Level of Detail for Complex Urban Scenes with Varied Animated Crowds, using XML

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EXTENDED ABSTRACT

Crowd simulation has gained attention recently in the movie and video game industry, still there are broader applications in which crowd simulation is associated, transportation and urbanism are some examples.

Even tough hardware capabilities are surpassed constantly by each new generation of hardware, the number of polygons, memory and computational resources are not enough to properly simulate dense crowds composed by millions of characters. This cannot be achieved without the aid of rendering techniques such as Level of Detail (LOD). Interactive virtual crowds require high-performance simulation, animation and rendering techniques to handle numerous characters in real-time. These characters must be believable in their actions and behaviors. Real-time crowd simulation brings different challenges compared with systems that involve a small number of interacting characters (i.e. most contemporary computer games) and non-real-time (i.e. crowds seen in movies or visualizations of crowd evacuations after offline model computations). In comparison with single agent simulations, the main conceptual difference is the need for efficient variety management at every level, whether is visualization, motion-control, animation or sound rendering [1].

A. Hybrid Hierarchical LOD System for large crowds using configuration files

We present a system capable of handling several thousands of varied animated characters within a crowd. These characters are designed to have geometric, color animation and behaviour variety, nevertheless when a crowd becomes bigger, more memory is needed and is often difficult to achieve this objective [2]. To solve this problem, we implemented two complementary data structures. The first structure is a skeleton with associated octrees for each limb that is used for applying, transferring animations and generating variety for characters at any level of detail, as shown in figure 1. The second structure is a scene tiling with an associated quadtree that represents the environment. This structure is used for rendering, LOD selection and for combining characters in areas far away from the viewer to further reduce resource consumption, allowing us to handle dense crowds.

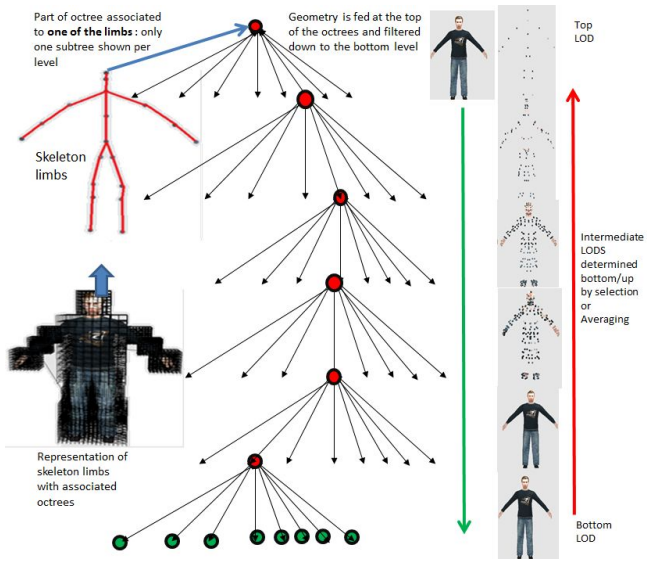

Figure 1: Creation of the skeleton and how LOD is built using our octree system. Each limb has an associated octree and data is stored inside the structure.

Extending this hybrid LOD method, and adapting it to use instructions from newer versions of OpenGL, we are implementing a complete authoring system based on XML configuration files with which we can create virtual environments that include buildings, trees, vehicles and people. We can declare the size of the crowd and create different groups, each of which will have different base geometry, rules for variety, distribution and behavior, and can be based on data that the user can provide to the system.

B. Results

Our LOD method outperforms traditional impostors and the most common variations in terms of memory requirements and/or computation. The work by Rudomin et al. [3] states that 12 megabytes of memory are used for each impostor, whereas the presented method only needs 75,532 kilobytes of memory to simulate a crowd composed of 65,536 characters. This is achieved because variety, animation and LOD are computed directly on the GPU, making possible to generate diverse crowds in real time. In comparison, traditional impostors would need 12 * 65536 Megabytes of memory to display the same crowd. Our representation needs less memory or computation that any of the traditional impostor methods (at run-time, since there is an initial cost of

generating and filling hierarchical structures when loading the scene). Figure 2 shows the achieved results using our method.

Figure 2: A crowd composed by 65,536 varied and animated characters.

The system is not limited to crowds composed only by humans, it is possible for us to create urban environments and incorporate props into the simulation. Figure 3 shows an example of a simulation created using this method.

Figure 3: A scene created with the system presented in this paper. It is possible to combine different kinds of geometry to create complex urban environments

C. Conclusion and Future Enhancement

Some of the main challenges faced in this work are to remove the least perceptible details for the simulation to preserve the global vision aspects without compromising visual quality and meanwhile, significantly improve computation times. This work is mainly focused on discrete level of detail, but some variations are interesting to study as well, for example adaptive LOD which gives more importance to certain areas of the geometry or the environment, enhancing visual quality without compromising the quality. Nevertheless LOD applications are broader than geometry simplification, in fact it is possible to make simulations more complex by implementing LOD variations that consider behavior, animation and collision avoidance just to mention a few.

References

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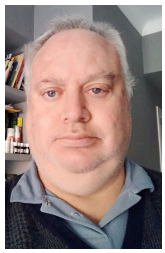
Author biography

Leonel Toledo received his Ph.D from Instituto Tecnológico de Estudios Superiores de Monterrey Campus Estado de México in 2014, where he was a full-time professor from 2012 to 2014. He was an assistant professor and researcher and has devoted most of his research work to crowd simulation and visualization optimization. He has worked at the Barcelona Supercomputing Center using general purpose graphics processors for high performance graphics. His thesis work was in Level of detail used to create varied animated crowds. Currently he is a researcher at Barcelona Supercomputer Center.



Isaac Rudomin is a senior researcher at the Barcelona Supercomputer Center, which he joined in 2012. His focus is on crowd rendering and simulation including generating, simulating, animating, and rendering large and varied crowds using GPUs in consumer-level machines and in HPC heterogeneous clusters with GPUs. Previously, Isaac was on the faculty at Tecnologico de Monterrey Campus Estado de Mexico (from 1990 to 2012). He finished his Ph.D. at the University of Pennsylvania under Norman Badler on the topic of cloth modeling.