Flap Flap Away - Animation Cycle Multiplexing

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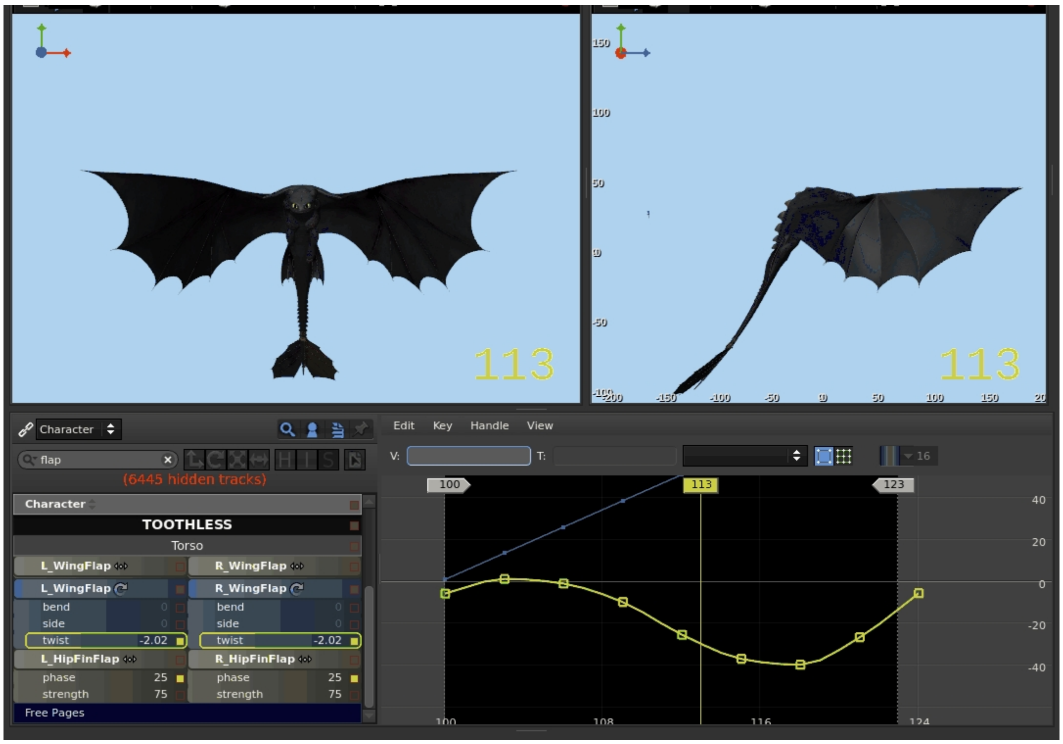

Figure 1: Toothless from *How to Train Your Dragon 2* using built-in flap

CCS CONCEPTS

• **Computing methodologies → Animation**;

KEYWORDS

Character Rigging, Procedural Rigging

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1 INTRODUCTION

The use of animation cycle multiplexing technique was first deployed on *How to Train Your Dragon* at Dreamworks to accomplish the ambitious task of animating many winged characters with limited resources. It has since been adopted through software platform changes, working with award winning software Premo, to its current form in *How to Train Your Dragon: The Hidden World*. It would not have been possible to accomplish the film with the level of visual complexity due to production budget and time constraints.

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2 SCOPE OF THE PROBLEM

At its most basic, the dragon wing is a typical arm setup with shoulder, upper arm, lower arm, and hand controls if mapped to animal anatomy. Additionally, with the design, it also has: 7 major bones with 5 segments per bone, 7 web sections with 3 areas for each section. That equates to about 60 purely FK, forward kinematics, controls as a basis. In addition, there are meta controls for folding the wing as an unit and secondary bending controls for each bone segment. One wing alone surpasses the amount of controls for a normal biped.

There were varied dragon species with different wing configurations and requirements. Some had to walk on their wings as hands, some had extra side wings as well as the major wings. A

technique was needed to allow the animator to focus on the acting instead of the technical aspect of wing mechanics. At the same time, the technique also needed to produce organic motion that can be art-directable.

From *How to Train Your Dragon* of 11 dragon types, to *How to Train Your Dragon: The Hidden World* with 26 different dragons, maintaining consistency in the dragons while retaining the distinct traits of each species was an important requirement. Many shots had 15 to 21 characters casted for unique hand animation, resulting in high complexity demands.

