Finding Hank: Or How to Sim An Octopus

Ryan Kautzman, Bill Wise,* Meng Yu, Per Karlsson, Mark Hessler, Audrey Wong
Pixar Animation Studios

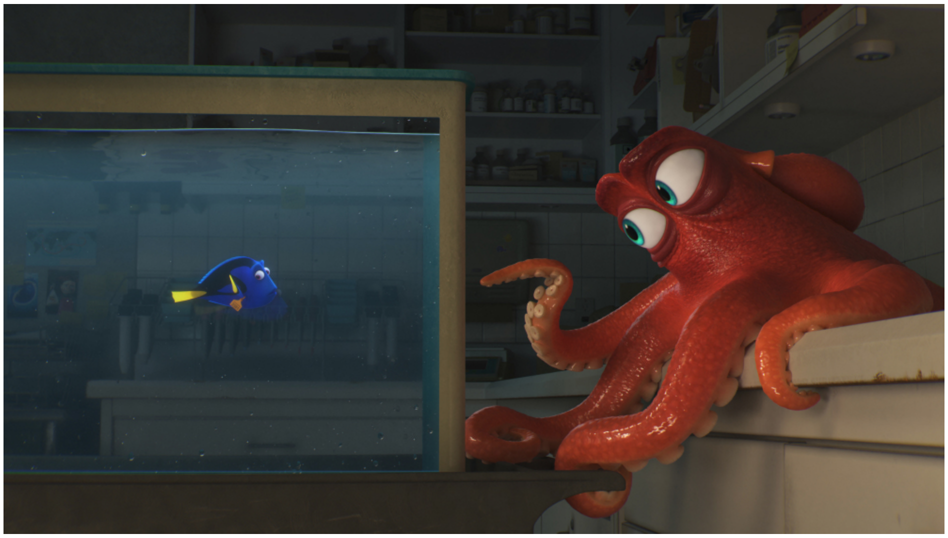

Figure 1: *Hank - Final film frame ©Disney/Pixar. All rights reserved.*

Abstract

The grumpy septapus Hank from Finding Dory presented our teams with a huge challenge. His charm immediately insured he would receive plenty of screen time, and his complexity meant we would need a host of techniques to bring him to the screen. Building on an already complex animation rig, the simulation team was tasked with adding flesh and skin simulation effects as well as tackling the serious challenge of Hank's suckers and Mantle behavior.

Keywords: animation, simulation

Concepts: •**Computing methodologies** → **Simulation and Modeling;** *Animation;*

1 A New Meshing Pipeline

Our previous tetrahedral meshes have been relatively coarse and unconformed, with a higher resolution triangle mesh embedded for collisions. Hank's high curvature, complex shape, and small scale features required more control so we implemented a new modular meshing pipeline with a series of independent operators for refinement, culling and conforming. These operators can be assembled in an almost arbitrary sequence, allowing us to refine different parts of the mesh independently - adding resolution where needed, culling away unwanted mesh elements, and thereby lowering the total number of tetrahedra - resulting in faster simulations. We used conforming meshes for greater collision accuracy and added several optimizations to our new conformers, including an iterative smoothing pass that attempted to fix inverted and highly distorted tetrahedra.

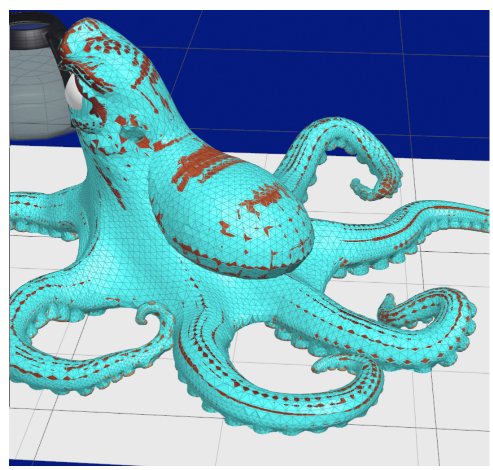

Figure 2: *An early version of Hank's conformed multi-resolution Tetmesh.*

For efficiency and control, we ultimately settled on separate meshes for the body, suckers, and mantle.

2 Mantle

The mantle used a coarser tetrahedral mesh than the other parts of Hank, allowing lesser degrees of freedom in the deformation, making it easier to hit specific look and feel requests from anima-

*e-mail:bwise@pixar.com

SIGGRAPH 2016 Talks, July 24-28, 2016, Anaheim, CA
ISBN: 978-1-4503-4282-7/16/07
DOI: http://dx.doi.org/10.1145/2897839.2927458

