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Assignment 5

STS 2500

Pixar Technical Memo #14-03: Subspace Clothing Simulation Using Adaptive Bases

This technical memo came from the Pixar Online Library and is a piece that largely builds upon existing research in subspace clothing simulation. This work, however, takes an original approach to creating better cloth simulations by using adaptive bases (basis vectors) dynamically generated during runtime. The authors of this work come from three locations on two different continents: Fabian Hahn[1,2], Bernhard Thomaszewski[2], Stelian Coros[2], Robert W. Sumner[2], Forrester Cole[3], Mark Meyer[3], Tony DeRose[3], and Markus Gross[1,2]. There was no indication by the authors whether or not this work has been used in any feature films yet, but the technical memo is only two and a half years old so it is likely to be expanded upon.

Current cloth simulations are limited by slow rendering times and consume a lot of computing resources. The authors of this piece attempt to mitigate these problems by using low-dimensional basis vectors that are created on-the-fly from previously stored data during initial full space simulations. The jargon is highly technical; however, the idea is relatively simple. The artists start with a skeleton-like model of the character to be animated and simple kinematic equations that dictate how the character will move in space. Due to the complexity of cloth simulation, additional clothing kinematic equations need to be created in order to accurately define non-linear movements of cloth wrapped around the body. After defining such equations, the artists run full-space simulations and record the data defining the clothing deformations in a brute force manner. This data is then interpolated to create basis vectors around points in pose space called sites. Essentially, a set of basis vectors is generated so that any position in pose space can be mapped to a unique set of basis vectors defining how the cloth should be positioned dictated by the kinematic equations.

Of course, the artists ran into several challenges during this process that deserve recognition. First, the kinematic equations defining the position of the cloth given a pose space position and movement parameters result in multiple solutions. To resolve this issue, a precedence order needs to be defined, or additional computing needs to take place. The authors of this work chose the latter option, which is computationally wasteful; conflict resolution, however, was not of importance to the team since external research has been done in the field to mitigate this problem significantly. The team chose to ignore this problem. Limiting the usage of computing resources was of concern to the team as well, and this problem motivated the team's use of low-dimensional basis vectors to store the cloth deformation data. The idea here was that a low-dimensional vector would use up less space in memory. The method of generating these low-dimensional bases is also clever in that it exploits spatial locality when generating them from vectors of similar positions in pose space through a process of interpolation, which can reduce memory access times. By dynamically creating basis vectors that define the cloth deformations in this way, the team of researchers had devised a way to simulate clothing movement up to 22 times faster than traditional methods while "still reproducing the rich set of wrinkles and folds evident in the full-space solution."

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