3 ANATOMY OF FLIGHT

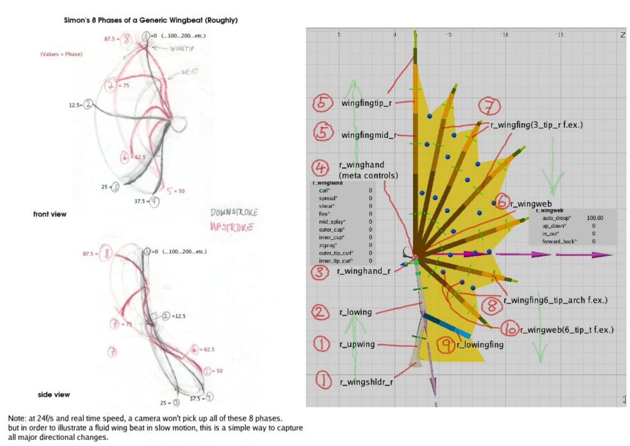

Figure 2: Left: Wing Phases, Right: Wing controls

There has been extensive effort into cycle blending of walking characters. It is obvious to see that the foot contact point and distance covered is different in a run compared to a walk. There is also more data gathered for bipedal or quadrupedal motion. At first glance, the flap seems straight forward, with an up and a down with some poses in between, but there are many mechanics that are more involved in the process.

There are about 8 phases of a flapping cycle, divided equally to downstroke and upstroke. Since the shape of the wing is vastly different depending on which part of the flapping it is in, simply animating a control to be a positive value versus a negative value will not provide realistic motion. The wing makes an "S"-shaped stroke on the way up and a straight path on the way down. To properly represent flight, a looping cycle is needed.

However, the linear blending approach of a simple flap cycle is also not sufficient for the high quality of animation that was desired. During a strong flap, the tips of the wings will flex or overshoot where in a weak flap, no rotation may be present in those bones. We identified that it was necessary to have at least 3 animated cycles per dragon to achieve more organic motion in all flight modes, from gliding to flight.

4 CYCLE IMPLEMENTATION

Most cycle editing concentrates on end-to-end blending and warping from [Lockwood and Singh 2011] and trying to detect phase in order to align the cycles [Bollo 2017]. We required a solution that did not require animators to lay down different cycles as they animated flight or run a blending section for transitions. For animation, reduction of animation controls was key to the success of animating all the dragons. Also, simulation of flapping or transitions was also out of the question due to frames per second performance and directibility. We narrowed it down to 2 controls: phase and strength.

Phase was presented to animation as a 0-100 value represented a complete cycle. Strength will take that phase in the cycle and find the value of the control based on the supplied cycles. That is where the multiplexing comes in. Strength represents the vertical axis of a graph, and phase on the horizontal, cycles are stacked and blended to produce a value in time as illustrated in Figure 3.

This approach frees up a new dimension of animation that is still only presented to the user as one value that is a sliding scale of the input cycles. We have a weak, normal, and strong cycle for the dragon wing that animation crafts for each dragon and is interpolated with a B-spline. Other interpolation formulas can be used depending on the number of cycles given and the spacing between them.

Since this data is immutable and cached once within the character, the evaluation of the cycles are optimized within the shot. The keyframe data per shot is also reduced with having to store the keyframe of phase and strength natively within the shot context.

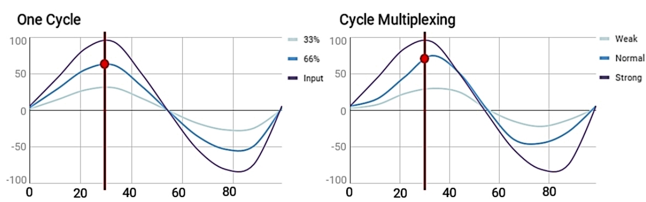

Figure 3: Evaluation of linear result with one cycle vs. multiplexing

5 CONCLUSION

Due to the usage of animation cycle multiplexing approach, animation was able to focus on artistic performance and achieve the complexity necessary for *How to Train Your Dragon: The Hidden World*. Flight shots were faster to animate than ground shots. The approach expanded to not just wings, but also body, arms and legs with their own individual phase and strength controls. This allowed a dragon to be in flight with the entire body being animated with a handful of curves and the same manipulation interface of the curve graph that animation already uses to do all their regular workflows. We can apply this approach in general cycle blending, thinking about the transitions of cycles of the same function in a dimension more than just transition in time blending.

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