M2 Thesis Draft – Sketch Based Animation of Dancing Couples

Sarah Kushner
École nationale supérieure d'informatique
et de mathématiques appliquées,
Institut polytechnique de Grenoble,
Advisers: Marie-Paule Cani and Rémi Ronfard
sarah-anne.kushner@ensimag.fr

April 20, 2017

Abstract

Your abstract goes here...

0.1 Introduction

Problem Statement

3D animation can be a painstakingly tedious activity. To create a desired animation, animators go through the long process of keyframing. Keyframes are set positions that define the start and end points of a movement, sequences of poses which are transformed in time. Typically, animators assign poses to certain frames over time, so that in-between motions can be generated by a computer. To get an accurate animation, artists usually must assign many keyframes, then spend time adjusting and editing them to be more precise. The fact that industry professionals take so much time and effort to do this shows that for an amateur or untrained artist, creating *good* 3D animation is close to impossible.

Researchers in the IMAGINE group at INRIA have noticed this problem. They have made significant progress on a project where they aim to offer more intuitive tools to author 3D digital content. The IMAGINE team has invented (1) a type of notation made especially for posing and animating 3D characters (2) a technique for posing called the line of action, in which a user can draw a line in the shape they want a kinematic chain to take and (3) a technique for animation called space-time sketching, in which a user can draw a line in the path they want a model to take and it will be animated accordingly. As the character follows the path, its model bends and changes shape in a physically realistic way. Their system currently supports creating different movements with the path such as bouncing, rolling, and twisting.

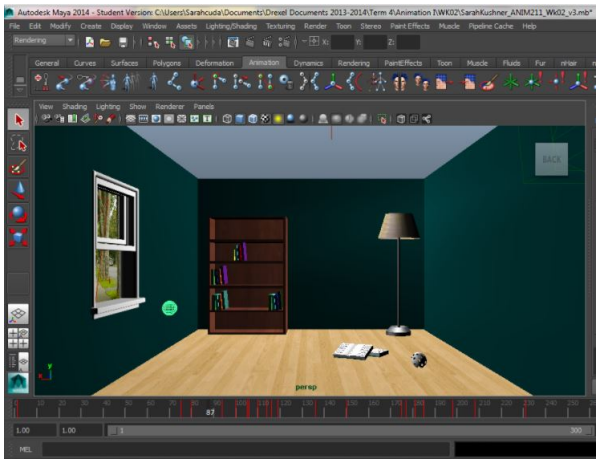


Figure 0.1: Keyframing.

Among the most complicated characters to animate in 3D animation are humanoid characters. To ease this task, animators create a skeleton for their character called a rig, that consists of joints connected by bones to give a structure to the character. Humanoid rigs can range in complexity from (relatively) simple to extremely complicated depending on the amount of detail desired by the user. The structure is a hierarchy of joints that can

also be seen as a tree with a root, which in the humanoid case, is usually the pelvis.

