The Making of "Age of Sail"

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Figure 1: A scene from the immersive short film *Age of Sail*.

ABSTRACT

"Age of Sail" tells the story of William Avery, an old sailor adrift and alone in the North Atlantic. When Avery rescues Lara, who has mysteriously fallen overboard, he finds redemption and hope in his darkest hours. In this production talk we'll go behind the scenes in the making of this multi-platform immersive animated short. Some of the unique challenges we'll discuss: bringing a 2D illustrated style to life in the medium of 6DoF VR with new non-photorealistic rendering techniques; immersing the viewer in a storm-tossed ocean without making them seasick; adapting a single story to multiple mediums (desktop/mobile VR, 360° video, and 2D film); creating a better sounding and more responsive sound mix with multiple surround formats and a new spatialization model; and optimizing it all to run at 60fps on a mobile phone.

CCS CONCEPTS

• **Computing methodologies** → **Non-photorealistic rendering**; **Virtual reality**.

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SIGGRAPH '19 Talks, July 28 - August 01, 2019, Los Angeles, CA, USA
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ACM ISBN 978-1-4503-6317-4/19/07.
https://doi.org/10.1145/3306307.3335041

KEYWORDS

non-photorealistic rendering, virtual reality, storytelling, animation

ACM Reference Format:
John Kahrs, Theresa Latzko, Cassidy Curtis, and Scot Stafford. 2019. The Making of "Age of Sail". In *Proceedings of SIGGRAPH '19 Talks.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3306307.3335041

1 THE STORY

Our intention in making *Age of Sail* was to tell an emotionally genuine story with a level of visual spectacle that demanded it be seen in VR. A photograph of the Grand Canyon is no substitute for actually being there. The open ocean is similar: it's been portrayed countless times in film, but never in a way captures what it's actually like to sail a forty-foot pilot cutter through the waves. The young medium of VR gave us an opportunity to make something that would feel true to that experience. We took research trips on historically accurate sailboats, gathering details so that every aspect of our story — from the mechanics of hoisting a jibsail to the play of wind and sunlight on canvas — would be grounded in that truth.

At its heart, *Age of Sail* is about an old man who feels he has nothing more to contribute to the world — a lie he believes, until circumstances prove him wrong. All of the other choices we made were in support of that emotional core.

2 A MOVING ILLUSTRATION

For the story to have the right impact, the world had to be believable enough that the audience could feel the characters' peril as their own. But it also had to be simple enough to run on a mobile phone. We felt a "moving illustration" style could support both goals. We embraced a strategy of the illustrators who inspired us: by *removing information* from the scene, we could invite the audience to fill in the gaps with their own imagination. We developed a visual language of polygonal shapes, limited color palettes, flat-colored regions with roughened edges, rounded shadows, subtle edge darkening, and indications of texture.

To adapt these 2D rules into stereoscopic 6DoF VR, we developed some new non-photorealistic rendering techniques: *MetaTexture*, an example-based multiresolution texturing method that adheres to the movement of 3D geometry while maintaining a consistent level of screen-space detail, and *Edge Breakup*, where we roughen the edges by warping the scene with structured noise. (Edge Breakup is based on the technique we originally developed for *Pearl* [Osborne et al. 2016], but with additional features to keep the roughness perceptually consistent as the camera and characters move and deform in 3D space.) For a more detailed explanation of these rendering techniques, see our paper in Expressive '19 [Curtis et al. 2019].

We coupled this visual style with believable, naturalistic movement on the characters, boats and ocean, so that while it *looked* like an illustration, it would *feel* like you're really there.

3 SAILING WITHOUT SEASICKNESS

Motion sickness is an all-too-common problem in VR experiences. And yet here we were, planning to set our story on a little sailboat rocking in the swells of a stormy sea. There was a distinct possibility that this was a terrible idea. To find out for sure, we built and tested a series of rapid VR prototypes to explore the relationship of camera, boat and ocean movement. In the process we found some guidelines that served to keep our audience safe from nausea: (1) the horizon must stay level at all times; (2) there must be visual detail in the sky, to anchor the viewer's peripheral vision on that stable horizon; (3) the boat can pitch, roll, rise and sink with the waves — but it must never come about (yaw) too quickly. We were pleased to hear from some more sensitive viewers that *Age of Sail* did not make them seasick at all — a significantly better experience, for them, than being on an actual boat.

4 AN OCEAN IN YOUR POCKET

Another great challenge of this project was the need to render a convincingly perilous animated ocean in real time on the full range of supported devices, including three-year-old mobile phones.

We used a kinematic deep ocean wave model [Tessendorf 2004] on very low-resolution geometry (about 70cm per face), with custom shaders with MetaTexture to add perceptually-consistent detail. To create the illusion of an endless ocean, we used repeating instances of a single animated tile, about 60m across, which would disappear beyond a false horizon and reappear in front of the boat, treadmill-style. We hid the repetition using spatially varying shader features. For object interactions like splashes, ripples, and wakes, we added detailed semi-transparent surface elements, pushed down the ocean's vertices to avoid intersections, and suppressed its texture so that it would merge seamlessly with these decorations.

5 THE FREEDOM TO SUBMERGE

At one point the story called for us to fall overboard with our hero, and spend some time floating along with him in the waves. Among the challenges this presented was that in 6DoF VR, the viewer could choose to duck her head below the water surface at any time. This was an idea we first explored in *Sonaria* [Stafford et al. 2017], but in this case it was greatly complicated by the fact that the ocean itself was constantly changing shape. We created an animated "trigger carpet" to detect these unpredictable moments in real time, and developed special story logic to control what the viewer sees and hears during these transitions.

There were also a few key storytelling moments that would only make sense if the viewer were above the surface. To guarantee the audience would not miss those beats, we clamped the camera's Y translation, briefly making it a "5DoF" experience.

6 IMMERSIVE AUDIO

The sounds of weather, waves, foam, flapping sails, and the groans of an old wooden cutter — many recorded for this project on historical wooden ships — immerse the audience more believably in each scene. To achieve this, we used a combination of individually animated audio objects; Ambisonic, Blumlein and quadraphonic soundfields; and headlocked stereo and binaural recordings. While most sounds track their sources' positions in 6DoF space, we intentionally placed the ambient sounds along the horizon in order to enhance the audience's sense of balance, another key element in avoiding seasickness.

In previous Spotlight Stories, real-time HRTF filters simulated surround sound on traditional stereo headphones, but discolored the source, damaging the sense of "presence," "air," and "life" in each sound. In order to preserve fidelity, we created a new spatialization model that mixes 3D audio down to a directional stereo signal which is calibrated to emulate how our ears directionally focus our hearing forward, without discoloring the source. This was especially important in allowing us to hear wind, ocean spray and the "champagne fizz" sound of sea foam which surrounds the audience.

The musical score was arranged, recorded and mixed spatially along a front-to-back axis. While every other sound is placed in 3D space around us, the directionality of the score is locked to our heads, representing both characters' unwavering determination to reach the ship that can save them.

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