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GPU-based Real-time Cloth Simulation for Virtual Try-on

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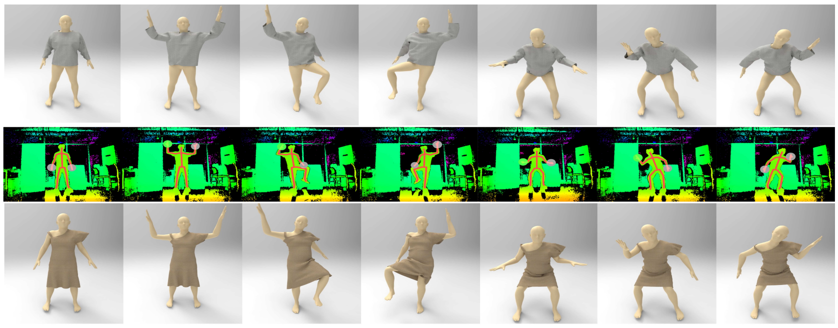

Figure 1: *Our GPU-based approach can achieve real-time cloth simulation on a human body. The meshes of two garments are represented by 6K and 7K triangles. Our simulator performs all of the computations in an entire parallel way. We have implemented it on both NVIDIA GTX 960 and GTX 1080. Our new parallel algorithms result in significant speedups over prior methods.*

Abstract

We present a novel real-time approach for dynamic detailed clothing simulation on a moving body. The most distinctive feature of our method is that it divides dynamic simulation into two parts: local driving and static cloth simulation. In local driving, feature points of clothing will be handled between two consecutive frames. And then we apply static cloth simulation for a specific frame. Both parts are ecxuted in an entire parallel way. In practice, our system achieves real-time virtual try-on using a depth camera to capture the moving body model and meanwhile, keeps high-fidelity. Experimental results indicate that our method has significant speedups over prior related techniques.

CCS Concepts

•***Computing methodologies*** $\rightarrow$ ***Physical simulation;***

1. Introduction

Cloth simulation has been a hot research topic for recent years because of the importance in games, films and virtual try-on systems. A number of algorithms have been proposed to simulate realistic clothing. But real-time cloth simulation remains a big challenge. To realize real-time clothing animation, a data-driven approach [GRH*12] analyzes the clothing deformation from precomputed clothing samples on different bodies, and gets acceptable results by assuming linear or local relationship between the transformed clothing and the body poses. Besides, [GPV*15] augment coarse cloth simulation with dynamic realistic-looking wrinkling to simplify simulation process. However, data-driven approaches only can be applied to close-fitting garments and need substantial computational resources for pre-computed samples and lack of motion inertia.

We present a local driving method to simulate dynamic clothing on moving body. We adopt a novel collision response method to handle the feature points described in section 2.1 and the rest points are regarded as static firstly and then will be driven by the static cloth simulation according to physical laws. To develop a fast and effective scheme for Feature Points Test (FPT), we employ Bounding Volume Hierarchy (BVH) to model the swept space of moving body mesh. Our system can simulate detailed dynamic clothing mesh (7,000 vertices) on moving body in real-time(Figure 1). Besides, we present an entire parallel pipeline on GPU, including BVH construction [Kar12], time integration and collision han-

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dling. For our system, we do not need any pre-computed samples like data-driven methods. Besides, it can be applied to almost all types of garment.

2. Overview

Our system can be summarized as follows:

- Capture the moving body pose and generate body model.
- Use Feature Points (FP) described in section 2.1 to resolve penetrations between two consecutive frames. Dynamic Bounding Volume Hierarchy (D-BVH) is used for acceleration.
- Apply static cloth simulation for a specific frame. It consists of Static Bounding Volume Hierarchy (S-BVH) construction and 20-30 iterations, including time integration and collision handling.

To summarize, our system costs about 20 ms for D-BVH and S-BVH constructions and 20-30 ms for iterations per frame, which results in a real-time performance and has much potential in interactive applications.

2.1. Feature points handling

We employ feature point to handle penetrations between two consecutive frames. If a mass point of clothing is in the swept space of the moving body mesh, it will directly collide with the body and we call this point a feature point. However, it is possible that one feature point can be in more than one D-BVs of triangles, shown as Figure 2. We use a distance-based selection method to pick out the appropriate triangle.

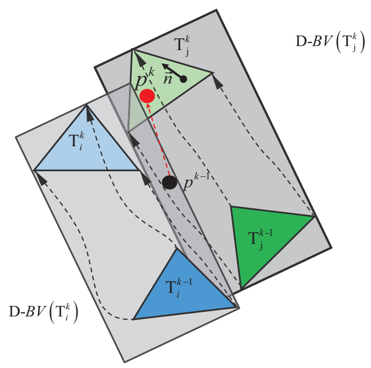

Figure 2: *One point in two D-BVs, we adopt a distance-based selection method to pick out true feature pair.*

In the k-th frame, for every feature pair $\{P_i, T_j\}$, we project the point p_i^{k-1} to the swept space's surface T_j^{k-1} along with the normal direction to get point p_{proj}. We use Equation 1 to get coefficient $\{\theta_0, \theta_1, \theta_2\}$ and solve the updating positon of the feature point P_i by Equation 2, in which $dist$ is the distance between the point p_i^{k-1} and the triangle T_j^{k-1}, $\vec{n}$ is the face normal of the triangle T_j^k, and $v_{j,0}^k, v_{j,1}^k, v_{j,2}^k$ are three vertices on triangle T_j^k.

$$p_{proj} = \theta_0 v_{j,0}^{k-1} + \theta_1 v_{j,1}^{k-1} + \theta_2 v_{j,2}^{k-1} \quad (1)$$

$$p_i^k = \theta_0 v_{j,0}^k + \theta_1 v_{j,1}^k + \theta_2 v_{j,2}^k + dist \times \vec{n} \quad (2)$$

2.2. Static cloth simulation

We apply static cloth simulation for a specific frame after FP response. It consists of 20-30 iterations, including verlet integration and collision handling. In order to fully utilize the parallel capabilities of current GPUs, we map the geometric mesh to streaming data representation and the computational procedures to GPU kernels as illustrated in Figure 3.

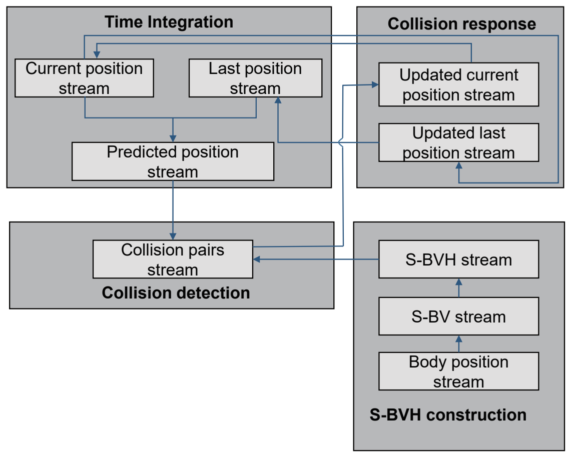

Figure 3: *All the geometric data are represented as GPU streams (shown in light grey boxes). Different kernels (shown in dark grey boxes) operate on these streams. The arrows refer to input/output relationship between these streams and kernels.*

3. Discussion and Conclusion

We present a GPU-based streaming cloth simulation algorithm for Virtual Try-on. It consists of parallel D-BVH and S-BVH constructions and efficient parallel algorithms for feature points handling. Our system achieves real-time cloth simulation and keeps high-fidelity compared to learning-based system and model-simplified system.

References

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