USER INTERFACE FOR FASHION DESIGN

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Abstract

This paper addresses interesting interface design issues in the designing of 3D clothes and 3D garments for synthetic actors. A complete methodology is presented for realizing what tailors and dress designers have done for centuries: cut flat pieces of cloth according to patterns and pin them around mannequins to see how they fit.

Keywords: interactive design, user interface, cloth, synthetic actor.

1. Introduction

The ultimate reason for developing realistic-looking synthetic actors is to be able to use them in virtually any scene that recreates the real world. However, a virtual scene -- beautiful though it may be -- is not complete without people.... Virtual people, that is. Scenes involving synthetic actors imply many complex problems we have been solving for several years [1].

Human-like synthetic actors have very irregular shapes that are hard to construct, especially for well-known personalities where a recognition factor comes into play. Once an initial human shape has been created, though, this shape should adapt and change during the animation. Ensuring the continuity and realism of the deformed surfaces is a very complex problem.

The process of animating humans is very involved and should be split into two areas: body motion control and facial animation. Basically a synthetic actor is structured as an articulated body defined by a skeleton.

Skeletal animation consists of animating joint angles. There are two main ways to do this: parametric keyframe animation and physics-based animation.

Another complex objective is modeling human facial anatomy exactly, including movements to satisfy both structural and functional aspects of simulation.

In order to improve the realism of synthetic actors, there are two important features to render: hair and clothes. This paper deals with clothes for synthetic actors.

We do not describe in detail the physics-based model involved in cloth animation; we only summarize these methods in the next section. Details about such a model may be found in an earlier paper [2]. What we do discuss, however, are the interesting interface design issues resulting from the design of clothes and garments for synthetic actors.

2. A brief history of garment design.

The importance of fashion in human history cannot be ignored. The garment industry has influenced countless lives and cultures with its notions of which styles and concepts become popular. Furthermore, fashion today is certainly a matter of taste -- a mechanism for expressing an individual's sense of self with a certain flair.

As one of the main criticisms of computer animated synthetic actors is their lack of "personality," it soon becomes obvious why clothing synthetic actors *fashionably* is of great importance. To achieve this end, we first considered real-life fashion design when planning our synthetic counterpart.

Successful fashion hinges on ideas and imagination, and it is the designers that first come up with the concept for their new garment. Shape, material, color, movement and flow -- all these qualities give a piece of clothing its uniqueness, and the designer uses drawings to communicates his intentions. Sketches of various views of the garment provide the clues needed for the next person involved in the garment design process: the tailor.

Tailors create two-dimensional patterns from the designer's drawings. These patterns, once cut out and sewn together according to the tailor's specifications, allow the garment to make the final step toward realization of the designer's dream.

3. A survey of cloth modeling and animation

Several models [3, 4, 5, 6, 7, 8, 9, 10, 11] have been proposed to animate deformable and soft objects such as rubber, paper, cloth, and so on. But it is somewhat difficult to realistically animate complex objects consisting of many surface panels like trousers or jackets without proper dynamic constraints. Problems include seaming the surface panels together, attaching them to other rigid objects, and calculating collision responses when they self-collide or collide with rigid objects.

In our approach, we work as a tailor does, designing garments from individual two-dimensional panels seamed together. The resulting garments are worn by and attached to the synthetic actors. When the actors are moving or walking in a physical environment, cloth animation is performed with the internal elastic force and the external forces of gravity, wind, and collision response.

Our work is based on the fundamental equation of motion as described by Terzopoulos et al. [4] with the damping term replaced by a more accurate one proposed by Platt and Barr [12]. When a collision is detected, we pass through the second step where we act on the vertices to actually avoid the collision. For this collision response, we have proposed the use of the law of conservation of momentum for perfectly inelastic bodies. This means that kinetic energy is dissipated, avoiding the “bouncing effect.” We use a dynamic inverse procedure to simulate a perfectly inelastic collision. Such collisions between two particles are characterized by the fact that their speed after they collide equals the speed of their centers of mass before they collide.

The constraints that join different panels together and attach them to other objects are very important. Two kinds of dynamic constraints [12, 13] are used during two different stages. When the deformable panels are separated, forces are applied to the elements in the panels to join them according to the seaming information. The same method is used to attach the elements of deformable objects to other rigid bodies. When panels are seamed or attached, a second kind of constraint is applied which keeps a panel's sides together or fixed on an object.