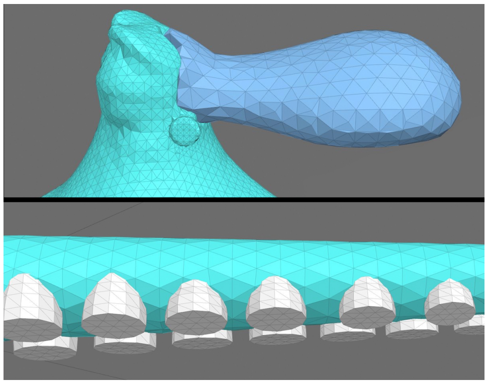

Figure 3: *Final meshes for Arm,Suckers and Mantle.*

tion. This also gave faster simulations and less complex parameter weight tuning. Hank and his mantle were modeled ”post-stretch”, and the tetrahedral mesh was derived from this, so a pre-sim scaling of the mantle had to be applied to compensate for the stretch introduced during simulation. In camera angles where mantle to body collision could not be seen, we used a linear spring to track the centroid of the mantle. The output of the spring was applied on top of the animation to add secondary motion. Similar springs were used for Hank’s ears.

3 Pre & Post Sim Sucker Control

Simulation was asked to handle sucker stiction, collisions, secondary skin and flesh ballistics, as well as targeting art-directed compression and release sucker shapes. A pre-sim script calculated the snapping and release of the suckers based on a heuristic of distance to a surface and the rotation of the suckers based on the animation. This allowed us a fast turn around, and gave us controls to easily modify the resulting simulation. The results were then used as an input target pose to the PhysBAM volumentric simulation. A combination of hard and soft constraint forces were used to target the input sucker shapes and to resolve self collision amongst suckers.

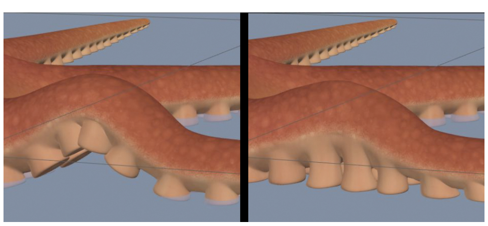

Figure 4: *Input animation vs final simulation.*

Each sucker was encased and rigged with a close fitting cylinderical low resolution tetrahedral mesh of identical topology, so all had the same dynamics regardless of size. Each sucker inherited from a master rig, and scripts were used to create 350 instances. The tops of the sucker tetrahedron meshes intersected the tentacle tetrahedron mesh and a binding force was applied to the overlapping tetrahedron points to give us mutual dynamics between the tentacle flesh and the suckers.

4 Skin Sim Improvements

Hank also required refinements to our skin simulation system. Dynamic particles are projected onto the animated surface using an analytic Phong projection from Ilya Baran. If we have multiple possible projections to choose from, we use DEC geodesics to determine the closest projection point, based on Crane et al. We also take into consideration the regional curvature of the target surface so that we don’t allow sliding in creased areas, or along boundaries. Finally, our new parallelized implementation ensures better performance in spite of doing a great deal more work.

5 Pre-Roll Complications

The convoluted shapes inherent in Hank and the extraordinary control scheme used to pose him precluded using a traditional pre-roll approach as employed for skeletal rigs. Individual controls along each arm may be posed directly using world space translates; or posed using FK bend angles as if in a chain of bones; or constrained to any other object in the scene (including other controls) and animated in the space of that constraint. To provide a clean pre-roll that avoids interpenetration, we developed a tool that analyzes the initial animation pose and computes the position and orientation of each control relative to its neighboring controls. This is used to configure the rig into a canonical control state and procedurally generates animation to sequentially unfold the arms and body. This includes a transition stage where all of the automatic posing behaviors of the rig are smoothly engaged, allowing them to actively manage the arm shape during the unfolding process. Generating this animation procedurally saved large amounts of animator and simulation artist time.

6 Summary

The work of Finding Hank was truly a joint effort between multiple departments, requiring the hard work and creativity of Tools, Animation, Characters and Simulation all working together to achieve.

Acknowledgements

Special thanks to Patrick Coleman, Jiayi Chong, Andrew Butts, Jonathan Page, Aimei Kutt and Frank Albers for their kind support.

References

COLEMAN, P., AND KAUTZMAN, R. 2012. Stable, art-directable skin and flesh using biphasic materials. In *SIGGRAPH 2012 Sketches and Applications*.

CRANE, K., WEISCHEDEL, C., AND WARDETZKY, M. 2013. Geodesics in Heat: A New Approach to Computing Distance Based on Heat Flow. In *SIGGRAPH 2013 Papers*.

D. PANOZZO, I. BARAN, O. D., AND SORKINE-HORNUNG, O. 2013. Weighted Averages on Surfaces. In *SIGGRAPH 2013 Papers*.

IRVING, G., TERAN, J., AND FEDKIW, R. 2004. Invertible Finite Elements for Robust Simulation of Large Deformation. In *Proceedings of SCA 2004.*, 131–140.

IRVING, G., , KAUTZMAN, R., CAMERON, G., AND CHONG, J. 2008. Simulating the Devolved: Finite Elements on WALL-E. In *SIGGRAPH 2008 Talks*.