Talking Trash:
Technologies and Techniques for Simulating the Dump in *Toy Story 3*

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The climax of *Toy Story 3* has Woody and the gang struggling through a garbage dump. These sequences presented us with a number of new technical and artistic challenges. While we had done trash before on *Wall-E*, it was generally a static part of the set with little character interaction. In contrast, on *Toy Story 3* we had to build and simulate environments full of dynamic, squishy objects which needed to be blown through the air, bulldozed, crawled through by characters, dumped into piles, shredded, and even burned. To accomplish this, we developed several new technologies and pipelines to simulate large numbers of deformable bodies.

Figure 1: *Dynamic, squishy trash ©Disney/Pixar. All rights reserved.*

1 Goals

On *Up* we developed a new rigid body pipeline focusing on efficiency and scalability in order to simulate large numbers of balloons. While this system was scalable to the large data sets needed for *Toy Story 3*, we could not use it to simulate soft and squishy items such as organic waste, fluttering plastic bags, or bags full of trash. This limited the viability of a pure rigid body approach. In the end, we wound up adding extensive 'fake' soft body features to our existing system to allow efficient simulating of thousands of squishy and rigid items together.

2 Dynamics Approach

To achieved a believable look of soft, squishy materials in our rigid body simulator, we developed tools allowing us to use variable numbers of rigid body primitives to approximate soft objects, connect them together with a mesh of constraints, and specify linear and angular spring forces between them. These primitives would then be used as 'bones' to deform the original geometry. Using this system we could get behavior that appeared soft while requiring only a few rigid bodies in the simulation. For hero trash, large numbers of primitives could be used, while for piles of trash or background trash, a smaller number of primitives was employed per piece. For some extra softness, collision constraints could be made to behave soft and spring-like as desired.

3 Rigging Tools

Getting the required diversity in the kinds of trash in the dump required many hundreds of different squishy shapes all with different material properties. We developed several tools to quickly rig a model with the bodies and constraint network mentioned above, such as 'splatting' the geometry into a low-resolution voxel grid, or approximating the surface with prims using an iterative clustering algorithm.

In some cases more control was required to get the dynamics we wanted. For instance, we had many filled trash bags and it was important to feel that the bags were made of thin plastic but had soft contents inside. We created a rig where the bag itself was rigged with many prims with strong linear constraints but soft angular constraints, which also included groups of freely moving softbodies on the inside. This allowed the bag to move like thin plastic but retain shape due to the internal contents. In this way we rigged many one-off hero objects with distinct behaviors we wanted.

4 Wind

A key visual element in the dump was blowing and flapping plastic bags, requiring us to employ simple wind approximations to achieve the highly distinct look of a light plastic bag floating on a breeze. For this we created a 'shaper' that could be used with our standard force-fields to limit the effect of a field to a given local axis of a body. In this manner, we could add noise and drag fields that would only affect the individual bodies comprising the bag when hitting them on their large flat sides, giving believable tumbling and blowing behavior to the overall multi-body shape.

5 Shredding

In one series of shots during the dump sequence, we see large pieces of trash being sucked into a large rotating shredder. To accomplish this, we added the rotating blade geometry to a simulation and pushed our squishy bits of geometry into it, which would naturally get caught by the blades, crushed, and sucked in. To reduce the amount of trash that would be deflected away by the high speed of the rotating blades, we added collision callback functions to cause objects to stick to the blades via temporary constraints. We also used collision callbacks to emit pre-made shredded geometry as objects were pulled through, increasing the visible chaos.

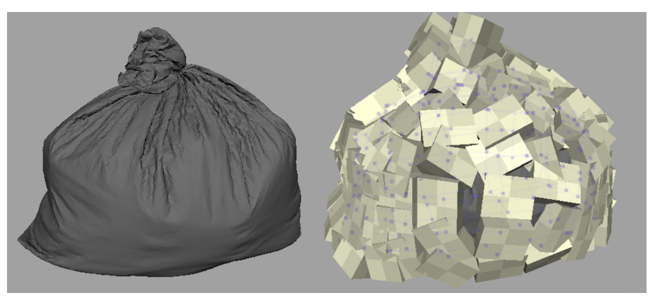

Figure 2: *Bodies used for squishy approximation. ©Disney/Pixar. All rights reserved.*

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