4. Why an Interface, and How ?

The designing of clothes and garments for synthetic actors presents some interesting interface design issues. Users of the software require ways of duplicating already-developed or imagined styles in a natural way. Provisions should exist for controlling not only the way a garment appears, but also the way it behaves (seams, physical properties, etc.).

Our approach to synthetic fashion is divided into two distinct stages. First, garments are planned and laid out in two dimensions. Then, they are sewn around the body and animated in three dimensions.

Separating the tasks in this manner is actually just a realization in computer terms of what tailors and dress designers have done for centuries: cut flat pieces of cloth according to patterns, and pin them around mannequins to see how they fit.

Furthermore, in user tests, professional designers created fairly complicated dresses and jackets, attesting to the functionality and ease of use of our design system.

5. Toolkit for Application Development.

Both parts of our clothing software employ the Fifth Dimension Toolkit [14]. The Toolkit simplifies the handling and processing of user input events and also allows for buttons, toggles, and other types of widgets to be easily integrated into programs. Furthermore, this interface builder -- a standard in our lab -- provides a uniform front-end and pleasant 3D "look" to all of our applications.

Toolkit applications are designed around a basic event loop, monitoring input and performing desired functions based on user action.

6. "Flat" Designs: 2D Garments and Panels.

The first step in creating a synthetic garment is specifying the panels that comprise the garment. In this sense, the term "panel" refers to one of the individual pieces of cloth that are to be sewn together. A simple t-shirt, for instance, may have only two panels, whereas a more complex jacket could have five or more.

Because the panel is the basic unit for garment construction, the two-dimensional interface employs the notion of a "current panel." Changes to a panel in the garment are made by selecting the desired panel as "current" and then modifying the current panel.

This current panel makes up the most important of the three windows used by the two-dimensional garment interface. (All significant work is done here.) The second window displays all the panels in a garment, and the third holds all the buttons and widgets needed by the user.

There are basically three primitives used in the construction of synthetic garments: the panel, the seam, and the attach line. (These last two are described later.) These divisions lead us to the four modes of operation in the Panel Window: Polygon, Seam, Attach, and Select. The first three are used for creating new panels, seams, and attach lines. The last mode is used for selecting any of the available primitives, so that vertices can be added, edited, or deleted.

In creating a panel, the user works in the Panel Window and defines a polygon with the mouse. An optional grid guides placement of polygon vertices, and the closed polygon's edges symbolize where a tailor cuts a panel out of a roll of fabric.

In fact, the size of the Panel Window represents the dimensions of the cloth. For a large panel, the user can resize the window for a larger and wider piece of fabric.

Many operations can be performed on defined panels. Users can edit, add, or delete vertices. They can resize panels. Panels can be saved, and pre-defined panels can be loaded. When panels transfer to become part of a garment, they either add to the garment's existing panels or replace one that has already been defined.

Some of the more useful design features in garment construction center around the "flip" capabilities. The vertices in the current panel can be mirrored horizontally or vertically for symmetry. If the front of a garment, for example, has two panels and one is a mirror-image of the other, the user need only define one of the two. By adding this first panel to the garment, flipping horizontally, and then adding this "second" panel, the front of the garment is finished.

A mechanism is also provided for flipping with retention. Here, a user can define half of a panel, flip it, and have as a result a wider, symmetrical panel.

7. Putting it Together: Seams and Attach Lines.

A most crucial capability of the two-dimensional interface involves the specification of exactly how the panels in a garment will be sewn together. Since the garment ultimately gets its shape from these seams, users of the interface must be able to clearly define and edit them.

Once a panel is transferred to the Garment Window (i.e., it becomes *part* of the garment) the user can enter "Seam Mode" and begin defining seams on that panel. Seams are basically line segments composed of any number of vertices. They are defined in pairs, consecutively, and for easy identification both halves are shown in the same color in the Garment Window.

When a seam is selected, its mate is drawn in white and its length is shown in a text widget. Seam length is important here, since our current seaming algorithm requires the lengths of both halves of a seam to be equal.

