Monkey Head: Highly-realistic Computer-animation Model for Macaque Facial Expressions

Sektion
Theoretische Sensomotorik
Section Computational Sensomotorics

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Motivation

Although facial expressions are generically dynamic most emotion research has focused on static faces, in humans as well as in non-human primates. The reson for this is the difficulty of the exact control of the relevant stimulus features in dynamic facial expressions. As an important step towards controlled electrophysiological experiments on the neural encoding of dynamic monkey facial expresions, we have developed a computer animation model that realizes highly-realistic facial expressions of macaques in real-time.

Problem

To present realistic real-time stimuli it is needed to create a highliy controlable mesh for animation with physically correct properties of hair and skin.

Skin has many subtle visual characteristics:

- wrinkles, pores, freckles, scars, and so on,
- surface reflectance: fresnel interaction with the topmost layer of the skin,
- slightly translucent ⇒ **subsurface scattering**, the process whereby light goes beneath the skin surface, scatters and gets partially absorbed, and then exits somewhere else.

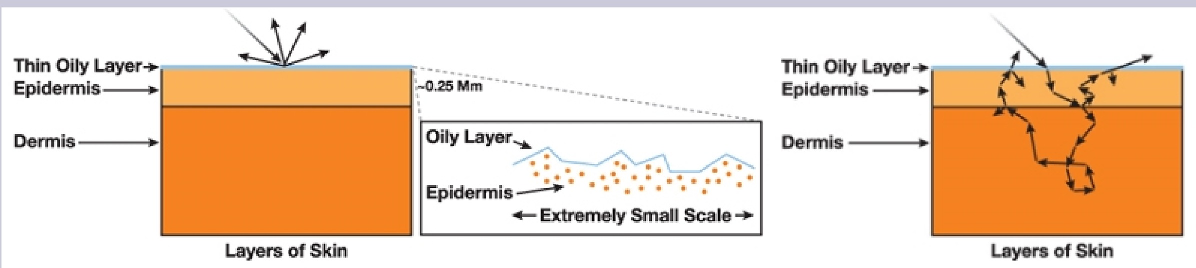

Figure 1: Oily and rough top layer (left), scattering and absorption in multiple layers (right).

Challenges for hair simulation:

- polygon strips with alpha maps added to characters to simulate hair strands ⇒ leads to static, boring and unnatural looking hair,
- simulating realistic hair with tens of thousands of strands is something that until recently was not possible in real time.
- NVIDIA provides a library which offers computational efficient algorithms applied directly on GPU for realistic hair properties (inter-hair collision, collision detection, self shadowing, etc.).

Asset Preparation

Figure 2: Noisy, irregular MRI scan (left) retopologized (middle) to mimic muscle flows (right).

Figure 3: Refined surface (7.3 million polygons) created in Autodesk Mudbox to extract high frequency details for low reselution mesh.

