The Rigid Body and Fluid Dynamics of LAIKA's "Missing Link"

David Horsley
LAIKA LLC
dfhorsley@gmail.com

Peter Stuart
LAIKA LLC
pstuart@laika.com

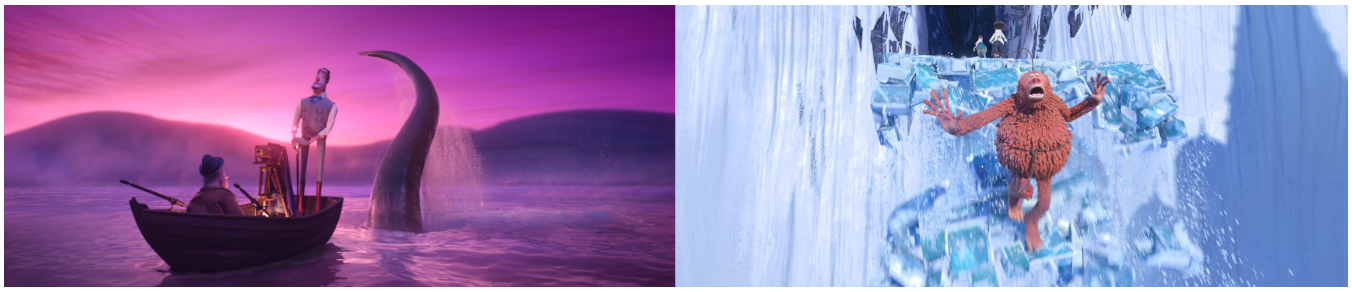

Figure 1: Water and bridge effects from LAIKA's Missing Link

ABSTRACT

LAIKA the animation studio is known for stop-motion and a unified fusion of art and stunning visual effects technology. This presentation will cover the techniques used to generate water effects and a collapsing bridge of ice for LAIKA's Missing Link.

Building on techniques for incorporating stylized water effects with stop motion animation developed for LAIKA's Kubo and the Two Strings [Montgomery 2016], the FX team used SideFX Houdini's [SideFX 2019b] guided ocean and narrow band FLIP tools to guide the action and manage the larger scale and more numerous shots required for Missing Link.

The collapsing ice bridge sequence presented an unusual challenge integrating stop motion animated characters with an animated CG set piece. To accomplish this difficult task, the normal course of production was reversed, and the CG animation was used to guide the character animation.

CCS CONCEPTS

• **Computing methodologies** → **Physical simulation**.

KEYWORDS

effects simulation, guided ocean, houdini, laika, missing link

ACM Reference Format:
David Horsley and Peter Stuart. 2019. The Rigid Body and Fluid Dynamics of LAIKA's "Missing Link". In *Proceedings of SIGGRAPH '19 Talks.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3306307.3328143

SIGGRAPH '19 Talks, July 28 - August 01, 2019, Los Angeles, CA, USA

ACM ISBN 978-1-4503-6317-4/19/07.
https://doi.org/10.1145/3306307.3328143

1 GUIDED OCEANS

On LAIKA's Missing Link's ocean and water simulations, our FX team was given the opportunity to create some seemingly physically impossible – and sometimes really silly scenarios; for example when our hero character is water skiing on the back of the Loch Ness monster and later climbing a giant almost vertical rogue wave in a steamship. All the while keeping our environment looking natural, and our water dynamics as physically realistic as possible, while stylizing the render in accordance to show style established by our art department.

Fortunately Houdini software provides a FLIP fluid solver [SideFX 2019a] that is unbounded, meaning it can flow freely throughout the scene. FLIP uses a container to calculate the velocities, but it is recreated at every frame, so this way you can translate the simulation to follow a steamship and keep realistic looking water interaction up close to the ship. Our fluid domain did not have to extend to the full distance of the boat's travel.

In addition to this, Houdini's guided ocean layer technique creates a flip sim of a thin particle layer on top of an ocean surface which they call "adaptive narrow band," freeing up a great deal of memory. Knowing this, we decided to use the method to simulate an entire rogue wave using animated and deforming sculpted geometry to guide the surface water keeping a narrow band of water on the surface.

The ocean surface at a specified depth acts as a collision layer underneath the particles, allowing the particles to closely match the ocean waves. A boundary layer of particles suppresses reflections at the edge of the tank, contributes ocean velocities back to the simulation, and maintains the water volume level to match the ocean. The Guided Ocean Layer can be a static simulation or it can follow a moving boat through the ocean.

The effect gave us some important surface detail around the boat but also provided velocities that were used for long lines of surface foam strips which we referred to as our bacon texture. The director Chris Butler would ask for extra bacon in several shots. [Zahed et al. 2019]

One feature with guided oceans is the ability to instance any number of hero waves to add variation to the oceanscape. On a few shots we decided to position hero waves directly in front of our steamship to see some ferocious splashes as it cuts through the instanced waves. We added a thin layer of fluid on the water surface to make the hero waves break and form foam, churn, and crestmist. This added an extra element of detail and naturalism. Usually if it looks appropriate and keeps that show style we are good to go.

