They’re Gonna Need a Bigger Boat: Building Moana's Kakamora Barge

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Figure 1: *The Kakamora barge, a floating pirate island with an unusual crew © 2017 Disney*

ABSTRACT

In Walt Disney Animation Studio’s “Moana”, a key moment in the story calls for the protagonists to confront a floating island-barge crewed with blood-thirsty coconut people: the Kakamora. The complexity of combining a large moving set on an animated ocean with active crowds, sails, ropes, and effects simulations required coordination across multiple departments and some on-the-fly innovations to handle the challenges the sequence presented. Existing and new automation and procedural tools saved a great deal of time and allowed for more creative design decisions and reuse.

1 DESIGN AND COORDINATION

The Kakamora barge presented the Moana crew with a by-then familiar challenge: animating characters on a moving “ground plane” floating on another moving ground plane, i.e. ships on the open ocean, but in this case on a much larger scale and with many more characters. It was an extremely complex set that was actually composed of three separate sub-barges with an intricate scaffolding network loosely holding them all together. The barge was covered in mechanical contraptions, sails, living coconut palm trees, and a healthy dose of nautical detritus from other plundered ships for good measure. This geometric weight and complexity was present in every shot, but very often the specific view of a given section necessitated adjusting major parts of the set, the amount of junk, and other factors shot-by-shot.

On top of this, the sequence called for an extensive action confrontation with our protagonists, Moana and Maui, that took place around and on the barge itself. Planning between the various character and environment departments involved was essential to avoid mis-steps that could complicate an already challenging effort. An example of one such challenge was addressing the scale of the props and the staging of action in a way that would allow Moana, a teen-age human, to believably run around in a vessel built for the Kakamora, who are roughly the size of actual coconut shells. Adjustments were made to average the camera height and framing to prevent her from appearing too much like a giant, while ladders and other elements she needed to interact with for specific shots could be adjusted for placement and scale to accommodate her.

2 CONSTRUCTION

To achieve the necessary flexibility, we designed and built the barge in modular pieces consisting of major sections and platforms. These bundles could then be assembled with relative transforms into the ‘master set’, our term for an asset collection of individually addressable elements. For shot-specific needs and composition, these subsections, each of which could contain dozens of individual elements such as platforms and ladders, could be individually adjusted and published for the given shot. The main barge had six modular groups when originally starting layout for the sequence, but that number grew as shot-to-shot adjustments were required to add detail or provide an alternate one-off view. Both the sections and the individual elements were further adjusted by animation for composition and to accommodate a path of action, meaning the overall construction logic of the barge constantly required 'truing up' based on their changes, a process requiring regular communication with layout finaling.

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Some of the junk piles on the barge required individually placed elements for larger items as well as junk that was in contact with simulated ropes, but the vast majority of the small pieces were procedural instances placed using the Disney XGen primitive generator. Even these still required some per-shot planning for optimization, as the total number of objects could reach many millions, severely impacting render times unless we pruned them out with extensive stochastic level-of-detail techniques.

3 ANIMATION AND CROWDS

The Kakamora themselves were a new type of character for Moana, and while they were broadly similar in their size and physiology, they varied widely in specific body shapes, face paint, weapons, hats, and other accessories. The crowd simulation department was able extend their animation cycle authoring process to include accessory-driven behavior, so a given Kakamora could brandish his or her assigned weapon properly, and location-specific behavior, so he or she could appropriately respond to the surrounding environment, climbing nearby ladders or operating barge mechanisms. Crowds was even able to automate the use of fx-driven spear throwing behaviors in the crowds when the Kakamora attack: animators published a clip with a spear in that Kakamora's hand, which was hidden and replaced with an fx animated spear on release that could fire in a shot-specified direction.

Because the three parts of the barge could move independently and had an intricate network of walkways, ropes and ladders, the crowds team developed a tool to automatically install the entire Kakamora crowd onto the barge, complete with behaviors and weaponry. This was possible because of planning with the modeling and layout teams to guarantee a consistent ship's architecture wherever possible. These tools came together so well that there was even bandwidth to create a pre-animated Kakamora "drumline" asset that could be dropped onto the barge in various locations for each shot. Their animation could be set to match the beat timing of the soundtrack, which saved significant effort compared to hand adjusting individual crowd instances.

4 SIMULATION AND EFFECTS

Although there are quite a few effects in the barge sequence, especially water-related, they ultimately did not require significant artist time, owing to previous work done to build and automate robust water simulation rigs used for many other sequences in the film. The rig we used to auto-simulate canoe wakes was able to scale to accommodate the immense barge, though it did require effects to create a large closed-surface proxy hull to make it geometrically water-tight. From there, the standard Moana boat and water interaction pipeline could be used. A pre-canned effects library set up for the show was used to produce both splashes and "squib" explosions of wood fragments from spear impacts as the fight ensues.

The numerous sails on the different sections were mostly able to be re-used from existing canoe sail rigs after upgrades to our simulation pipeline were made to address the nested groupings of sails in the barge. There was also a need in some cases to add a coconut palm tree to the sail rig as it was used as a mast in several cases. We found that the sails generally needed to be simulated per shot to appear realistic, given the changing motion of the barge. Ropes were in some ways a simpler problem than the sails, but in others a much more difficult challenge. Many ropes were able to simply use baked cycles for keep-alive, with the simulation pipeline available for specific motion or interaction. However, the barge was built using many different lengths and tensions of rope, some dangling loosely around posts and rails, others stretching tightly around junk piles, and still others strung from platform to platform, numbering in the thousands in all. Many of the rope crossings happened over boundaries between modular construction groups, meaning they often needed to be re-anchored due to in-shot adjustments or else removed entirely. Maintaining continuity from shot to shot was not essential given the visual density of the set and pace of action, however keeping the ropes themselves looking consistent with each other within a shot, in terms of thickness, scale, and material detail under heavy deformation, was a constant challenge.

5 SETTING SAIL

The final barge structure contained roughly 36,000 unique parts with 84,000 texture maps and 4200 individual lengths of rope with a total of 96 million instanced pieces. The largest crowd shot had around 1900 animated Kakamora. The film sequence itself contains 140 finished shots and is almost four and a half minutes of total screen time. The most render-heavy shot, which reveals the entire barge emerging from the fog with thousands of Kakamora ready

to fight, required over 1200 CPU hours per frame, even with significant geometric and light transport optimizations applied. Needless to say, most shots required far less time than that, averaging around 200 hours per frame across the sequence. In the end, every shot required much less artist time than originally bid thanks to the variety of automation and construction techniques we devised to build and animate our massive Kakamora barge.