

Reference List 15-464 / 15-664 Feb 5, 2015

This SIGGRAPH 2014 course contains a great deal of useful information

Alec Jacobson, Zhigang Deng, Ladislav Kavan, J. P. Lewis.

[Skinning: Real-time Shape Deformation](#)

SIGGRAPH Course, 2014.

We started out by talking about direct techniques. Linear blend skinning (LBS) and its problems are described in the first section of the SIGGRAPH course notes. In particular, there is a nice description of the candy wrapper effect.

Pinocchio, however, uses LBS with nice results. Code is available and you can try it out.

Baran, Ilya, and Jovan Popović. "Automatic rigging and animation of 3d characters." In *ACM Transactions on Graphics (TOG)*, vol. 26, no. 3, p. 72. ACM, 2007.

<http://www.mit.edu/~ibaran/autorig/>

Much research, however, has focused on maintaining the speed and ease of use of LBS and removing the artifacts. We talked about this paper, which uses dual quaternion blending to remove twisting artifacts

Kavan, Ladislav, Steven Collins, Jiří Žára, and Carol O'Sullivan. "Geometric skinning with approximate dual quaternion blending." *ACM Transactions on Graphics (TOG)* 27, no. 4 (2008): 105.

<http://dl.acm.org/citation.cfm?id=1409627>

<https://www.youtube.com/watch?v=LUOJccOZfWQ>

.. and this paper introducing the idea of differential blending (breaking up large rotations into collections of small ones), which works well even for very large twists and deformations, such as might be needed for cartoon effects.

Öztireli, A. Cengiz, Ilya Baran, Tiberiu Popa, Boris Dalstein, Robert W. Sumner, and Markus Gross. "Differential blending for expressive sketch-based posing." In *Proceedings of the 12th ACM SIGGRAPH/Eurographics Symposium on Computer Animation*, pp. 155-164. ACM, 2013.

<https://graphics.ethz.ch/publications/papers/paperOzt13.php>

An alternative approach is to use cages. Cages are a very old idea dating back to early (vector!) graphics

Burtnyk, Nester, and Marcelli Wein. "Interactive skeleton techniques for enhancing motion dynamics in key frame animation." *Communications of the ACM* 19, no. 10 (1976): 564-569.

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.151.8234&rep=rep1&type=pdf>

The technique developed in this 1976 paper was used in the movie *Hunger* by Peter Foldes

<https://www.nfb.ca/film/hunger>

Here is a more modern paper showing some of the effects that can be sculpted using the cage based approach

Ju, Tao, Qian-Yi Zhou, Michiel van de Panne, Daniel Cohen-Or, and Ulrich Neumann. "Reusable skinning templates using cage-based deformations." In *ACM Transactions on Graphics (TOG)*, vol. 27, no. 5, p. 122. ACM, 2008.

<http://www.cse.wustl.edu/~taoju/>

We also talked briefly about the idea of more general purpose deformer which may be programmed to achieve a variety of effects. Here are two papers discussing how deformer may be created and used

Mohr, Alex, and Michael Gleicher. "Building efficient, accurate character skins from examples." In *ACM Transactions on Graphics (TOG)*, vol. 22, no. 3, pp. 562-568. ACM, 2003.

<http://research.cs.wisc.edu/graphics/Gallery/SkinFromExamples/>

Kavan, Ladislav, and Olga Sorkine. "Elasticity-inspired deformer for character articulation." *ACM Transactions on Graphics (TOG)* 31, no. 6 (2012): 196.

<http://igl.ethz.ch/projects/eid/>

The idea of example based techniques can be made more general, as in this 2000 SIGGRAPH paper on Pose Space Deformation. The challenge is to find interpolation techniques that work well for sparse examples in high dimensional spaces

Lewis, John P., Matt Corder, and Nickson Fong. "Pose space deformation: a unified approach to shape interpolation and skeleton-driven deformation." In *SIGGRAPH 2000*.

<http://dl.acm.org/citation.cfm?id=344862>

<https://www.youtube.com/watch?v=XPxRftplwJM>

On use of Pose Space Deformation in the film Bolt:

<http://disney-animation.s3.amazonaws.com/library/poseSpaceDef.pdf>

Use of Pose Space Deformation with CT scans

Kurihara, Tsuneya, and Natsuki Miyata. "Modeling deformable human hands from medical images." In *Proceedings of the 2004 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pp. 355-363. Eurographics Association, 2004.
<http://dl.acm.org/citation.cfm?id=1028571>

We touched briefly on simulation or optimization approaches to skinning, which can achieve volume preservation and dynamic effects (at cost of long runtimes). However, I will defer those to later in the course. A mixed approach is to collect examples from simulation and then use them with Pose Space Deformation or to create custom deformers.

It may be said that we cannot get good results without considering the underlying human anatomy. In that context, the following paper is interesting

Dicko Ali-Hamadi, Tiantian Liu, Benjamin Gilles, Ladislav Kavan, François Faure, Olivier Palombi, Marie-Paule Cani.

[Anatomy Transfer](#)

ACM Transaction on Graphics 32(6) [Proceedings of SIGGRAPH Asia], 2013.

<https://www.youtube.com/watch?v=ddp996DIZOk>