Animating Wind-Driven Snow Buildup Using an Implicit Approach (543)

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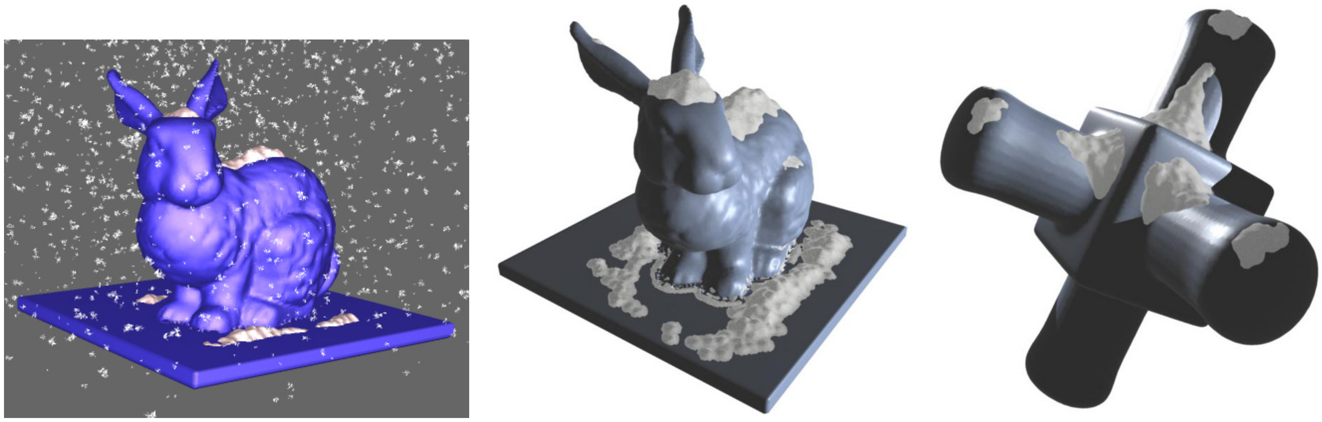

Figure 1: Temporary results using our implicit snow engine. Left: Screen-shot of animation with snowflakes advected by a stable fluid solver. Center and right: Ray-tracing of accumulated snow on two different models after 20 minutes of simulation.

1 Introduction

We present an implicit approach to modeling and animation of progressive accumulation of wind-driven snow on static surfaces. Our contributions can be summarized a follows: (1) *Dual compact level sets*, [Nielsen and Museth 2006], are used to represent the surfaces of the dynamic snow and the static boundaries. This allows for topologically complex modeling of snow. Additionally, the signed distance representation of the compact level sets serve as acceleration data structures for voxel classification as well as closest-point and normal computation. (2) Our snow model is based on a steady-state description where each frame represents a snapshot of the physically based buildup. This effectively allows us to animate the progressive snow buildup. (3) The transport model includes sliding as well as erosion and redistribution in an incompressible stable wind field. In contrast, previous work [Fearing 2000; Feldman and O'Brien 2002; Aagaard and Lerche 2004] employ explicit surface representations and require an iterative refinement step to finalize a stable distribution of snow.

2 Method

Our general approach is based on the concept of so-called *snow packages* which we define as Lagrangian tracker particles representing discrete volumes of snow. Typically these snow packages represent substantially larger volume than a single snowflake, but the size can be varied arbitrarily. We advect these snow packages in a dynamic wind-field produced from a standard Navier-Stokes solver, that accurately handles the deforming boundaries of the accumulating snow and static surfaces. We represented all the surfaces using the efficient DT-Grid level set data structure of [Nielsen and Museth 2006] that essentially stores distance values in a narrow band around the zero crossing (i.e. the surface). This results in very low memory footprints and allows for high-resolution surfaces. The snow surface is initialized as the static boundary surface and the snow volume is then defined as the CSG difference.

We assume three different mechanisms for snow modeling: *Buildup* from local accumulation, *sliding* from snow impacting very steep or slippery surfaces and *erosion* when accumulated snow gets air-born due to strong winds. Using the snow packages and level sets introduced above we model the snow transport as follows. First we note that collisions between snow packages and the level sets are efficiently computed using the signed distance transform of the former. When such collision are detected we use a physically based stacking test (depending on surface normals, material, package sizes and temperature) to determine how much of the impacting snow leads to a stable buildup. The corresponding snow volume is then "added" to the snow surface by a local level set dilation operation. The remaining (unstable) volume of the snow package is then converted into a *slide package* that essentially represent a mini-avalanche. Slide packages are advected separately along the projection of the gravity vector onto the surface tangent plan. During this advection new stability tests are evaluated to account for buildup by local sliding. Should a slide package slide off a surface it is simply converted into a snow package and advected in the flow field. Finally we note that erosion is simply implemented as a local level set erosion operation of the snow surface with strong winds. The eroded volume is then injected into the wind field as snow packages. For visualization of snowflakes (as oppose to snow packages) we use a modification of the movement model described in [Aagaard and Lerche 2004].

References

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