UC DAVIS
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COMPUTER SCIENCE

Attachment-Based Character Deformation

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Problem

Posing digital characters often requires using multiple deformer systems (e.g. skeletal skinning, lattices) to achieve the right shape. We propose a deformation method that enables highly configurable shape control at both the anatomical and surface levels.

Related Work

- Stretchable and Twistable Bones (Jacobsen and Sorkine, 2011)
- Surface Deformation
  - Laplacian Surface Editing (Sorkine et al., 2004)
  - As-rigid-as-possible (Sorkine and Alexa, 2007)
- Sketch-based interfaces
  - SilSketch (Zimmerman, Nealen, and Alexa, 2007)
  - Differential blending (Öztireli et al., 2013)

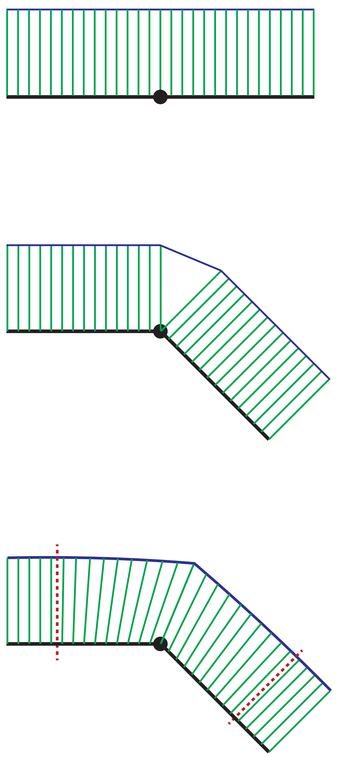
Our method

Explicit attachment points between mesh vertices and bones:

1) act as reference points for deformation
2) replace skinning weights
3) enable new modes of shape control

- GPU-accelerated for real-time use
- Shared sketch-based interface for skeletal posing and surface deforms

Deformation



Given vertex v and endpoint weight $t_v \in [0,1]$ for a bone (p,c), we define attachment point a_v and scale vector s_v as:

$$a_v = p + t_v(c-p)$$
$$s_v = v - a_v$$

After posing the skeleton:

$$a'_v = p' + t_v(c'-p'),$$
$$v' = a'_v + R(a_p,\theta_p)s_v = a'_v + s'_v$$

where $R(a_p,\theta_p)$ is the axis-angle rotation of p.

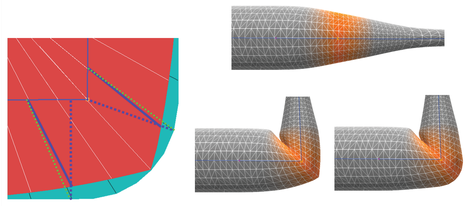
Let $\theta_v = 1 - \frac{t_v}{p_i}$, where $p_i \in [0,1]$ is the influence size of p along the bone.

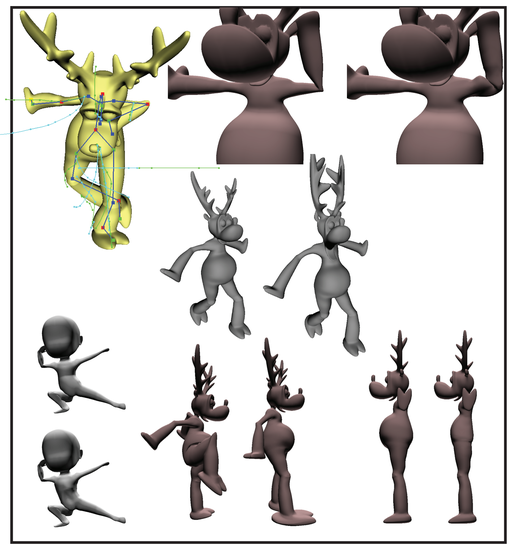
Let $\Delta = R(a_p, \theta_v\theta_p)$ be the local rotation around a'_v.

