Hero Quality Crowds in *Madagascar 3: Europe's Most Wanted*

Nathaniel Dirksen Justin Fischer Jung-Hyun Kim Kevin Vassey Rob Vogt
DreamWorks Animation

1 Introduction

For *Madagascar 3: Europe's Most Wanted*, we set ourselves the goal of creating crowds which rivaled our main characters in terms of quality of appearance and performance. We could achieve top quality deformations by driving our full animation rigs with the results of our Massive sims, but disk space and network bandwidth constraints made it infeasible to bake out large crowds. Instead, we developed an architecture for *Render-Time Deformations (RTD)*, where geometry is generated on the fly. This technique required significant changes to our animation rigs. We created *Multidimensional Rigs*, where a character can run in a service mode, delivering any model for any pose as requested by the renderer. High quality deformations allow crowd characters to be pushed closer to camera, where their acting performance is highlighted. To permit direction of theses performances, we developed a system called *Hero Promotion* to allow the crowd character to be treated as full hero assets, with animation keys matching the original hand-animated cycle for easy augmentation.

2 Render-Time Deformations

Within the DreamWorks pipeline, all crowd cycles are key-framed by animators. Massive is used to blend these cycles, outputting joint locations that drive our animation rigs, from which models are baked and ultimately rendered. For even mid-sized crowds, the disk-space and network bandwidth requirements make this approach infeasible if full resolution models are used. Instead, when the renderer determines it needs a piece of a character's geometry, a request is sent to the RTD server and the resulting models are passed back. This bypasses the need to store these models on disk; the RTD server requires only the joint positions, animation curves and character variation, decreasing disk usage to 2 percent of the conventional method. Running the RTD server on the same box as the renderer provides similar improvements to network bandwidth consumption. RTD also provides Lighting flexibility in setting level of detail, since models at any requested resolution can be generated on the fly.

Figure 1: ManA's Multidimensional Rig outputs any of 3 bodies, 6 heads, and various wardrobe items for a total of 119,750,400 unique combinations.

3 Multidimensional Rigs

Traditionally a character is loaded in the context of a shot, with a specific body, face and wardrobe. However, instantiating a character incurs a significant time-penalty, and having the RTD server do so for each member of a crowd would be unfeasibly slow. Instead, we created Multidimensional Rigs, which can be loaded in a stateless context, outputting models for any geometric variation or animation as needed. Then, character instantiation occurs only once, and models for the entire crowd can be cheaply generated afterwards. To allow this, all potential character body, face, hair and wardrobe variantions must be loaded simultaneously. This multidimensionality was accomplished via improvements to our rig architecture, allowing changes to the body and face to flow downstream to components (like shirts or hair) that must adjust themselves in response. For example, if we switch to a new head, the hair changes how it warps around the face. Adding this flexibility meant we also needed to ensure animation mapped properly between changing face types.

4 Hero Promotion

There is often a need to art-direct performances of crowd characters positioned close to camera. To allow Animation to work on the hero rig, the joints output from Massive must first be converted into animation curves which represent the same poses. Typically an approach is used where joint positions are plotted at each frame, and per-frame keys are set to achieve the pose. Even if a curve simplification algorithm is run to simplify the resulting curves, they can still be difficult to work with. The controls used will differ (IK vs. FK, twist vs. orbit, foot rocker vs. foot rotation), and animation keys associated with a particular key pose or breakdown pose will no longer line up on the same frame.

The Hero Promotion system significantly improves upon plotted animation by re-timing the keys from the original hand-animated cycles to match the sim. This ensures the controls and animation methodology are maintained. We are able to extract the original cycle IDs and frame ranges to re-time from Massive's output by specially annotating each input cycle. This technique provides key-identical output, as long as Massive is only playing back one action. In the short frame ranges where massive blends multiple actions, animation cycles cannot simply be re-timed, and we instead blend evaluated curve values at each frame.

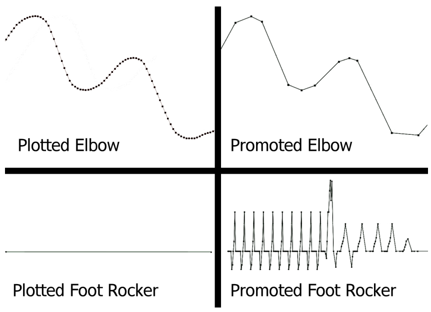

Figure 2: Plotted elbow bend (upper left) has keys every frame, Hero Promoted version (upper right) has keys only where animators placed them. Foot rocker control (bottom right) is used in Hero Promoted animation, but has motion too difficult to reverse engineer for plotted solutions

Re-timing keys from the original cycle will not place any globally spaced controls (like the body or IK goals) correctly. Positioning these from Massive's ouptut is difficult, since typical mocap rigs do not have a stable reference platform from which to calculate them. We augmented both our massive and animation rigs with a new joint which tracks the position of the hips, but only has locomotive motion applied to it. This new joint replaces the hips as the root of our hierarchy in Massive, and by examining its output position, as well as the relationship between it, the body, and the body pivot in the corresponding frame of the original cycle, we can drive the body control to place the character correctly. Similar techniques can be used for the IK goals.