The Art and Technology of Hair Simulation in Disney's *Moana*

Marc Thyng, Christopher Evart, Toby Jones, Aleka McAdams
Walt Disney Animation Studios

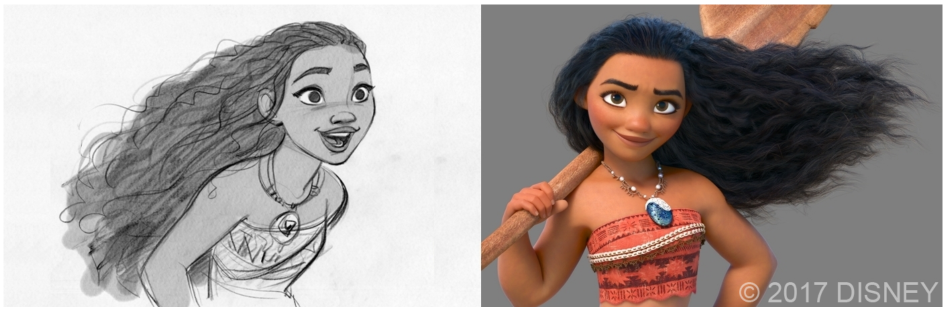

Figure 1: Moana hair concept art (by Jin Kim) alongside final rendered version. ©Disney

ABSTRACT

Beginning with the early concept art, *Moana* featured characters with long curly hair interacting heavily with both the characters and their environment. This level of complexity in hair interactions and dynamics presented demanding simulation needs which led to changes throughout the hair simulation pipeline, from grooming to technical animation. In order to overcome these challenges we implemented a new hair model and data type, as well as overhauled how we handled hair collisions. We discuss the motivation and details of our hair simulation and technical animation process, as well as the implications of the new model both to artist interactions and our overall pipeline.

CCS CONCEPTS

•**Computing methodologies** → **Animation;** *Physical simulation;*

KEYWORDS

hair animation, hair simulation

ACM Reference format:
Marc Thyng, Christopher Evart, Toby Jones, Aleka McAdams. 2017. The Art and Technology of Hair Simulation in Disney's *Moana*. In *Proceedings of SIGGRAPH '17 Talks, Los Angeles, CA, USA, July 30 - August 03, 2017,* 2 pages.
DOI: http://dx.doi.org/10.1145/3084363.3085072

1 TECHNOLOGY

In order to better model curly hair, we implemented a new elastic rod hair model based on Discrete Viscous Threads [Bergou et al. 2010], which accurately captures both the bending and twisting modes required for the natural motion of curly hair.

Correctly modeling twist necessitated creating a new geometric curve-based data structure that embedded this twist data and a base frame as first class data along with positions. These augmented curves were then bundled into a new shape which could encapsulate multiple curves. This new data type allowed for dramatically increasing curve count in grooms and simulation rigs, as well as exposing frame data along the curve throughout the pipeline. However, this creation of a new shape type also had far reaching implications, since all the tools and deformers throughout the pipeline needed to be aware of and accurately preserve this augmented data.

Additionally, the hair-hair interaction was modeled using repulsion springs, and a new set of timers and attenuation parameters similar to those in [Iben et al. 2013] were added to allow more artistic control of hair interaction in simulation.

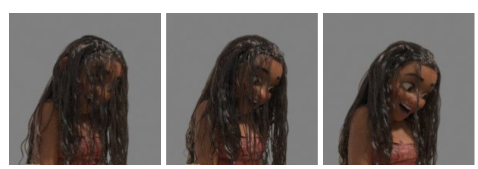

Figure 2: Different clumping behavior of hair created by varying the break distance parameter of dynamic wire connections to create a wet-hair look. ©Disney

2 SIMULATION SETUP

One of the key components of hair simulation on *Moana* was the choice to support the volume of the groom through dynamic hair-hair collision response, as opposed to static hair-hair connections. Because of this, any negatives space in the hair style would cause the hair volume to collapse under movement, which presented challenges to the artists that were grooming the hair style. As a

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).
SIGGRAPH '17 Talks, Los Angeles, CA, USA
© 2017 Copyright held by the owner/author(s). 978-1-4503-5008-2/17/07…$15.00
DOI: http://dx.doi.org/10.1145/3084363.3085072

Figure 3: The force-based grab node allowed artists to control complex hair interaction to meet artistic direction. ©Disney

result, a new process was developed that allowed iteration between the hair grooming and simulation department. This allowed the grooming artist to see the hair style in motion, and the simulation artist to make adjustments to the structure of the groom, before the hair style was finalized.

