Preventing Tangled Cloth

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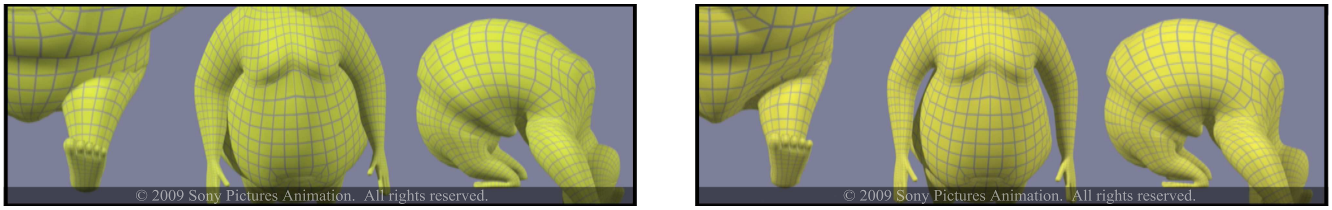

Figure 1: *(a) Animated character with pinched geometry.* *(b) Pinch free geometry.*

Abstract

Geometric pinching can result in cloth simulation output that is a tangle of cloth. We present a technique that eliminates pinching problems prior to simulation. The subsequently solved cloth simulations are cleaner, less tangled, and execute faster when compared to the no preprocessing case. The core algorithm is formulated as a general case mesh problem enforcing a minimal distance invariant, and thus it is applicable to a wide variety of geometric problems. We provide results from its use on feature film productions.

CR Categories: I.3.7 [Computing Methodologies]: Three-Dimensional Graphics and Realism—Animation

Keywords: meshes, animation, cloth, collision, deformation

1 Discussion

In CG feature film production, typically the character animation is approved first and then handed off to another artist for cloth animation. The cloth artist's task is to generate an appropriate animation of cloth meshes with respect to the given character animation and the director's aeshtetic vision. The character animation is approved from the film camera view. This approved geometry often exhibits the *pinching* problem, which exists when two surface areas inter-penetrate each other, pinching the cloth surface between them. Given this input, it is difficult for a cloth simulation engine to provide a reasonable solution. Often, the result is tangled cloth at the pinched frame and all subsequent frames.

Our approach differs from other approaches that are internal to the cloth simulation engine, such as [Baraff et al. 2003]. In those approaches, they first identify pinched areas, and then they compute reasonable cloth mesh positions for the given case. These are difficult cases to resolve because the input data is over-constrained.

We address the pinching problem directly. By eliminating the creation of pinches, we avoid having to resolve them. Using our technique, the cloth artist work flow is as follows: The artist defines one (or more) pairs of surface regions on the body mesh and a minimal distance value to be satisfied. The optimal minimal distance value is determined by costume design, simulation constraints, and the desired visual style. A typical example is an arm region, a torso region, and 2 cm. Starting from an intersection free frame, the character animation is pre-processed, and a pinch free animation of the character's body mesh is computed.

The core component of the technique is a robust algorithm that guarantees the minimal distance criteria is enforced, over time, between two surface areas. The *input assumptions* of the algorithm are: (a) Animated poly-meshes with constant topology; (b) Each of the two surface areas is a set of mesh faces; (c) The vertices in one face set are unique from the vertices in the other set; And (d) there is a clean non-intersecting frame to start solving from. The algorithm *computes the deformations* by: (1) By subdividing the generalized problem into a temporal series of sub-problems, each with an upper bounds on mesh displacement; (2) Using the solution from the previous sub-problem as a starting point for the current sub-problem; (3) Separating apart pairs of surface points that violate the distance invariant; (4) Relaxing surface points back to their animated positions; (5) Re-distributing vertices in the surface tangent plane to minimize texture distortion; (6) Repeating steps 3-5 until a given tolerance is achieved. (7) Repeating steps 2-6 per sub-problem.

2 Conclusion

We address the tangled cloth problem by removing the creation of pinched geometry. The algorithm is independent of any particular cloth engine and needs to be computed only once for repeated simulations. In our experience, pre-processing results in cloth simulations executing 2 to 4 times faster on average, while generating cleaner results and fewer tangles. The algorithm is applicable to all quad-tri poly meshes and is easily applied to various feature film production problems as illustrated in Figure 2.

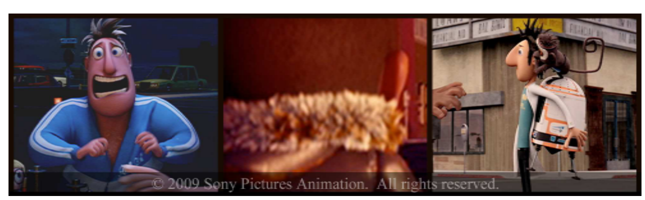

Figure 2: *(a) Body deformation, (b) Fur bounding volume deformation, and (c) Deformation extended to include props.*

References

BARAFF, D., WITKIN, A., AND KASS, M. 2003. Untangling cloth. In *SIGGRAPH '03: ACM SIGGRAPH 2003 Papers*, ACM, New York, NY, USA, SIGGRAPH, 862–870.

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