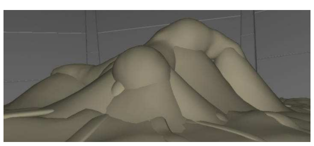
The Birth of Sandman

Christoph Ammann   Doug Bloom*   Jonathan M. Cohen   John Courte   Lucio Flores   Sho Hasegawa
Nikos Kalaitzidis   Terrance Tornberg   Laurence Treweek   Bob Winter   Chris Yang
Sony Pictures Imageworks

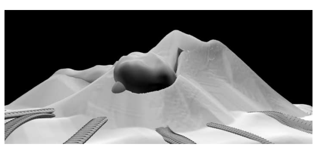
1 Introduction

The *Birth of Sandman* sequence in *Spider-Man 3* involved creating a human-sized character who emerges from a pile of sand in full view under a well-lit environment. The scale of the shot ranges from macro close up views of single sand grains to distant views of the entire sand pile as Sandman emerges. The sequence begins with a fully CG 2,672-frame shot that slowly revolves around sandman as he forms. The Imageworks Sand FX team had an enormous challenge of transferring character animation into a physically plausible animation of hundreds of millions of sand grains forming into a human form.

To accomplish this task, we built a variety of simulation engines and developed techniques for driving the simulations from character animation. We used everything from a Houdini DOPs simulation of sand grains settling for the extreme close-ups, to a surface-based relaxation algorithm derived from [Onoue and Nishita 2003], to a grain-grain simulator similar to [Bell et al. 2005]. Our rendering system was based on RenderMan and included a continuous level-of-detail system that allowed us to zoom in or out from a pile of sand, blending from rendering grains as individual points from far away to rendering polygonal models for close-up grains.



(a) original animation.



(b) Erosion simulation.

(c) Low resolution grain simulation.

(d) Final render.

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2 Heightfield Erosion Simulation

In addition to animating the Sandman character, animators added hand-animated “skirts” showing how the sand piled up around Sandman as he pushed moved around (see Figure 1a). We began by converting these animations into heightfields via ray casting, and then into a difference format, where we stored the difference from the current frame of the heightfield to the previous frame. We then ran temporal and spatial filters over these differences, and added successive differences in order to play back the animation. The heightfield was then eroded using the method of [Onoue and Nishita 2003] to generate a shape that looked more like sand (see Figure 1b). During this erosion process, we simulated collision with solid parts of Sandman's body. This heightfield-based system was highly efficient, able to process the entire 2,672-frame shot in under 30 minutes.

Figure 2: Sandman's hand collapses. This shot was fully CG. ©Columbia Pictures Industries, Inc. All rights reserved.

3 Low Resolution Grain-Grain Simulation

We generated a low resolution sand grain model by stacking a shallow layer of large sand grains (5-10x correct grain size) evenly over the entire surface (see Figure 1c). The particles were simulated with an efficient sand grain simulation system similar to [Bell et al. 2005] called *spheresim*. The spheresim process typically involved about 100,000 particles, and simulations took between 20 seconds and 1 minute per frame.

4 High Resolution Simulation

The result of spheresim was then converted into a uniformly sampled velocity field respresenting the particle motion. High resolution particles were then advected through this vector field, and additionally constrained to lie on or near the eroded surface. Grains that were detected to be falling off or sliding down the surface were re-simulated with full high resolution dynamics. This complex layering allowed us to avoid simulating grain-grain interactions for high resolution simulations, but still resulted in simulations that have plausible volumetric layering, stacking, and grain interactions, as shown in Figure 1d.

Figure 2 shows a frame where Sandman's hand collapses. For highly detailed sections like this, we actually simulated grain-grain interactions at the highest resolution.

References

BELL, N., YU, Y., , AND MUCHA, P. J. 2005. Particle-based simulation of granular materials. In *ACM SIGGRAPH/ Eurographics Symposium on Computer Animation*.

ONOUE, K., AND NISHITA, T. 2003. Virtual sandbox. In *11th Pacific Conference on Computer Graphics and Applications*, 252–259.

*contact e-mail: dougb@imageworks.com