Merging Bipedal and Quadrupedal Functionality into One Rig for *Madagascar: Escape 2 Africa*

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Figure 1: One rig for Alex, the lion, supports both bipedal and quadrupedal performance.

The film *Madagascar: Escape 2 Africa* requires that characters fluidly move between bipedal and quadrupedal (bi-quad) performance. On prior films we created two separate rigs to attempt to address this. However, the "two-rig" approach produces significant complexity across the entire production pipeline and doesn’t allow transitions between bipedal and quadrupedal performance on screen. We wanted animators to have more flexibility to make creative decisions in a shot without having to pre-plan whether their character would be acting in a bipedal or quadrupedal style. Our main challenge was to find a way to limit setup complexity and provide a powerful but simple set of animation controls in one rig.

Here we describe our development of a bi-quad rig which allows onscreen transitions, acting flexibility, and saves character setup and maintenance as well as animation time.

1 Animator Skeleton Controls

We studied the (cartoon) anatomy and mechanics of our characters to understand the similarities and differences between bipedal and quadrupedal modes. Then we designed a suite of animation controls that we applied to one rig that were intuitive and complimentary. Animators preferred controls that were blendable, layerable, and non-modal. From this research, we developed the following skeleton controls.

For the leg we use a layered foot pivot system to drive a two bone inverse kinematic(ik) solver for the femur and tibia. For bipedal movement, a foot pivots off the ground from three points: heel, ball, and tip of foot. For quadrupeds, the foot pivots off the ground from two points: the ball and tip of foot. To address this, we implemented controls to rock the foot between heel and ball, then rock the foot between the ball and the tip of foot. We found it helpful to add separate scale controls for femur, tibia, metatarsals and phalanges that modified bone length from either end of the bone.

The arm applies the same foot system as above for quadrupedal locomotion. For the arm’s two bone ik system, animators preferred the elbow’s bend axis to be oriented differently when acting as a biped or quadruped. An elbow axis control was added to allow the animator to blend in different elbow bend behavior. For forward kinematic(fk) arm gesturing, we implemented an ik/fk snapping system, allowing the animator to easily move between both methods of animating the arms.

For the spine, the vertical verses horizontal orientation is the main issue. Our cartoon character design requires regional posing, so the hips and shoulders are siblings in the joint hierarchy. Animators wanted to choose the local space from which bones move so that controls felt intuitive, e.g. 'up' always meant up for hips and shoulders in bipedal or quadrupedal poses. Therefore, we added controls that allow one to blend between different spaces for hips, shoulders, and arms. Adding these controls was important for the head, as well, so that it stayed upright, eyes facing forward, however the spine was oriented.

2 Deformations

We encountered two categories of challenges for bi-quad deformations: (1) accommodating the design differences between bipedal and quadrupedal versions of the same character, and (2) delivering the increased range of motion necessary to handle both bipedal and quadrupedal motion from the same deformation rig.

Our film’s bipedal and quadrupedal designs of the same character can have significant design differences. For example, Alex, the lion, as a biped, has a thumb, whereas quadrupedal Alex does not. Quadrupedal Alex needs larger feet, broader shoulders, and his chest volume is pushed further up his torso. Alex’s muscular connection between his head and neck favors the back of the skull when he’s quadrupedal, but connects near the base of the head when he’s bipedal.

Combining the range of motion for a bipedal and quadrupedal rig stresses the deformations in several key areas. Hips of any character are typically challenging, however on a bi-quad character a greater range of motion is required. The upper leg swings back in a bipedal push pose, and forward for a quadrupedal sit pose, totaling a range of motion of 240 degrees. The neck and head’s range of motion increases approximately 90 degrees when combining the rigs, requiring a range of roughly 270 degrees. Using a layered deformation approach with proprietary relaxation techniques enabled us to maintain the art directed designs as our characters were pushed and pulled through these large ranges. For many of our bi-quad's, the head-neck connection is obscured by a thick layer of fur, or a mane for the lions. This transference of deformation challenges from the skin to the mane necessitates rethinking how we deal with large masses of hair. For this we use an addendum to our hair system which allows direct control of the silhouette and volume of hair with standard deformation techniques. This hair system allows for a much greater range of motion of the head and neck, maintaining the clean graphic designs, and compensating for volume.

3 Production

This bi-quad rig is currently used with great success in the production of the film, *Madagascar: Escape 2 Africa*. Animators make onscreen bi-quad transitions and are finding unique and unexpected uses of the new features on the rig. The production supports 15 unique lion setups, which is a great savings verses 30 setups that would be required for a "two-rig" approach. The bi-quad concepts are being applied to our general rigs and on future films.