The new hair model has a small number of physically intuitive parameters, which allows the simulation artists to spend less time searching wide parameter spaces to obtain a desired behavior. Artistic direction is more easily obtained by understanding the fundamental characteristics of hair and how they affect motion. These simpler settings also made it easy to modify the behavior of the hair in a predictable way, for example to appear either wet or completely underwater.

The motion of hair is dictated by the complex interactions of individual hairs. For *Moana*, the hair rigs were simulated at the level of individual clumps, and hair-hair interaction was controlled by dynamic edge-edge repulsion springs. In order to get stable hair motion, as well as controllable break-up under animation, we added *stiction* to these springs, with the ability to automatically transition between repulsion, stiction, and breaking modes, similar to the procedure described in [Iben et al. 2013]. We extended this with the addition of collision attenuation parameters based on the relative and absolute velocity of the curves. Artists could control the hair-hair interactions by adjusting the force strengths, as well as the position and velocity-based controls over the transition points between stiction and breaking.

3 TECHNICAL ANIMATION

The technical animation team adapted their in-shot hair simulation process around the new hair model. These new collision-driven hair rigs produced richer, more organic complex motion; however, the freedom of movement produced by the new collision and hair model meant that any non force-based interaction would stand-out visually. Furthermore, ensuring continuity between shots became more important since the hair was often not in the original groomed state after character motion.

The hair rigs contained more individual simulation curves than we had worked with previously. This meant staying in simulation longer due to the increased complexity of matching hand sculpted edits to the organic and detailed simulation results. Post shaping and cleanup were still done, but the majority of the performance was achieved in simulation. Simulating curled curves exacerbated the difficulty of handling detailed interaction between the hair, character, and environments; this led to the development of a new force-based grab node which handled this complex interaction as seen in Figure 3.

The outdoor setting of the film required various levels of wind on the characters' hair. From subtle keep-alive to turbulent storms, the hair needed to fit into the surrounding environment. Building off of our existing hair-wind pipeline [Wilson et al. 2014], we ended up using wind fields in almost every shot in the film, which was a first for the studio. Initially there was a very time consuming workflow to replicate the effects of wind shadowing by painting custom maps and adding extra fields. To address this a wind shadowing model was implemented that supported self and external shadowing, allowing artists more time to concentrate on the art direction.

REFERENCES

Miklós Bergou, Basile Audoly, Etienne Vouga, Max Wardetzky, and Eitan Grinspun. 2010. Discrete Viscous Threads. *ACM Trans. Graph.* 29, 4, Article 116 (July 2010), 10 pages. DOI:http://dx.doi.org/10.1145/1778765.1778853

Hayley Iben, Mark Meyer, Lena Petrovic, Olivier Soares, John Anderson, and Andrew Witkin. 2013. Artistic Simulation of Curly Hair. In *Proceedings of the 12th ACM SIGGRAPH/Eurographics Symposium on Computer Animation (SCA '13)*. ACM, New York, NY, USA, 63–71. DOI:http://dx.doi.org/10.1145/2485895.2485913

Keith Wilson, Aleka McAdams, Hubert Leo, and Maryann Simmons. 2014. Simulating Wind Effects on Cloth and Hair in Disney's Frozen. In *ACM SIGGRAPH 2014 Talks (SIGGRAPH '14)*. ACM, New York, NY, USA, Article 48, 1 pages. DOI:http://dx.doi.org/10.1145/2614106.2614120