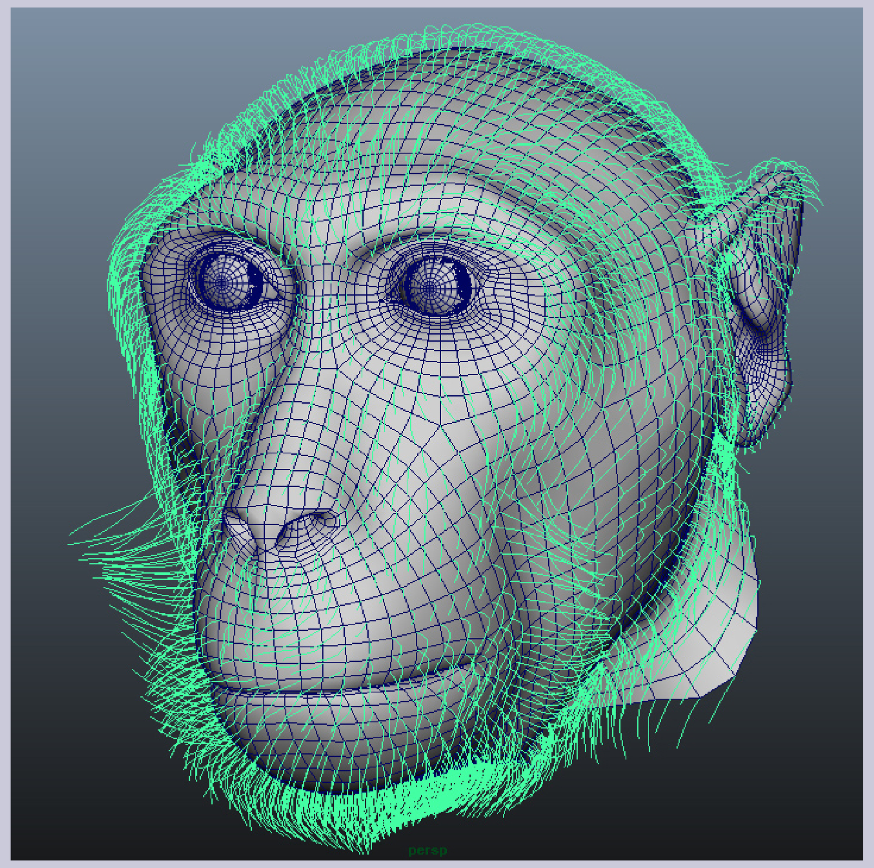

Figure 4: Guide Hair Curves. Set of control (guide) curves on a surface mesh (growth mesh) using standard Maya hair tools.

Figure 5: Texture maps for skin shader.

Real-Time Rendering

To minic translucent properties of the skin we applied weighted linear combinations of k Gaussian blurred diffuse textures I with variance v_i and blur radius r,

$$\sum_{i=1}^{k} w_i I * G(v_i, r), \quad G(v, r) = \frac{1}{2\pi v} e^{-r^2/(2v)},$$

in combination with a thickness parameter and variations on the expression $(\mathbf{N} \cdot \mathbf{V})$ [1].

For specular reflectance we used bidirectional reflectance distribution function (BRDF) [2].

Since DiretX 11 compute shader enable heavy computations on graphic cards like hair simulation. For hair simulation it is used to compute goal positions of curve vertices given various constraints (lenght, shape, etc.) and simulation parameters (stiffness, clumping, etc.).

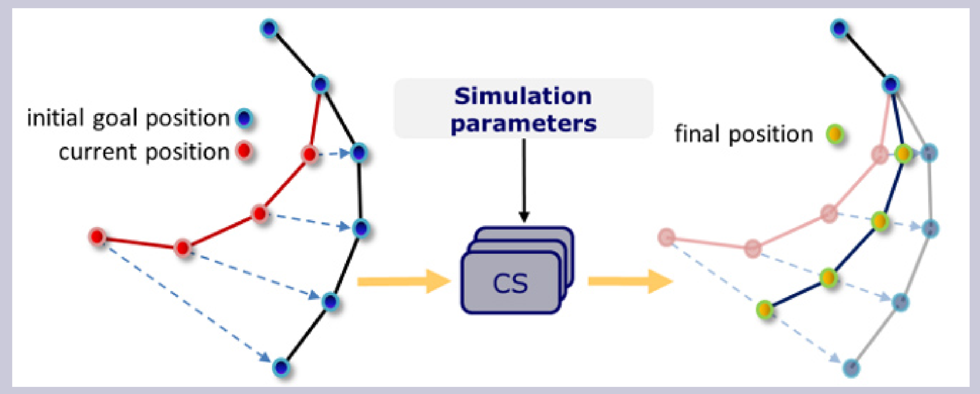

Figure 6: Compute pass for simulation.

Conclusion

We developed a CG monkey head based on MRI scans, created texture maps and applied physically accurate materials for a realistic simulation in real time. For a realistic hair simulation we integrated NVIDIA's HairWorks package. For **future work** we will apply machine learning methods to control the emotional expressivness of the stimuli.

References

[1] Simon Green. Real-time approximations to subsurface scattering. *GPU Gems*, 1(1):263–278, 1991.

[2] Xiao D. He, Kenneth E. Torrance, François X. Sillion, and Donald P. Greenberg. A comprehensive physical model for light reflection. *SIGGRAPH Comput. Graph.*, 25(4):175–186, July 1991.

Acknowledgements

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