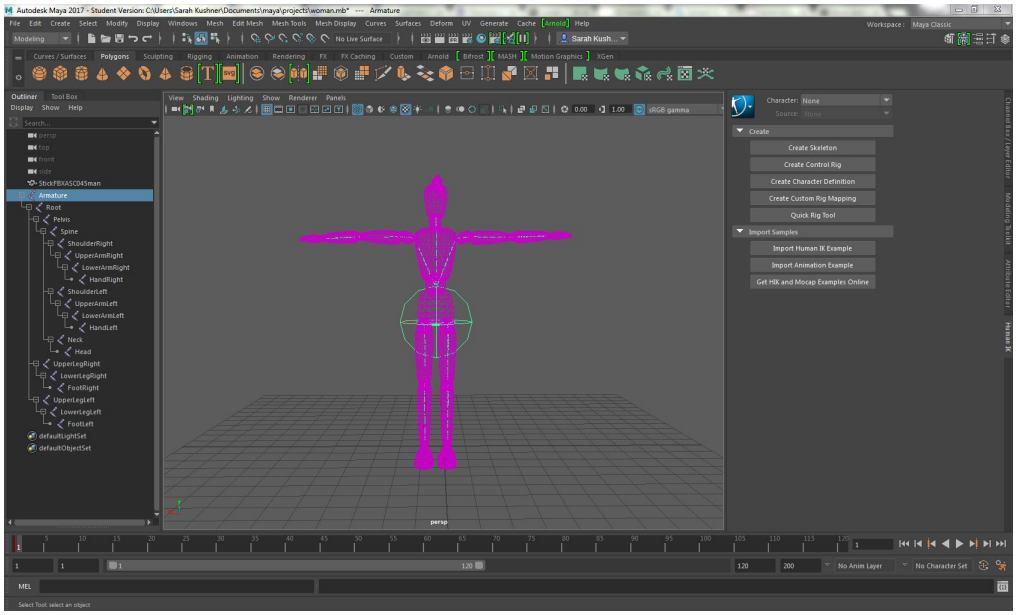


Figure 0.2: Example of a humanoid skeleton.

Forward and Inverse Kinematics

In order to animate this structure successfully, controls are added that allow for forward and inverse kinematics. These controls help the animator move the character into poses that will then act as keyframes.

Forward kinematics is a method of calculating the position and orientation of the end of a kinematic chain (i.e. a hand or foot) given the positions and angles of the joints higher up in the chain all the way to the root.

Inverse kinematics is the opposite method of forward kinematics. That is, the goal is to calculate the angles and positions of joints in the chain, given the angle and position of just the end of the chain. This goal much harder to reach, seeing that more information needs to be calculated than is given.

Multiple Characters

The animation of multiple characters, along with all the previously mentioned challenges, comes with its own unique set as well. The line of action technique

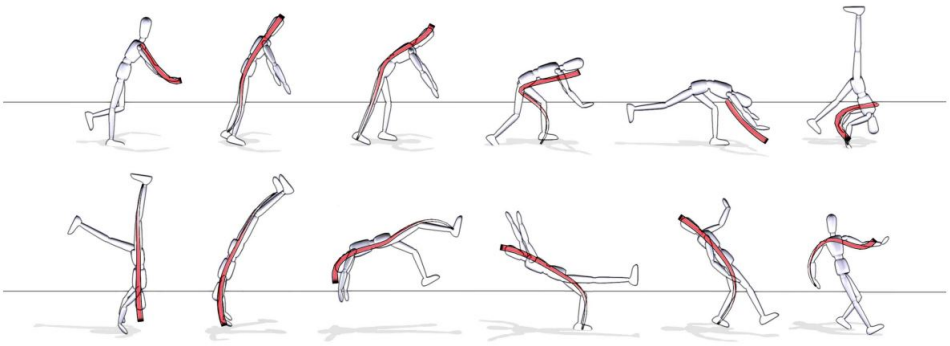


Figure 0.3: One character's keyframes using the line of action technique.

works extremely well for a single humanoid character, and even multiple humanoid characters separate from each other. The problem is discovered when the humanoid characters interact, when they are in close proximity to each other or when they touch each other.

Occlusion?

Collisions

0.2 State of the Art

sketching for posing and animation

The Line of Action: an Intuitive Interface for Expressive Character Posing – 2013
Adding dynamics to sketch-based character animations – 2015
Space-time sketching of character animation – 2015

Artist-oriented 3D character posing from 2D strokes – 2016
people in Switzerland also did the posing
Sketch to pose in Pixar's presto animation system – 2015

cleaning/editing animation

FootSee: an Interactive Animation System
Footskate Cleanup for Motion Capture Editing
SketchiMo: Sketch-based Motion Editing for Articulated Characters – 2016
sketching for editing trajectories and poses

retargeting motion

Retargetting Motion to New Characters
Using an Intermediate Skeleton and Inverse Kinematics for Motion Retargeting

generating animation

Motion Graphs
Style-Based Inverse Kinematics – 2004
generative models for motion capture sequences used to build animations

Displacement constraints for interactive modeling and animation of articulated structures – 1994
fitting geometric constraints using physics

A constrained inverse kinematics technique for real-time motion capture animation – 1999
Dancing-to-Music Character Animation

synthesis

Synthesizing Dance Performance Using Musical and Motion Features – 2006
between music and an animation generated from a motion graph built from motion capture

analyzing/classification

Analysis of impression of robot bodily expression
Convolutional Pose Machines

graph theory

FINDING ALL THE ELEMENTARY CIRCUITS OF A DIRECTED GRAPH
A New Search Algorithm for Finding the Simple Cycles of a Finite Directed Graph
An Algorithm for Combining Graphs Based on Shared Knowledge

math/algorithms

The Conjugate Residual Method for Constrained Minimization Problems – 2015
Constrained Closed Loop Inverse Kinematics – 2010

dance notation

Sutton Dance Writing
Labanotation
Benesh Movement Notation

0.3 Proposed Solution

Line of Action Notation

Taking inspiration from Sutton Notation, we propose a new notation for representing the poses of two characters both together and separately.

