Art Directing Rigid Body Dynamics as a Post-process

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Introduction

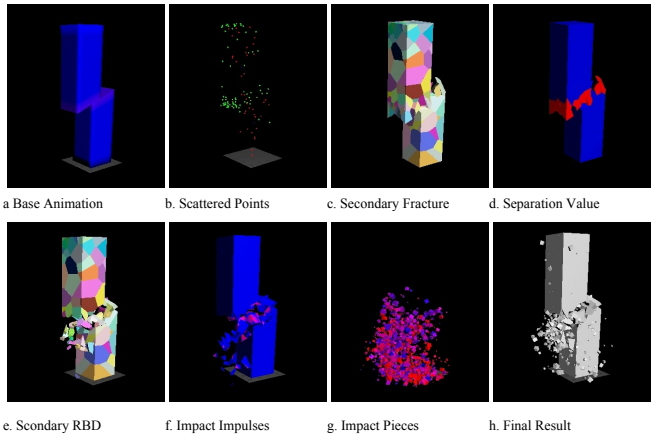
Rigid body dynamics is a frequently used tools in VFX. In this talk, we propose a few post processing approaches to add detail to existing simulations, or deform the geometries so they behave like other materials.

Secondary Fracture

Our first attempt was to fracture and simulate again on top of an approved base animation, keyframed or simulated, without changing the general motion.

With the base animation cached on disk (Figure 1.a), we scatter points inside the base geometry (1.b). In areas that have more potential to break, such as creases, more points are created so they can fracture into finer pieces. Impact data are also recorded and used as seed positions for additional points. Then we use these points to run voronoi fracture on the base geometry to get the secondary pieces.

Transform matrices are extracted and stored in secondary points, so by using the transform data from the base simulation, we now have secondary pieces track with the base simulation (1.c).



a Base Animation b. Scattered Points c. Secondary Fracture d. Separation Value

e. Scondary RBD f. Impact Impulses g. Impact Pieces h. Final Result

Figure 1. Secondary RBD

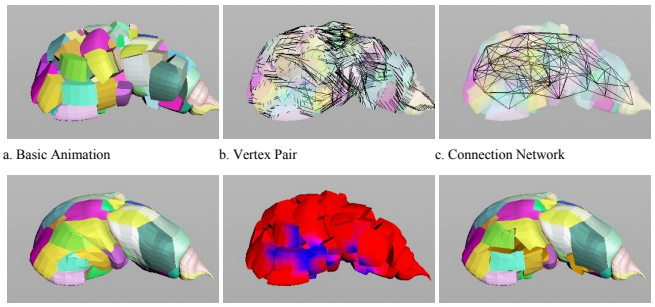
Each vertex stores its separation value (1.d) from its closest pair. When the separation passes certain threshold, it is marked as detached and the secondary pieces use it to determine when to release and be taken over by secondary RBD solver (1.e). Impact impulses are also translated into separations when collision happens (1.f), so we can release finer pieces when there is a collision in the base animation (1.g).

In the secondary simulation, when two pieces from the base sim start to separate or hit something, smaller pieces detach and fall as if they are simulated together.

Deforming, Tearing and Snapping

We use RBD to mimic behaviors in a FEM solver when such kind of solver is not accessible. With the vertex pair information (2.b), we can establish a connection network that connects all adjacent pieces and create spring constraints (2.c). To seam all pieces together, we use wrap deformer with those dynamic pieces as deforming targets to achieve a smooth and seamless look (2.d).

We also mimic tearing and snapping with the wrap deformer mentioned above if we disable wrap deforming at vertices where its separation value passes certain threshold (2.e). This is done after the simulation, so we can adjust the threshold to get the desired snapping timing and tear opening in post with deterministic result which cannot be done with any other solver on the market (2.f).



a. Basic Animation b. Vertex Pair c. Connection Network

d. Wrap Deformed e. Separation Threshold f. Post Tearing

Figure 2. Deforming & Tearing

Reversed Destruction

In the final act of DreamWorks' *Mr. Peabody & Sherman*, we have an unique opportunity to make a reversed destruction effect when they try to restore the broken Trojan Horse with the time machine. We combined all above techniques to implement this heavily art directed shot.

The idea is to simulate it forward and playback backwards. With a base simulation and a lots of keyframing, we first have our base animation approved by the director. Then we fracture the horse again to run the secondary simulation, which not only adds details but also connects simulated and keyframed pieces together naturally. On top of that, we use wrap deformer to mimic wood bending and snapping with methods mentioned above.

To make the reverse motion more interesting, each piece is retimed to have ease in and out effects. We also apply curl noise on top of its trajectory, so it feels like each piece is guided by different forces. These are all done in post so we can easily adjust it based on director's notes.

These types of effects can easily take months before simulation gets approved. However, with this post-process approach, we managed to have the simulation approved in a week. This is quite a success for this approach.

Conclusion

This proposed method can work with any cached polygon geometry without any extra data. In some extreme cases, if an artist inherits a shot where the simulation is approved but no longer reproducible, the artist can still work with the existing data on disk without needing to reproduce the same result.

Post-processing a simulation is a time saver in fast-paced production for its ability to lock a version and add multiple layers of details without changing the general look.