Wave Displacement Effects for *Surf's Up*

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1 Introduction

For *Surf's Up*, our challenge was to create realistic waves for an all-CG surfing mockumentary. The surfing waves were designed to be character animated, and it was the job of the effects animation team to ensure that the rest of the water effects combined seamlessly with the surfing waves. These included ocean surface displacement effects as well as particle effects for spray, splashes, drips, and white water. This sketch focuses specifically on the various surface displacement effects that were used in the film. The wave displacement effects can be generally categorized into ambient ocean procedural displacements, surfing wave-specific procedural displacements, and character-driven interactive water displacements.

2 Ambient Waves

Realistic ocean surfaces get their signature texture from ambient waves. We modeled the displacement from these waves as the sum of infinite wave trains traveling in a variety of directions with a physically-based speed based on wavelength, similar to the approach of [Hinsinger et al. 2002]. We arbitrarily divided our wave trains into sets of low, medium, and high frequencies, and created a system in Houdini to let artists easily define wave trains with specific wavelength, amplitude, and direction characteristics, getting real-time feedback by watching a displaced grid while they adjust parameters. The shape of a wave train in our system is based on a Gerstner wave with an additional adjustable "cuspiness" parameter. Once we created the sets of waves, we used specification files to define different ocean styles, which allowed us to adjust the amplitude scale, cuspiness, and domain noise (to break up regularity) for each of the three frequency sets.

For most shots, the low and medium-frequency wave trains had to be specified early. Because these larger wave trains create significant surface displacement, the layout artists and character animators needed the displaced surfaces in Maya in order to accurately place cameras and animate the surfing characters. Layout artists would select and publish a wave style file based on the desired choppiness of the ocean for the shot. Maya tools were created to allow artists to visualize the wave trains on specific patches of ocean and waves. We also made tools for Houdini artists to create wave-trains-displaced surface geometry for water interaction effects such as character splashes. And finally the wave trains functions were implemented in our RenderMan displacement shader for the surfing waves and ocean. Extra controls were added to the shader in order to apply noise to the amplitudes, modify specific amplitudes with artist-created projection maps, and add extra high frequency noise displacements for finer surface texture.

3 Surfing Wave Displacements

In addition to the ambient wave texture that covered the entire ocean, some procedural displacements were defined specifically for the surfing wave. The first of these is the cuspy foam pattern that forms on the lip of a breaking wave, a pattern we dubbed "liptrains," since its look was borrowed from the wave trains pattern. In addition to displacement, the peaks of these liptrains were used to birth spray particles from the lip of the wave. Some of the other procedural wave displacements included a falling displacement pattern with foam on the pouring face of a breaking wave, and the foam patterns left behind a wave as it passes.

4 Interactive Displacements

Our interactive displacements include ripples, surfboard wakes, and foam patterns due to water surface interaction with characters, objects, splashes, and water droplets. These displacements were created either using image maps projected from a virtual camera onto part of the wave or ocean, or from point cloud data generated at the surface.

The main tool we used to create ripples from character interaction was based on Tessendorf's *iWave* algorithm [2004]. The artist would use a setup in Houdini created from the character animation, any extra objects, and a patch of the water displaced with ambient waves to determine intersections. Projection displacement maps were created after running the algorithm and applying some post-processing filters to the resulting images. We used another method for smaller secondary ripples from water droplets hitting the surface, which created circular ripple patterns expanding from a set of source points on the surface. A special case was surfboard wakes, which were not created using a fluid simulation technique, but were generated from the character animation in the reference space of the wave, and written out as an additional set of displacement maps. Interactive foam patterns were created from the board wakes, as well as from splashes hitting the water surface. These were computed in the displacement shader using point clouds generated from particle simulations and also hand-placed by artists. Additional standing foam patterns based on procedural noises were also available in the shader.

References

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TESSENDORF, J. 2004. Interactive Water Surfaces. In *Game Programming Gems 4*, ed. A. Kirmse, Charles River Media, 265-274.