Realistic and Fast Cloud Rendering In Computer Games

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1 Introduction

Clouds are an important aspect of many computer games, particularly flight simulators. Our system extends texture splatting on particles to model a dozen cloud types (e.g. stratus, cumulus congestus, cumulonimbus), an improvement over previous systems which modeled only one type of cumulus. We also achieve a 100x speed-up for scenes with dense cloud coverage.

We created a new shading model which uses artist-driven controls to approximate lighting. We also introduce a way to do cloud formation and dissipation with texture splatted particles.

2 Cloud Modeling and Rendering

We extend the texture splatting on particles developed by [Harris and Lastra 2001] to create a dozen visually different cloud types, such as nimbostratus, cumulonimbus, and altocumulus. We do this by "mixing-and-matching" 16 distinctive textures on the particles. We use foggy textures for stratus, textures with high-contrast shading details for cumulus and cumulonimbus, and flat-bottomed textures to produce the bottoms of cumulus clouds. We created a tool for artists to control the cloud shape and automatically place particles within a 3-dimensional volume. As a computer game with a pool of artists, this utilizes our resources more effectively than creating an entirely automated algorithm. Figures 1, 2, and 3 show examples of our cloud types.

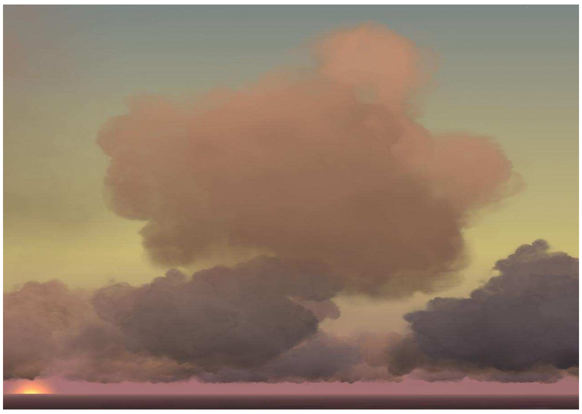

Figure 1: Cumulus congestus at sunset.

We achieve a 100x speed-up over [Harris and Lastra 2001], and are able to render overcast skies packed with clouds, a limitation of their system. Our technique is used in Microsoft Flight Simulator: A Century of Flight, which requires aggressive performance even on low-end PCs. We render a dense set of clouds in 10 milliseconds on a 733 MHz machine, which would have required over 1 second for Harris [2001]. To achieve the speedup, we use a ring of 8 impostors, an application of the technique introduced by [Schaufler 1995]. We render numerous distant clouds into a single impostor, reducing overdraw.

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Figure 2: Three cloud layers: (bottom to top) stratus, cumulus, altocumulus.

Figure 3: Nimbostratus at dawn.

We created a new shading model which gives a high degree of artistic control and fast performance, in exchange for some small lighting inaccuracies. We simulate dark cloud bottoms from sky lighting by interpolating vertex colors, based on height within the cloud, between a set of vertical color levels specified by artists. We simulate sun light by adding a directional component to the vertex color based on its position within the cloud and the angle to the sun, so that parts of the cloud facing the sun receive more directional lighting. Both sky and sun light values are interpolated based on the time of day.

We introduce a method of creating and dissipating clouds for the texture splatting system by changing the transparency of the sprites. Giving the sprites at the edge of the cloud a higher degree of transparency makes the clouds appear to build from a core and dissipate from the edges first.

References

HARRIS, M., AND LASTRA, A. 2001. Real-time cloud rendering. In *Computer Graphics Forum*, Blackwell Publishers, vol. 20, 76–84.

SCHAUFLER, G. 1995. Dynamically generated imposters. In *Modeling Virtual Worlds - Distributed Graphics*, MVD Workshop, 129–136.