Art-Directable Dynamic-Hair Shells in *Madagascar: Escape 2 Africa*

Stephan Osterburg
PDI/DreamWorks

Nathaniel Dirksen
PDI/DreamWorks

Rob Vogt
PDI/DreamWorks

The character design for *Madagascar* emphasizes the preservation of strong lines, shapes, and silhouettes. Applying these directives to the hair was a major challenge in the first movie, as most dynamic hair solvers have difficulties providing believable simulated motion while adhering to those artistic constraints. Our hero character, Alex the lion, provided an additional hurdle with his mane growing not only on the scalp, but also from the neck and chest. Animators also had only limited control over the shapes generated, and fine tuning individual shots was time consuming and expensive. With a larger cast of lions in the sequel *Madagascar: Escape 2 Africa*, we set out to find a solution that would preserve the movie's artistic design, provide better animator controls, and could be easily set up on a wide range of characters.

1 The Hair Shell

In the first *Madagascar* movie, we utilized a proprietary hair dynamics system to simulate the motion of guide hairs, which were later interpolated between to create the final hair geometry [Scapel and Boylan 2005]. In *Madagascar: Escape 2 Africa* we introduce an additional pre-simulation step: creating simple geometry to represent the shell (silhouette) of the hair, and then using our established deformation techniques to control it. This idea allows us to cast the complex hair problem as a simpler geometry deformation problem we are experienced at solving. A simple deformation cage is first attached to various surfaces on the head and body to determine the mane's basic shape. Procedural rules are then applied which adjust the points of the cage to maintain the desired volume and silhouette, while avoiding body penetration during animation. Finally, controls are provided so that the animators can manipulate the points of the shell directly, ensuring their desired silhouette is achieved. This system uses the same methodology and pipeline as our body deformations.

We extended our hair dynamics system to work in conjunction with the shell geometry. In a typical setup the hair root is attached to the closest (u,v) coordinate on the skin's surface. With the hair shell, we also attach the hair tips to their nearest neighbor on the shell surface. Prior to the simulation running, the optimal positions of the tips are computed based on their attachments to the deformed shell, and the hairs are then oriented towards these locations. Hairs can also be stretched so that the tips maintain a constant offset to their parent position. Once the hairs have been adjusted to match the desired silhouette, additional motion is applied via our proprietary hair simulation package.

The shell approach typically provides better results than purely dynamic solutions. Even with no simulation, the hair silhouette will achieve the desired shape. Therefore, the simulation must only provide believable motion based on the character's actions, which is much easier than using it to reach the desired shape under a variety of poses. The solutions are faster and more stable as well, since the shell ensures the input to the simulation is clean, removing the need to perform collision detection between the hair and body.

2 Art-Directable Controls

Animators have been given direct control over the silhouette of Alex's mane, allowing them to enhance the artistic composition of their shots. Furthermore, since the shell automatically positions itself in reaction to his body deformations, the hair maintains its graphic style through a wider range of motion, freeing animators to focus on strong performances rather than endlessly tweaking simulation parameters. On *Madagascar: Escape 2 Africa* the benefits continue to spread down the pipeline; for instance, mane variations can easily be generated by moving the shell points to new locations.

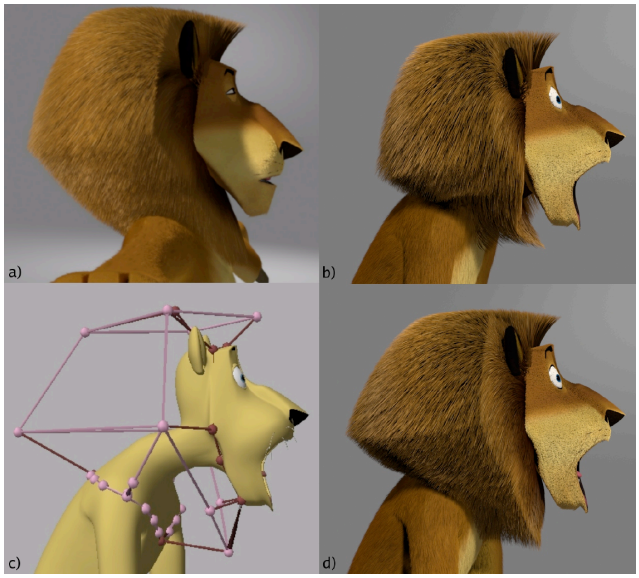

Figure 1: *(a) Neutral Alex (b) Original non-shell dynamics (c) The hair shell visualized (d) Final shell-based render*

3 Discussion

We are currently using the shell approach on *Madagascar: Escape 2 Africa* in hundreds of shots on a variety of characters. However, while the shell has proven successful in many situations, for longer and looser hair styles, basing the motion on a simple deformation cage is not always appropriate. In these cases, the motion is influenced much more heavily by dynamics than the deformation of the underlying geometry, and an approach more oriented towards physical realism than maintaining artistic style is necessary.

Within those limitations, the shell approach provides many benefits to character setups. Since the problem has largely been cast in terms of normal body deformations, we can leverage our existing knowledge when creating hair setups. The simulation parameters that remain are much more forgiving than on a purely dynamic setup, providing better results in fewer iterations and faster development. Animators are allowed a greater range of character motion and silhouette control for stronger performances. Most importantly, as the approach is quite simple, it is both more robust and easier to debug than standard hair setups, making it well-suited for a production environment.

References

SCAPEL, N., AND BOYLAN, T., 2005. The wig system. ACM SIGGRAPH Sketch.

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