Simulating Whitewater Rapids in *Ratatouille*

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In Pixar's *Ratatouille*, a key story point involves a rat being swept through the sewers of Paris, plummeting down waterfalls and along steeply sloping tunnels, through a series of high-speed S-bends which cause the torrent of water to bank up sharply on each turn. Bringing the director's vision of this wild and perilous rapids sequence to the screen required us to use a wide variety of water effects techniques to give the appearance of rushing water, spray, foam and bubbles. One of the greatest challenges was to pull these diverse techniques together into a seamless sequence.

Figure 1: Whitewater rapids image from *Ratatouille*. ©Disney / Pixar. All rights reserved.

1 Water Simulation

The process of taking an effects sequence from storyboards to final images is always complex. In the case of the rapids sequence in *Ratatouille*, the complexity was magnified by the interaction of camera and character animation with the water simulation.

Before the director and layout department could decide on camera angles and camera animation, they needed an initial water simulation to drive their planning. The sequence depended on cameras that tracked along the tunnel with the water and the character, so the camera motion was affected by water position and speed. We did a coarse low-resolution simulation of the entire length of the rapids for several hundred frames of animation time, and the layout department selected camera angles and animated camera moves based on that sim. The water was simulated using our in-house particle-based simulator, *splasht*, and a surface mesh was extracted from the particles as described in [Shen 2007].

After the sequence was broken into shots with specific camera moves, the intent was to simply increase the detail and quality of the simulation, while reproducing the overall motion of the coarse simulation. In practice this proved to be impossible. The rapids were turbulent and chaotic by definition, and the simulations were very sensitive to initial conditions. Initial conditions were often impossible to reproduce due to changes in the sewer tunnel design during the several weeks since the coarse simulation was done. Moreover, the sequence of shots used pieces of the coarse simulation out of order, and in some cases the speed of the water mesh motion had been scaled up to match a desired camera move.

This meant that we had to construct new detailed simulations shot-by-shot, making them match the camera moves as well as possible while still appearing natural and having the necessary shot-to-shot continuity. We used a variety of tools and tricks to control the simulated water: invisible collision objects to channel the water flow in a desired direction, carefully positioned sources to add water and sinks to drain it away, and wave trains and lattice deformers to directly sculpt the water surface. In two shots where the water flow was less turbulent, we even replaced the simulated surface with a non-simulated height-field wave surface. Although the resulting rapids were detailed and convincing, the layout department had to adjust the camera moves for some of the shots in response to the new water surface.

With the detailed water surface in place, the shots went to the animation department for character animation. After animation, the shots returned to the FX department for a final pass to add foam, spray, mist, and bubbles, as well as secondary splashes and character/water interactions.

2 Foam, Spray, Mist and Bubbles

Because of the roughness of the water surface and its violent motion, most shots required a foamy white water surface, with flying spray and floating clouds of mist. These effects were generated by fluid and particle simulations in Maya, driven by the results of the water surface simulations. Custom plugins and mel code were added to Maya to efficiently access the huge splasht particle sets and water surface meshes.

Effects artists positioned a series of particle emitters called "agitators" in each shot. The agitators emitted particles of spray or surface foam when water particles passed through them. The spray picked up initial velocity from the water particles that triggered the agitator, and then moved ballistically. Spray was rendered as a normal particle system consisting of tiny blobs of water. Separately, the surface foam particles were advected by the flow of water particles, and the density of foam particles in the neighborhood of each water surface mesh vertex was tagged directly onto the mesh. The density was used during shading to control the color and displacement of the foam on the water surface.

Mist was produced using a Maya fluid simulation, with temperature, density, and velocity imparted by particles from the water simulation. The resulting vapor clouds were volume rendered and composited with the other elements.

For underwater shots, bubble particle emitters were placed in areas of violent water motion and on characters and other objects. Bubbles were pulled upward by buoyancy forces and advected with the flow of water particles. All bubbles were rendered as blobs with noise-based shape variations to give the impression of pressure-induced shape changes as the bubbles moved through the water.

References

SHEN, C. 2007. Extracting temporally coherent surfaces from particles. *SIGGRAPH 2007 Sketches*.