Beginning Premature Effective Garment recreation to interactive fashion design

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ABSTRACT:
Virtual garment design and simulation involves a combination of a large range of techniques, involving mechanical simulation, collision detection, and user interface techniques for creating garments. Here, we perform an extensive review of the evolution of these techniques made in the last decade to bring virtual garments to the reach of computer applications not only aimed at graphics, but also at CAD techniques for the garment industry. As a result of the advances in the developments of virtual garment simulation technologies, we then detail a framework which fits the needs of the garment industry of virtual garment design and prototyping, concentrating on interactive design, simulation and visualization features. The framework integrates innovative tools aimed towards efficiency and quality in the process of garment design and prototyping, taking advantage of state-of-the-art algorithms from the field of mechanical simulation, animation and rendering.

Keywords: Cloth simulation; Virtual garments; Fashion design; Pattern prototyping

1. Introduction

The challenges of virtual garment simulation are numerous, and have attracted research efforts for more than a decade. First dedicated to the realistic simulation of the mechanical behaviour of cloth, it soon evolved towards simulation of virtual garments on synthetic characters. While computer graphics gets the most obvious benefits from garment simulation on animated virtual characters, virtual prototyping of garment models is another major application field for the garment industry.

Virtual garment simulation is the result of a large combination of techniques that have also dramatically evolved during the last decade. Unlike the mechanical models used for existing mechanical engineering for simulating deformable structures, a lot of new challenges arise from the highly versatile nature of cloth. The central pillar of garment simulation obviously remains the development of efficient mechanical simulation models, which can accurately reproduce with the specific mechanical properties of cloth. However, cloth is by nature highly deformable, and specific simulation problems arise from this fact. First, the
mechanical representation should be accurate enough to deal with the nonlinearities and large deformations occurring at any place in the cloth, such as folds and wrinkles.

Cloth simulation has, however, matured enough to introduce its potentials to the garment industry. The main needs to be fulfilled are mostly related to virtual garment prototyping, as well as visualization applications related to and virtual fashion and prototyping.

2. State-of-the-art in virtual garments

Garment simulation, which started in the late eighties with very simple models such as Weil’s approach [54], has taken much benefit from the increasing performance of computer hardware and tools as well as the development of specific simulation technologies which have nowadays lead to impressive applications not only in the field of simulation of virtual worlds, but also as design tools for the garment and fashion industry.

2.1. The beginnings of garment simulation

In the field of computer graphics, the first applications for mechanical cloth simulation appeared in 1987 with the work of Terzopoulos et al. [43,44] in the form of a simulation system relying on the Lagrange equations of motion and elastic surface energy. Solutions were obtained through finite difference schemes on regular grids. This allowed simple scenes involving cloth to be simulated, such as the accurate simulation of a flag or the draping of a rectangular cloth. However, the first applications that really simulated garments started in 1990 (Fig. 1) with the considerations of many other technologies complementing cloth simulation [7,33], such as body modelling and animation, and collision detection and response [55]. These applications innovated by providing the first virtual system allowing virtual garment patterns to be sewed together around a character.

2.2. Mechanical models

Fig. 1. ‘FlashBack’: early virtual garments used context-dependent simulation of simplified cloth models.
The accurate reproduction of the mechanical behavior of cloth has always been a key issue for garment simulation. The mechanical behavior of cloth is usually measured using standardized protocols, such as the Kawabata Evaluation System (KES), or the simpler FAST method, which are based on the experimental measurement of strain-stress curves for elongation, shearing and bending on normalized samples of fabric. Different representations of the cloth surface mechanics then allow the virtual reproduction of the behavior of cloth.

Finite elements have only had a marginal role in cloth simulation. The main attempts are described in [10,19,25]. Most implementations focus on the accurate reproduction of mechanical properties of fabrics, but restrict the application field to the simulation of simple garment samples under elementary mechanical contexts, mostly because of the huge computational requirements of these models. Furthermore, accurate modelling of highly variable constraints (large nonlinear deformations, highly variable collisions) is difficult to integrate into the formalism of finite elements, and this sharply reduces the ability of the model to cope with the very complicated geometrical contexts which can arise in real-world garment simulation on virtual characters.
2.3. Garment design and simulation

Since the first developments to produce simulated garments on virtual characters [7,33], cloth simulation and garment animation has made its way not only in computer research (Fig. 3) [49], but also into commercial products aimed both for 3D computer design and the garment industry. Two kinds of products are currently available: those oriented for general cloth simulation and animation, and those specialized for draping and fitting garment models on virtual mannequins. The first category offer tools for simulating any kind of deformable surface mechanically. They usually offer a simple mechanical model containing only the basic mechanical parameters of cloth (stiffness, viscosity, bending, gravity) modelled as a spring-mass particle system and simulated using state-of-the-art integration techniques. They allow the computation of realistic cloth animation, but do not provide any tool for designing garments. They also offer general collision detection schemes for interaction with any other objects.

3. Garment animation

Tight clothes in Layer 1 follow the deformation of the underlying skin. These deformations are calculated thanks to the mapping of the attachment data of the skin to the garment surface. For Layer 2 that is composed of loose clothes, the relative movements of clothes to the skin remain relatively small, keeping a certain distance from the skin surface. Consider the movement of sleeve in relation with the arm: for a certain region of the garment, the collision area falls
within a fixed region of the skin surface during simulation. With this in mind, the scope of the collision detection can be severely limited. A basic assumption made is that the movement of the garment largely depends on that of the underlying skin and yet it should not follow the skin surface rigidly. It is necessary to simulate the local displacement of the garment from the skin surface.

![Cross-Section of a limb with garment](image)

**Fig 5:** Cross-Section of a limb with garment

### 4. Conclusion

However, new virtual simulation may also offer new paths toward innovative design techniques for the garment industry. For instance, the design of the garment could be done directly in 3D, with automatic generation of the pattern shapes as output for the pattern maker. In a further step, new 3D interaction tools and advanced features, such as development in automatic recognition of shapes out of sketches of a fashion designer, is a vast area of new potentialities.

### References