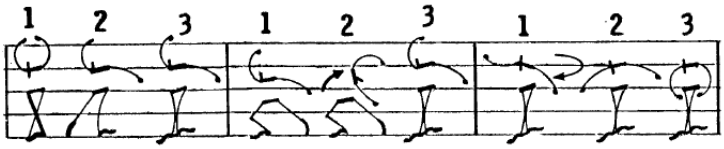


Figure 0.4: An example of Valerie Sutton's Dancewriting.

Common Multi-character Poses

Figure 0.5: Dancing in the Dark.

There is a dance scene in the film "The Band Wagon," where Cyd Charisse and Fred Astaire start out by walking together side by side, exchanging twirls until it morphs completely into a swing style dance. This scene is our use case for inventing a notation which extends seamlessly to more than one character.

To determine which poses for these dancers were common, I annotated the video with what I thought good keyframes would be if the two characters were treated as one.

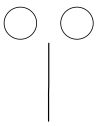
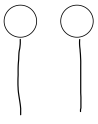
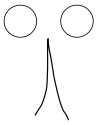
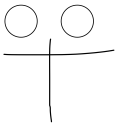
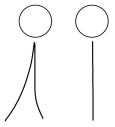
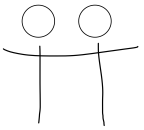
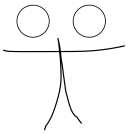
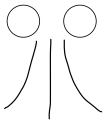
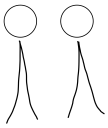
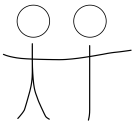
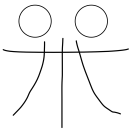
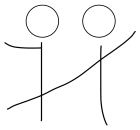
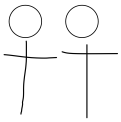
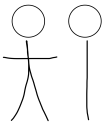
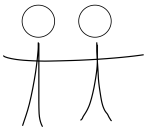
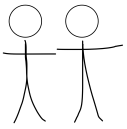
	Separate	Together		
1 LOA				
2 LOA				
3 LOA				
4 LOA				
				
5 LOA				
6 LOA				

Table 0.1: Types of Keyframes for Two Dancing Characters

There are 6 poses combinations for the characters separately. The asymmetrical poses for the odd number of LOAs can be mirrored (for 3 and 5 LOAs); therefore there are actually 8 poses for two characters separately. There are 10 combinations for the characters together, treated as one character. There are 2 poses which can be mirrored, so there are actually 12 poses together. Overall, 20 poses exist for 2 articulated humanoid characters.

Bibliography

[1] Metro-Goldwyn-Mayer (MGM), 1953.

[2] Hisham Al-Mubaid and Said Bettayeb. An algorithm for combining graphs based on shared knowledge.

[3] Marguerite Causley. *An Introduction to Benesh: Movement Notation*. Ayer Company Pub, 1980.

[4] Byungkuk Choi, JP Lewis, Yeongho Seol, Seokpyo Hong, Haegwang Eom, Sunjin Jung, Junyong Noh, et al. Sketchimo: sketch-based motion editing for articulated characters. *ACM Transactions on Graphics (TOG)*, 35(4):146, 2016.

[5] Behzad Dariush, Youding Zhu, Arjun Arumbakkam, and Kikuo Fujimura. Constrained closed loop inverse kinematics. In *Robotics and Automation (ICRA), 2010 IEEE International Conference on*, pages 2499–2506. IEEE, 2010.

[6] Jean-Dominique Gascuel and Marie-Paule Gascuel. Displacement constraints for interactive modeling and animation of articulated structures. *The Visual Computer*, 10(4):191–204, 1994.

