Ways to Skin a "Hairless" Cat:
Building a Creepy Kitty Villain at Tippett Studio

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Figure 1: *Final frame of Kitty Galore*

1 Introduction

After more than 25 years of mastering the art of furry creatures and character animation, we were approached with a new challenge: creating the CG anthropomorphic "Kitty Galore," the hairless sphinx cat villainess in *Cats & Dogs 2: The Revenge of Kitty Galore*. And by "hairless" we mean creating 2-million hairs of peach fuzz and sparse patches of long hair on a cat that has skin and wrinkles that shift, stretch and bunch as the cat moves along with her manic acting, talking and expressive movement.

2 Our Approach

Initially we went through a process of testing to come up with the best way to tackle the wrinkle challenge. Cloth sim, height displacement maps, and world-space vector displacement maps were all tried but did not provide us with the detail, quality and performance we needed. Our solution: sculpt both muscle and wrinkle passes in Zbrush on posed models; convert the sculpts to vector displacement maps using an in-house tool which compares the original low-resolution model to the high-detailed sculpt and renders the maps via the GPU; and encode the maps in tangent space in order to apply them during animation. A Renderman plugin provided identical tangent information to shaders. In the end, 75 sculpts were created, including more than 20 for the face.

Tangent-space vector displacement maps were multiplied by a scale factor at render time by comparing polygon edge lengths to base meshes in order to compute stretch and compression; and we also used a trainable pose-based solver in the rig to infer artist-settable scale factors. To our knowledge, this was the first application of layered tangent-space vector displacements that were also both automatic and artist-controllable, notably in the presences of sparse fur on top of the displacement.

3 Our Process

For rigging and animation, a rigger would choose blend weights by hand for several example poses, and our pose-based animation solver would use those as training data and compute interpolated poses. If an interpolated pose needed to be corrected, it was subsequently added to the set of training data. These weights contributed to vector displacement map scale values for the face and other wrinkles.

After the rig, dynamics, and a muscle system were applied, the stretch or compression of the skin along each polygon edge was computed by a custom Maya node, incorporating the values during shading to automatically drive vector displacement map scale values (e.g. compression fired a wrinkle sculpt and strain fired a ripped muscle sculpt).

Skin shading was a particular challenge, with subsurface scattering playing a major role. A unified solve of the scattering proved difficult to tune and gave inconsistent results. The solution was to break scattering into two passes: shallow back scattering and deep forward scattering, both using an inset copy of the mesh from the rig acting as a light-absorbing blocking object. The subsurface scattering look was further enhanced by Pixar's gummi lights[1]. Surface reflection used a LaFortune[2] skin specular model. The strain data aided in controlling the color of the skin; more stretch fired a flushed color.

The large number of vector maps meant that the shader needed to be optimized to access only required maps for a given pose, or else texture cache thrashing became an efficiency killer. Also, in some shots seams were visible in displacement at UV borders. The seams were never completely gone, but were greatly minimized by always smoothing surface normals, and ensuring the tangent encoding and decoding was identical in all stages of the process.

Kitty had as much fur as a typical cat, but it was very short and thin. Simulating the fur with a velvety *fake fur* shader was tried, but results were unacceptable in close-ups. *Furator*, our in-house fur system, added support for dynamic vector displacement driven by the same strain and pose weights with a tunable offset. The hair generation then aligned with the rendered surface by matching all strain computations and wrinkle dynamics.

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[1] Cho, Jun Han; Xenakis, Athena; Gronsky, Stefan and Shah, Apurva. "Anyone Can Cook – Inside Ratatouille's Kitchen". Siggraph 2007, Course Notes, Course Number 30.

[2] Lafortune EPF, Foo S-C, Torrance KE, Greenberg DP. "Non-linear approximation of reflectance functions". Proceedings of SIGGRAPH'97, 1997. p. 117-126.

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