One requirement for a LAIKA film is to make our CG effects harmonious and collaborative to the stop-motion practical stage. This helps define the show style but also helps integrate our tactile stop-motion characters.

To give our water environments a feeling of being manufactured for the stop motion stage we applied 2D textures on almost all our surfaces including water, smoke, snow, etc. Water was particularly fun since we had to select textures that had a natural flow to the pattern like marble or wood grain. Technically we accomplished this by using dual rest fields on the flip fluid surface which is used to track the position of the water over time. If a texture became unrecognizable due to rough seas, a new dual rest field was created every 50 frames or so and the old mangled texture was faded out. We did not want this effect to dominate the look so we kept it more subtle.

Our use of saturated color blended with colorful surface foam and underwater churn aided in the stylizing, yet this style could have existed in nature under just the right conditions.

Cellular foam patterns generated by Houdini's whitewater solver [SideFX 2019c] guided by the water surface (which considers acceleration, curvature, and vorticity) aided in capturing show style since a lot of our styles reflected repeating patterns found in nature. [Wikipedia contributors 2019]

Figure 2: Big ocean wave with show pattern surface texture.

2 COLLAPSING ICE BRIDGE

In one sequence of LAIKA's Missing Link, the characters run on a bridge made of ice blocks as it is falling apart. At our studio, all of the critical character animation is conceived in stop-motion with puppets. With all of the parts and space required for an appropriately scaled bridge it would have been impossible to do this sequence fully practically. Instead, we created several smaller sections of a practical bridge for use for close ups when the bridge is static, and then used a CG version of the bridge for the underside, wide shots, and as the bridge is crumbling. This hybrid approach introduced a greater level of difficulty in animating the practical characters since they have to interact with a complicated moving surface that doesn't exist on the stage. To solve these complications and simplify the character animation process we reversed the normal course of production and started with the bridge animation and used that to drive the character animation.

The bridge collapse animation was a straightforward application of Houdini's rigid body dynamics using the bullet solver [Coumans 2019] and a simple constraint network. The constraints would break apart moving away from the center of the bridge thus allowing the blocks to fall. To add additional anticipation to the advancing line of falling blocks, a sagging effect was applied before the constraints break using "Point Deform SOP". The deformer works well with packed primitives since it will apply the deformation to the transform and keep the geometry of the blocks themselves from changing shape.

The bridge animation was then injected into the previs process to setup cameras and timing for each shot in the sequence in order to convey the appropriate feeling of danger. In particular the edge of breakup on the bridge would often need to be seen getting closer to the characters as they run away. Usually this meant the bridge animation was actually two-three times faster than normal.

The camera data from the previzualized version of the shot was passed off to the camera motion control rig and some of the basic measurements of the bridge dimensions were taken and used to position the characters relative to the camera. The resulting plates would then have to be match-moved since there were inevitably slight differences in the real camera move. Characters in most of the shots were tracked as well so that they could cast accurate shadows on the CG bridge, and adjustments could be made to line the blocks up with footsteps.

Finally the bridge animation for the shot was finalized with the new character animation and camera. Each shot underwent essentially the same basic steps. First the bridge animation was brought into the shot and retimed to match up with the pre-vis animation. The "Transform Pieces SOP" was used to apply the initial pre-vis rigid body animation to complicated high res final geometry. The bridge would then be deformed slightly if needed to better match the feet of the object tracked characters. Some shots required hero block animation to match individual or groups of blocks up with character footsteps. Finally some secondary effects were added to support the bridge breakup including small chunks that were emitted in places where the blocks broke apart with a lot of force, and some fine dust sourced by the chunks.

REFERENCES

Erwin Coumans. 2019. Bullet Real-Time Physics Simulation. https://pybullet.org/wordpress/.

John Montgomery. 2016. Kubo and the Two Strings: water effects. https://www.fxguide.com/featured/kubo-and-the-two-strings-water-effects/.

SideFX. 2019a. FLIP Solver dynamics node. https://www.sidefx.com/docs/houdini/nodes/dop/flipsolver.html.

SideFX. 2019b. Houdini. https://www.sidefx.com/.

SideFX. 2019c. Whitewater Solver dynamics node. https://www.sidefx.com/docs/houdini/nodes/dop/whitewatersolver.html.

Wikipedia contributors. 2019. Pattern formation — Wikipedia, The Free Encyclopedia. https://en.wikipedia.org/w/index.php?title=Pattern_formation&oldid=894685972. [Online; accessed 6-May-2019].

Zahed, Butler, and Fry. 2019. *The Art of Missing Link.* Insight Editions.