15-464 / 15-664 Reference List for Feb 4, 2019

We started with a review from this paper, outlining variations on classic Jacobian techniques for inverse kinematics:

Buss, Samuel R. "Introduction to inverse kinematics with jacobian transpose, pseudoinverse and damped least squares methods." *IEEE Journal of Robotics and Automation* 17 (2004): 1-19. http://web.cse.ohio-state.edu/~parent/classes/694A/Lectures/Material/IKsurvey.pdf

The following paper expands on this approach, adding the notion of priorities and illustrating well the results of using this approach for character posing.

Yamane, Katsu, and Yoshihiko Nakamura. "Natural motion animation through constraining and deconstraining at will." *Visualization and Computer Graphics, IEEE Transactions on* 9, no. 3 (2003): 352-360. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1207443

The classic Jacobian based approach to IK has been parallelized to work quickly for many degree of freedom characters on a modern GPU. This paper is also worth reading for one more description of this classic approach.

Harish P, Mahmudi M, Callennec BL, Boulic R. Parallel inverse kinematics for multithreaded architectures. ACM Transactions on Graphics (TOG). 2016 May 25;35(2):19. http://dl.acm.org/citation.cfm?id=2887740

However, in some applications, even faster results may be desired. For fast IK, CCD is the standby approach, as we saw last week.

Lander, Jeff. "Oh My God, I Inverted Kine!." *Game Developer Magazine* 9 (1998): 9-14. http://graphics.cs.cmu.edu/nsp/course/15464-s15/www/lectures/lec06/jlander_gamedev_sept98.pdf

Lander, Jeff. "Making kine more flexible." *Game Developer Magazine* 1, no. 15-22 (1998): 2. http://graphics.cs.cmu.edu/nsp/course/15464-s15/www/lectures/lec06/jlander_gamedev_nov98.pdf

However, CCD can create artifacts such as the end effector curling in on itself. The following approach is also very fast and in the same style, but seems to create more visually pleasing and consistent results.

Aristidou, Andreas, and Joan Lasenby. "FABRIK: a fast, iterative solver for the inverse kinematics problem." *Graphical Models* 73, no. 5 (2011): 243-260.
http://www.andreasaristidou.com/FABRIK.html
https://www.youtube.com/watch?v=tN6RQ4yrNPU

You can see from the other papers listed on the same webpage that the authors have made this model work for humanoid characters, using heuristics to reconstruct full body character poses from a few markers or end effector trajectories.
https://www.youtube.com/watch?v=wjn19jBzJCE

The following classic IK paper points out that using iterative approaches is a little silly if we only want the final pose. Why not pose the problem as a more general optimization problem and let one of the vast library of solvers out there do the work of finding an answer?

Zhao, Jianmin, and Norman I. Badler. "Inverse kinematics positioning using nonlinear programming for highly articulated figures." *ACM Transactions on Graphics (TOG)* 13, no. 4 (1994): 313-336. http://ai.stanford.edu/~latombe/cs99k/2000/badler.pdf

This paper is the IK survey that plotted a timeline of the various techniques and contains many IK references:

Aristidou, Andreas, Joan Lasenby, Yiorgos Chrysanthou, and Ariel Shamir. "Inverse Kinematics Techniques in Computer Graphics: A Survey." In *Computer Graphics Forum*, vol. 37, no. 6, pp. 35-58. 2018. https://onlinelibrary.wiley.com/doi/pdf/10.1111/cgf.13310

The following paper covers posing using lines of action and has been used as a final project topic in this class.

Guay, Martin, Marie-Paule Cani, and Rémi Ronfard. "The line of action: an intuitive interface for expressive character posing." *ACM Transactions on Graphics (TOG)* 32, no. 6 (2013): 205. https://dl.acm.org/citation.cfm?id=2508397
https://www.youtube.com/watch?v=QgrQuBwlbSE

This paper creates poses from silhouette drawings. You may check whether their software is available online to try out.

Bessmeltsev M, Vining N, Sheffer A. Gesture3D: posing 3D characters via gesture drawings. ACM Transactions on Graphics (TOG). 2016 Nov 11;35(6):165. http://dl.acm.org/citation.cfm?id=2980240
https://www.youtube.com/watch?v=8C3uZOXLBIA

We saw this paper, which adds a bit of physics cleanup to motions in an interactive keyframing setup.

Rabbani, Amir H., and Paul G. Kry. "PhysIK: Physically Plausible and Intuitive Keyframing." In *Graphics Interface*, pp. 153-161. 2016. https://dl.acm.org/citation.cfm?id=3076161
https://www.youtube.com/watch?v=UmwAR4wnYIM

.. and this paper, which uses anatomical constraints for IK for the human hand.

Aristidou, Andreas. "Hand tracking with physiological constraints." *The Visual Computer* 34, no. 2 (2018): 213-228. https://link.springer.com/article/10.1007/s00371-016-1327-8
https://www.youtube.com/watch?v=ajSU_oOAido

This paper uses machine learning techniques to model human motion with the goal of constructing very realistic looking motions from a few “handles” or “pins.”

Huang, Jing, Qi Wang, Marco Fratarcangeli, Ke Yan, and Catherine Pelachaud. "Multi-Variate Gaussian-Based Inverse Kinematics." In *Computer Graphics Forum*, vol. 36, no. 8, pp. 418-428. 2017.
https://onlinelibrary.wiley.com/doi/full/10.1111/cgf.13089
http://www.cse.chalmers.se/~marcof/publication/cgf2017/

This paper has a similar goal

Holden, Daniel, Jun Saito, and Taku Komura. "A deep learning framework for character motion synthesis and editing." *ACM Transactions on Graphics (TOG)* 35, no. 4 (2016): 138.
https://dl.acm.org/citation.cfm?id=2925975
https://www.youtube.com/watch?v=urf-AAIwNYk

And this one allows you to move around in an “emotion space.”

Aristidou, Andreas, Qiong Zeng, Efstathios Stavrakis, KangKang Yin, Daniel Cohen-Or, Yiorgos Chrysanthou, and Baoquan Chen. "Emotion control of unstructured dance movements." In *Proceedings of the ACM SIGGRAPH/Eurographics Symposium on Computer Animation*, p. 9. ACM, 2017. https://dl.acm.org/citation.cfm?id=3099566
https://www.youtube.com/watch?v=dkrMOQel8rU

One thing I forgot to talk about are the next two papers, which consider the problem of inverse kinematics on meshes which have no skeleton. The first of the two is the classic paper. The second offers suggestions for improvements.

Sumner, Robert W., Matthias Zwicker, Craig Gotsman, and Jovan Popović. "Mesh-based inverse kinematics." In *ACM Transactions on Graphics (TOG)*, vol. 24, no. 3, pp. 488-495. ACM, 2005.
http://people.csail.mit.edu/sumner/research/meshik/

Wampler K. Fast and reliable example-based mesh IK for stylized deformations. ACM Transactions on Graphics (TOG). 2016 Nov 11;35(6):235.
http://dl.acm.org/citation.cfm?id=2982433

You may also be interested in this paper, which allows puppeteering non-humanlike characters using your entire body. This one has been the topic of a final project for this class. The students brought in a Kinect and let us try it out.

Seol Y, O'Sullivan C, Lee J. Creature features: online motion puppetry for non-human characters. InProceedings of the 12th ACM SIGGRAPH/Eurographics Symposium on Computer Animation 2013 Jul 19 (pp. 213-221). ACM. http://dl.acm.org/citation.cfm?id=2485903