions to create more normal-looking skirts, while users with little sewing/design experience used the wires to help them judge the volume of the skirt.

One user who had not sewn since childhood said designing her own dress during testing inspired her to take up sewing again and she planned to put together her printed out design as soon as she got home (Fig. 7). Though our focus was making the process of designing dresses and patterns easier for novices, both experienced designers and casual users preferred to make their patterns by this system versus traditional methods, though for different reasons. Casual users stated they would feel restricted by a store-bought pattern since the design was not their own, and had no idea how to make their own patterns outside of this system; experienced designers cited that traditional pattern-making was tedious in comparison to using this system.

DISCUSSION AND FUTURE WORK

We would like to extend the variety of the clothes that can be designed by the system. Not all clothes have strictly tight

²modified so as to not infringe on complete image's copyright.

and voluminous parts, so we would like to introduce a tool that can make individual sections of cloth looser or tighter. We would like to add operations such as the creation of darts and gathers, and extend the mannequin anatomy to allow creation of sleeves and pants.

Additionally, we would like to improve the user's ability to predict the kind of garment they will create. Users suggested the ability to scan in fabric to apply as a texture to the cloth. The introduction of cloth simulation to the system would add sync between the dress shown and the dress created and also give the user the ability to generate designs that had particular folds and drapes [11].

REFERENCES

1. Mori, Y., Igarashi, T. . “Plushie: An Interactive Design System for Plush Toys”. *ACM Trans. Graph.* 26, 3, (45), 2007.
2. Schkolne, S., Pruettt, M., Schroder, P. “Surface Drawing: Creating Organic 3D Shapes with the Hand and Tangible Tools”. In *Proc. SIGCHI*, pages 261–268, 2001.
3. Turquin, E. Wither, J., Boissieux, L., Cani, M. P. Hughes, J. “A Sketch-Based Interface for Clothing Virtual Characters”. *IEEE CG&A* 27, 1, pages 72–81, 2007.
4. Wang, J., Lu, G., Li, W., Chen, L., Sakaguti, Y. “Interactive 3D garment design with constrained contour curves and style curves”. *Computer-Aided Design* 41, 9 , pages 614–625, 2009.
5. Willis, K. D. D., Lin, J., Mitani, J., Igarashi, T. “Spatial Sketch: Bridging Between Movement & Fabrication”. In *Proc, TEI*, pages 5–12, 2010.
6. “Optitex Fashion Design Software”. <http://www.optitex.com>.
7. “Starting a Clothing Line”. <http://www.startingaclothingline.com>.
8. Abels, A.; Kruusmaa, M. “Design of a shape-changing anthropomorphic mannequin for tailoring applications”. In *International Conference on Advanced Robotics*, pages 1–6, 2009.
9. Decaudin, P., Julius, D., Wither, J., Boissieux, L., Sheffer, A., Cani, M.-P. “Virtual garments: A fully geometric approach for clothing design”. In *Proc. Eurographics*, pages 625–634, 2006.
10. Igarashi, T., Igarashi, Y. “Implementing As-Rigid-As-Possible Shape Manipulation and Surface Flattening”. In *JGT* 14, 1, pages 17–30, 2009.
11. Umetani N., Danny M., Igarashi T., Grinspun E. Sensitive couture for interactive garment modeling and editing. *ACM Trans. Graph.*, 30:90:1–90:12, August 2011.
12. Yee B., Ning Y., Lipson H. “Augmented Reality In-Situ 3D Sketching of Physical Objects”. In *IUI Sketch Recognition Workshop*, 2009.