Snow avalanche effects for Mummy 3

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For the recent production of *The Mummy3*, Rhythm and Hues Studios have developed methods and tools to simulate small scale snow avalanche effects, such as snow flooding into a hallway.

Snow avalanche pipeline

Snow avalanche effects have been produced many times in prior film productions. Usually, such phenomena is set on a large scale (e.g. over a mountain) from a distance camera. This time, for the effects in The Mummy 3, the studio had to deal with smaller scale avalanche, where individual snowball could be clearly seen and its motion could be visually tracked well. This presented a couple of new challenges in the film production.

1) At larger scale, interaction between snowballs had to be accounted for. Usual particle system based approach would result in snow penetrating each other, and this was not acceptable in the scale we worked with (about the size of a room). 2) Snowballs had to interact with other objects in the scene (e.g. wall), reacting in a visually plausible way (such as a fast moving snowball breaking into pieces upon collision against a wall). 3) Snowballs also had to leave fine features such as trailing mist, broken snowflakes, etc.

There are three main ingredients to the avalanche system. At the top level, we used a mix of rigid body simulators. Large scale snow chunks were simulated as a rigid body that binds several smaller chunks and could break upon collision. For medium scale snow pile, we developed a new particle-based rigid body simulator that would simulate each snowball as a moving sphere with varius radi. At finer scale, dozens of particle system layers were used, each contributing to such features as mist, snowfall, etc.

The rigid body simulation

For largest chunks, we created snow geometries that contained several breakable chunk within them. Simulation of such pieces were done through Houdini DOP rigid body simulator. Such (large) rigid body pieces would break its bindings upon collision and also spawn new particle systems to simulate the crash event.

For smaller level chunks, we developed a new particle-based rigid body simulator that computes collision between moving spheres. The simulator took care of snow piling on top of each other after initial collisions. This simulator was implemented as a velocity filter that takes input velocity from the particle system and outputs modified velocity due to collisions. This allowed a seamless integration to our F/X pipeline built around Houdini.

To enhance the performance, we limited the number of acceleration hierarchy (kd-tree) updates to just a few first iterations, and reuse the collision candidates in subsequent iterations. In theory, this could miss newly generated collisions during iterations, but statistically the probabilty was very low ($<.1\%$). These small amount of penetration would be solved at the next frame. This trick sped up the whole simulation by several times, enabling us to use as many as 200K spheres with overnight simulation on a single cpu.

Particle splitting

When snow hits something hard, it tends to break into pieces, often leaving a trail of snow powders. This was simulated by spawning a new particle system when snow pieces experience an abrupt change in velociy due to collision. This newly created particles would represent debris coming off the large snow chunks as well as mist caused by such collision events.

Mist and trails

There were dozens of layers of particle systems used to complete the shots. Some particles were constatnly created through invisible surfaces that would represent the *fingers* of the avalanches, rendered as mists. Some other particles were created to represent trails of large snow chunks.

Snow rendering

All the particles we created in various stages were eventually converted to volumentric representation with a process internally known as *wisp* in the proprietary volume data scripting tool (Felt). Each particle would represent certain area of structured noise (such as smoke, mist, trail, etc.) and would contriubte different amount of volume density to the final volume data. These volume clouds were then rendered with in-house volume renderer and compositied with the snowball geometries.

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