A Collision Detection Method for High Resolution Objects using Tessellation Unit on GPU

Thiti Rungcharoenpaisal[1] and Pizzanu Kanongchaiyos[2]

Department of Computer Engineering, Chulalongkorn University

Figure 1: 200M polygons in wireframe (left), tessellated polygons in potential collision areas(center), collided polygons in green (right)

Introduction

Currently, collision detection in virtual worlds is an important research topic, since it can be applied to many categories of simulations. The current trend of research is focused on the development of Bounding Volume Hierarchies (BVHS), and how to accelerate collision detection with speed, accuracy in a way that can be applied to many types of objects such as soft and rigid bodies. As a result many previous works have focused on developing BVHS to update its bound efficiently, data structures with filters that can effectively prune the objects or areas of objects that are not going to collide as well as developing methods to detect collisions in parallel on a GPU [Min, Dinesh et al. 2011]. However, the major problems of this type of research are limitations on the object to be used, which must not have a high resolution of millions of polygons, due to limited memory on the GPU, which is not enough to retain the BVHS data structure of the whole model. Thus, if only the area of collision has a high resolution, there can be enough memory to process this kind of object. Furthermore, a Tessellation Unit on the GPU, which can tessellate the object in areas or at factors that the user wants, is currently available, but it is only used to represent the high quality images, and there is no work focusing on using it for general purpose work. Therefore, this research proposes a method to detect collisions that can be used on objects with high resolution up to millions of polygons via integration with the Tessellation Unit by tessellating objects to high resolution only in the collision areas, which can be determined in parallel using a grid in GPU. Thus, the experimental results show that this method can reduce the amount of memory usage on the GPU, but still provide accurate results in collision detection.

Proposed Method

In this research, the overview of our method using the GPU is divided into three steps as follows.

1) Grid Pruning: At this stage, two coarse triangular polygonal objects that have potential collisions and a position buffer derived from the simulator simulating deformable objects are the inputs to be pruned using a grid-based method for finding only potential collision areas as shown in Figure 2(left).

2) Tessellation: At this stage, objects will be tessellated with the displacement map from the simulator in the presence of a collision only. The information is stored in the GPU memory in the next step as shown in Figure 2(center).

3) Collision detection: At this stage, the potential collision areas are assigned to the hash table which is used to find pairs of triangular polygons with a chance of a collision. The polygon pairs will be tested to find contact points, before forwarding them to the simulator to simulate and display results of simulation, as shown in Figure 1(right).

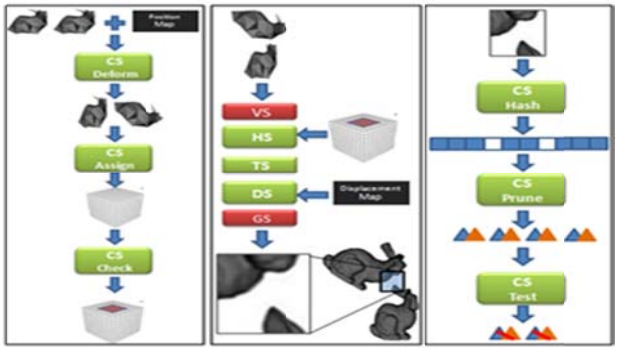

Figure 2: Grid pruning using compute shader (left), Tessellation using directx11 graphics pipeline (center), Collision detection using compute shader(right)

The experimental results show that the proposed collision detection method for high-resolution tessellated object can give the exact collision in high speed. A sample of the experimental result of 200 million triangular polygons in high resolution mesh objects shows the querying time of our collision detection method in 50 ms in an average. Our method presented is to show the way to use the Tessellation unit in the general purpose. This approach can also be modified using others data structures and can be optimized for the improvement further.

Reference

Min, T., M. Dinesh, et al. (2011). Collision-streams: fast GPU-based collision detection for deformable models. Symposium on Interactive 3D Graphics and Games. San Francisco, California, ACM

[1]e-mail:myths.bass@gmail.com
[2]e-mail:pizzanu@chula.ac.th

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