Real-Time Smoke Rendering and Light Interaction

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Abstract

In computer graphics, smoke can be represented by using particle systems. Adding shadows to particle systems can go a long way to improve visuals and realism. Our work is concerned with external shadows cast onto a particle system by an occluding object, for which shadow mapping is combined with the particle system in an implementation that uses the Graphics Processing Unit (GPU).

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Animation; I.6.8 [Simulation and Modeling]: Types of Simulation—Gaming

1. Introduction

Modern computer games attempt to immerse players in realistic virtual worlds, which can be greatly improved by the addition of effects that simulate natural phenomena. Our work aims to produce a method for rendering dynamic smoke with shadows and light scattering. This work is still in progress and this document presents initial results achieved using our system. The focus of this work is the rendering of smoke and not its simulation. A GPU-based particle system is used to represent the smoke and shadow mapping is used to cast external shadows onto the particle system (see Figure 1).

Figure 1: *External shadows on a smoke particle system.*

2. Related Work

The rendering of natural phenomena, such as smoke, enhances the realism of scenes in computer-generated images. A good summary of the representation of smoke in computer graphics is presented by Stopford [Sto06], detailing most of the common off-line techniques used in smoke rendering. However, there exists only a small body of work in the field of real-time smoke rendering, which is divided in two different approaches. Zhou et al. [ZRL*08] introduced a method for rendering smoke under dynamic low-frequency lighting in which rendering was achieved through compensated ray marching through the smoke volume. Their model provides an estimate for light scattering and shadowing. It handles rendering of smoke volumes, which is different from the other approach to smoke rendering which employs a particle-based solution, which is the approach that we have selected for our work.

Green [Gre08] presented a particle system that casts shadows and implements self-shadowing, using a model that utilises the GPU through the CUDA [Buc07] GPGPU (General Purpose GPU) language to achieve real-time speeds. This model, however, does not provide a solution to particle system shadowing from external occluding objects, which is a topic that our work investigates.

External shadows are an important effect to improve the visuals of rendered smoke. Our research provides a simple method for adding this effect to a GPU-based particle system for representing smoke, combining shadow mapping with semi-translucent particle systems.

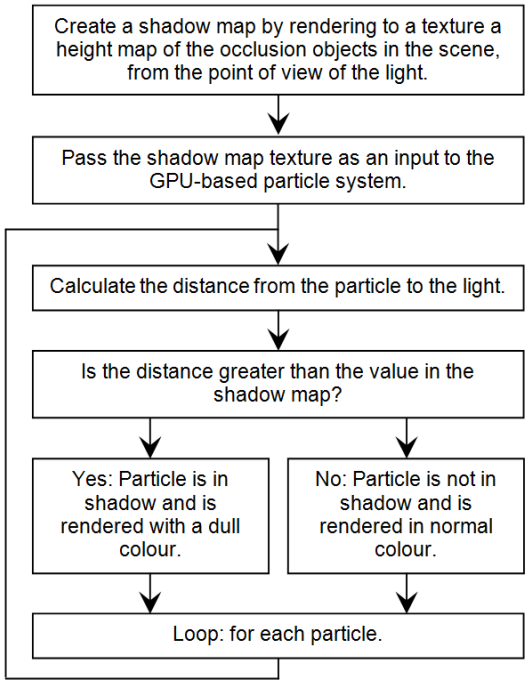

Figure 2: *Flowchart detailing our approach.*

3. Approach

In our method (see Figure 2), occlusion objects in the scene are shadow mapped. The shadow map is passed as an input to the GPU-based particle system shader, which determines if a particle is supposed to be in shadow and then renders the particle in the correct shade of colour. This provides a simple solution to casting external shadows onto a GPU-based particle system, which to our knowledge is not found in existing particle-based smoke rendering solutions, which handle self-shadowing but do not attempt to cast shadows onto particle systems. We believe that the effect of casting an external shadow onto the particle-based smoke greatly enhances the realism of the scene.

4. Initial Results

While still work in progress, our prototype allows external shadows to be cast onto smoke particles (and beyond) using a shadow mapping technique. Figure 1 shows a screenshot of our initial results. In its current form this has not yet been optimised and runs at around 150 fps on an NVidia 8800 GTS graphics card.

5. Summary and Future Work

This document shows the initial results of our work on real-time smoke lighting and rendering, which is still ongoing. The system handles external shadows cast from an occluding object onto a GPU-based particle system. There are a number of areas where further work can take place to improve our basic model:

- Future work could improve the model by using a more advanced shadow mapping algorithm than the one currently employed to smooth out the typical shadow mapping artifacts and create softer shadows.
- The use of depth sprites [AMH02, Sto06] for the smoke particles instead of using 2D billboards could also help to improve the resulting visuals.
- Optimising the particle system itself is likely to allow for a greater number of particles to be used in the particle system.
- Self-shadowing could be implemented alongside our method to further improve realism, for which the techniques discussed by Green [Gre08] provide a promising starting point.

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