Similar to the seaming line but slightly different in function is the "attach line." Currently used only at the waist of a synthetic actor, attach lines fix panels to the body. This capability is quite useful in the design of skirts, for example. The waistband of the skirt can be made to directly attach to the waistline of an actor, like a belt. Ensuring that skirts stay in place through all of an actor's movements, attach lines can also be used on dresses and pants.

When attach lines are selected, a user can enter the "attach values" that dictate more precisely just how they should behave. If the waist of an actor is considered an ellipse, then an attach line can be specified to act on a certain portion of that ellipse. For instance, the front of a two-panel skirt could extend from 0 to 180 degrees. There is also mechanism for specifying that the attach line should take effect at a small distance above or below the "physical" waist of the actor.

8. Giving Clothes Depth: The Transfer to 3D.

Though the two-dimensional interface both designs the garments and specifies seaming, its clothes are still basically flat approximations of fashion. The 3D counterpart gives them life by, basically, giving them depth.

Importing 2D designs into the three-dimensional application is simple enough. But certain changes occur to the panels as they are converted. Panels are no longer considered only as vertices and edges defining an interior. They are discretized and become collections of nodes in a three-dimensional mesh [2].

Users have the option of mapping the 2D panel onto either a plane or a cylinder. This second choice is useful for clothing panels such as sleeves which go around an arm or a leg, for instance.

Calculations for a garment are performed at each node in each panel; it is therefore important to note that the distance between these nodes depends on the grid from the panel's creation in 2D. The size of the grid is user-controlled; a denser grid allows more detail, but a sparser grid means faster calculations.

9. Working in 3D.

After we import the 2D garment file, we are ready to begin using the three-dimensional interface for positioning the garment's panels around the body. We then continue, activating the seaming and attaching processes.

The first step is to turn "on" the parts of the body that are required for the particular garment at hand. (In practice, we have found it extremely useful to divide a synthetic actor's body into a number of sections, using only those sections we need.) Because we perform collision detection on all active sections of the body during seaming, turning some of them "off" decreases computation time drastically.

Next, we activate the Animation Window (Fig. 2). This window is used for two things: initial positioning on a non-moving body and animation on a moving body. (While seaming forces continue to significantly deform a garment, the clothes are considered unstable and we cannot calculate any animation sequences.)

First, we position our clothes around the body of the synthetic actor. At this point, the garments are either two-dimensional planes or simple cylinders, so we only place them approximately, and at distances far enough away from the body so they do not touch the actor. It is important to note here, that each panel's normal vectors should be directed away from the body. (As to just which side of a panel is "out," we follow a convention used in the 2D interface.)

In order to move these panels and garments around the actor, we use the mouse to select which panels or garments we desire, and then use a 3D input device such as the Spaceball to position the selected objects. Users then control panels and the camera's view with six degrees of freedom, making the initial approximate positioning of garments rather painless. (For the case when a Spaceball is not available, we rely on the Toolkit's convention of using the mouse as a Trackball.)

In the event that a sleeve should be placed on a bent arm or leg, simultaneous interaction with both the mouse and spaceball allows picking of specific portions of the panel for the desired deformations.

We can now begin seaming and attaching.

Attach lines jump to their specified locations on the body, and seaming pairs try to join together around the body. As seaming forces cause panels to collide with the actor, the clothes respond according to a physically-based elastic model [2].

Once the dress is stable on an unmoving actor, we can animate the actor according to a generated movement sequence. Collisions with the moving body apply, to each node in the clothing mesh, a small velocity and force that displace the node and, more generally, deform the garment. We can control the way a specific garment responds to these collisions by modifying certain characteristics with the three-dimensional interface's main menu.

Among these are included some environmental characteristics such as gravity, inertia, and even wind. Furthermore, we define two special values *alpha* and *beta* that control how much a garment stretches and bends, respectively. (For further information regarding these properties, the user is directed to publication [2] in the reference list.)

From all these values we can re-create, for instance, a dress made of silk or a jacket of heavy leather.

10. Data structures.

The garment data structure is maintained as a pointer to the first panel and a total number of panels. In the linked list of panels, each element contains a record for color, a number-of-vertices counter, a pointer to the head of the linked list of panel vertices, a bounding box showing size limits, and the panel's value for grid density (in cloth coordinates). And finally, a pointer to the next panel in the garment.