[7] Michael Gleicher. Retargetting motion to new characters. In *Proceedings of the 25th annual conference on Computer graphics and interactive techniques*, pages 33–42. ACM, 1998.

[8] Keith Grochow, Steven L Martin, Aaron Hertzmann, and Zoran Popović. Style-based inverse kinematics. In *ACM transactions on graphics (TOG)*, volume 23, pages 522–531. ACM, 2004.

[9] Martin Guay, Marie-Paule Cani, and Rémi Ronfard. The line of action: an intuitive interface for expressive character posing. *ACM Transactions on Graphics (TOG)*, 32(6):205, 2013.

[10] Martin Guay, Rémi Ronfard, Michael Gleicher, and Marie-Paule Cani. Adding dynamics to sketch-based character animations. In *Proceedings of the workshop on Sketch-Based Interfaces and Modeling*, pages 27–34. Eurographics Association, 2015.

[11] Martin Guay, Rémi Ronfard, Michael Gleicher, and Marie-Paule Cani. Space-time sketching of character animation. *ACM Transactions on Graphics (TOG)*, 34(4):118, 2015.

[12] Donald B Johnson. Finding all the elementary circuits of a directed graph. *SIAM Journal on Computing*, 4(1):77–84, 1975.

[13] Lucas Kovar, Michael Gleicher, and Frédéric Pighin. Motion graphs. In *ACM transactions on graphics (TOG)*, volume 21, pages 473–482. ACM, 2002.

[14] Lucas Kovar, John Schreiner, and Michael Gleicher. Footskate cleanup for motion capture editing. In *Proceedings of the 2002 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pages 97–104. ACM, 2002.

[15] David G Luenberger. The conjugate residual method for constrained minimization problems. *SIAM Journal on Numerical Analysis*, 7(3):390–398, 1970.

[16] Mentar Mahmudi, Pawan Harish, Benoît Le Callennec, and Ronan Boulic. Artist-oriented 3d character posing from 2d strokes. *Computers & Graphics*, 57:81–91, 2016.

[17] Jean-Sébastien Monzani, Paolo Baerlocher, Ronan Boulic, and Daniel Thalmann. Using an intermediate skeleton and inverse kinematics for motion retargeting. In *Computer Graphics Forum*, volume 19, pages 11–19. Wiley Online Library, 2000.

[18] Toru Nakata, Taketoshi Mori, and Tomomasa Sato. Analysis of impression of robot bodily expression. *Journal of Robotics and Mechatronics*, 14(1):27–36, 2002.

[19] Takaaki Shiratori, Atsushi Nakazawa, and Katsushi Ikeuchi. Dancing-to-music character animation. In *Computer Graphics Forum*, volume 25, pages 449–458. Wiley Online Library, 2006.

[20] Takaaki Shiratori, Atsushi Nakazawa, and Katsushi Ikeuchi. Synthesizing dance performance using musical and motion features. In

Robotics and Automation, 2006. ICRA 2006. Proceedings 2006 IEEE International Conference on, pages 3654–3659. IEEE, 2006.

[21] Ryan Stelzleni, Bret Parker, Tom Hahn, Sarah Shen, Dan McGarry, and Chen Shen. Sketch to pose in pixar's presto animation system. In *ACM SIGGRAPH 2015 Talks*, page 26. ACM, 2015.

[22] Valerie Sutton. *Sutton Movement Shorthand: Writing Tool for the Dance*. Movement Shorthand Society Press, 1979.

[23] Wen Tang, Marc Cavazza, Dale Mountain, and Rae Earnshaw. A constrained inverse kinematics technique for real-time motion capture animation. *The Visual Computer*, 15(7):413–425, 1999.

[24] Shih-En Wei, Varun Ramakrishna, Takeo Kanade, and Yaser Sheikh. Convolutional pose machines. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pages 4724–4732, 2016.

[25] Herbert Weinblatt. A new search algorithm for finding the simple cycles of a finite directed graph. *Journal of the ACM (JACM)*, 19(1):43–56, 1972.

[26] KangKang Yin and Dinesh K Pai. Footsee: an interactive animation system. In *Proceedings of the 2003 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pages 329–338. Eurographics Association, 2003.