Then the smoothed skinned position is:
$v'' = a'_v + \Delta s'_v = a'_v + s''_v$

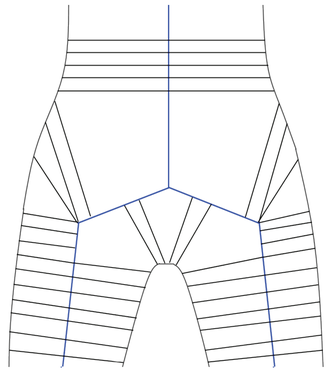
Length Adjustment

"Tip" artifact occurs as joint bend increases. Correcting this involves adjusting the scale vector length. A post-skinning projection test produces smooth bends around joints.

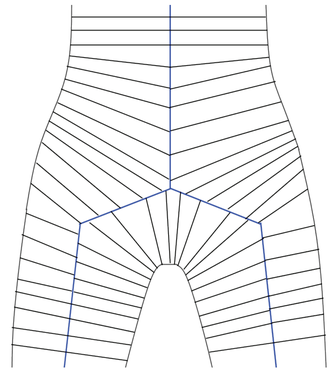




Attachment Binding



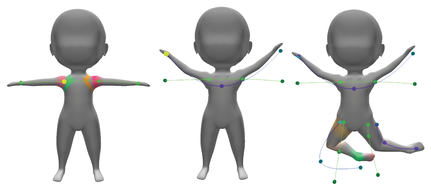
In complex regions, attaching vertices to skeleton via closest projection can introduce gaps and violate adjacency.



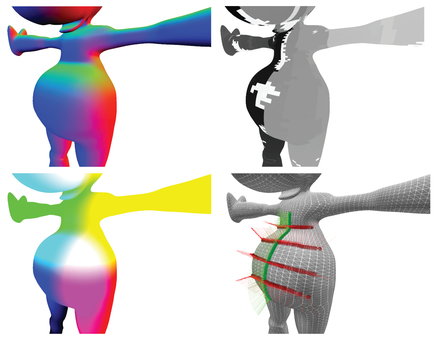
Options for improved binding quality:

- Visibility checks
- Interleaved Laplacian smoothing and reprojection steps
- Mesh contraction

Sketch interface and deferred rendering



Baseline strokes select joints, and offset strokes define the desired pose. Bones are rotated and optionally stretched to best match the pose. To refine the pose, the user can adjust control knots on the strokes or draw new ones.



Rendering to framebuffer textures permits fast and accurate surface queries using the input stroke as coordinates for texture lookup. The results are used to define deformation regions of interest. This approach works with any number of mesh deformers, including animations!

References

Alec Jacobson and Olga Sorkine. 2011. Stretchable and Twistable Bones for Skeletal Shape Deformation. ACM Trans. Graph. 30, 6, Article 165 (Dec. 2011), 8 pages.

A. Cengiz Öztireli, Ilya Baran, Tiberiu Popa, Boris Dalstein, Robert W. Sumner, and Markus Gross. 2013. Differential Blending for Expressive Sketch-based Posing. In Proceedings of the 12th ACM SIGGRAPH/Eurographics Symposium on Computer Animation (SCA '13). 155–164.

Olga Sorkine and Marc Alexa. 2007. As-rigid-as-possible Surface Modeling. In Proceedings of the Fifth Eurographics Symposium on Geometry Processing (SGP '07). Eurographics Association, Aire-la-Ville, Switzerland, Switzerland, 109–116.

O. Sorkine, D. Cohen-Or, Y. Lipman, M. Alexa, C. Rössl, and H.-P. Seidel. 2004. Laplacian Surface Editing. In Proceedings of the 2004 Eurographics/ACM SIGGRAPH Symposium on Geometry Processing (SGP '04). 175–184.

Johannes Zimmermann, Andrew Nealen, and Marc Alexa. 2007. SilSketch: Automated Sketch-based Editing of Surface Meshes. In Proceedings of the 4th Eurographics Workshop on Sketch-based Interfaces and Modeling (SBIM '07). 23–30.

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