Seams are maintained in a doubly linked list. Ordering in the list determines which seams are sewn together. For instance, in a dress with three seams, there would be six elements in the seam list. The first would be sewn to the second, the third to the fourth, and so on in pairs. Each half of the seam makes up one element of the list. Each element of the list tells which panel the seam belongs to, how many vertices are in the seam, a pointer to the head of the vertex list, and pointers to the previous and next elements of the list.

Attach lines are supported with many of the same procedures as seams.

11. Current Expansion Areas and Research.

In extensive testing of our clothing software, users have designed many types of complicated clothing: jackets, dresses, jeans, shirts, etc. But we came to realize there were many areas for potential improvement, especially in terms of user interface.

In the panel-based two-dimensional portion, we are working on incorporating more garment-oriented features. A skeleton or simple representation of an actor would be useful as well, conveying size information to the designer. Also, the ability to add buttons or other decorations to panels would make simple dresses more spectacular.

Significant research is going toward creating a much more comfortable environment for users in the three-dimensional part of our clothing software. It proves difficult for users to get an accurate feel for the objects they are manipulating when positioning panels and garments around an actor.

We are investigating virtual reality as an alternative. Users could wear Eyephones and a DataGlove and fully interact with their creations. Our goal, though somewhat ambitious, is to allow real humans to feel they are actually “dressing” their virtual counterparts.

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References.

1. Magnenat-Thalmann N, Thalmann D (1991) "Complex Models for Animating Synthetic Actors," *IEEE Computer Graphics and Applications*, Vol.11, No5, pp.32-44.
2. Carignan M, Yang Y, Magnenat Thalmann N, Thalmann D (1992) "Dressing Animated Synthetic actors with Complex Clothes," *Proc. SIGGRAPH'92*, Computer Graphics, Vol. 26, No 2, Chicago, pp. 99-104.
3. Weil Jerry. "The Synthesis of Cloth Objects." In *Proc. SIGGRAPH'86*, *Computer Graphics*, Vol.20, No.4, 1986, pp.49-54.
4. Terzopoulos D, Platt J, Barr A, Fleischer K (1987) "Elastically Deformable Models," Proc. SIGGRAPH'87, Computer Graphics, Vol. 21, No.4, pp.205-214
5. Kunii TL, Gotoda H (1990) "Modeling and Animation of Garment Wrinkle Formation Processes." In *Proc. Computer Animation'90*, Springer, Tokyo, pp.131-147.
6. Lafleur B, Magnenat Thalmann N, Thalmann D (1991) "Cloth Animation with Self-Collision Detection." In *Proc. IFIP Conference on Modeling in Computer Graphics*, Springer, Tokyo, pp.179-187.
7. Aono M (1990) "A Wrinkle Propagation Model for Cloth." In *Proc. Computer Graphics International '90*, Springer, Tokyo, pp.96-115.
8. Hinds BK, McCartney J (1990) "Interactive garment design," In *The Visual Computer*, Vol. 6, pp.53-61.
9. Y. Yang, N.Magnenat-Thalmann, D.Thalmann, "**3**D Garment Design and Animation — A New Design Tool For The Garment Industry," *Computers in Industry*, Vol.19, 1992, pp.185-191.
10. Mangen A, Lasudry N (1991) "Search for the Intersection Polygon of any Two Polygons: Application to the Garment Industry." In *Computer Graphics Forum*, 1991, Vol.10, pp.19-208.
11. Breen DE, House DH, Getto PH (1991) "A Particle-Based Computational Model of Cloth Draping Behavior," in: Patrikalakis NM, *Scientific Visualization of Physical Phenomena*, Springer-Verlag, Tokyo, pp.113-134
12. Platt JC, Barr AH (1989) "Constraints Methods for Flexible Models." In *Proc. SIGGRAPH'89 , Computer Graphics*, Vol.23, No.3, pp.21-30.
13. Barzel R, Barr Alan H. "A Modeling System Based on Dynamic Constraints." In *Proc. SIGGRAPH '88, Computer Graphics*, Vol. 22, No4, 1988, pp.179-188.
14. Turner R, Gobbetti E, Balaguer F, Mangili A, Magnenat Thalmann N, Thalmann D, "An Object-Oriented Methodology Using Dynamic Variables for Animation and Scientific Visualization," *Proc. Computer Graphics International '90*, Springer Tokyo, pp.317-328.