

# Simulating Cloth

By Andy Pierce

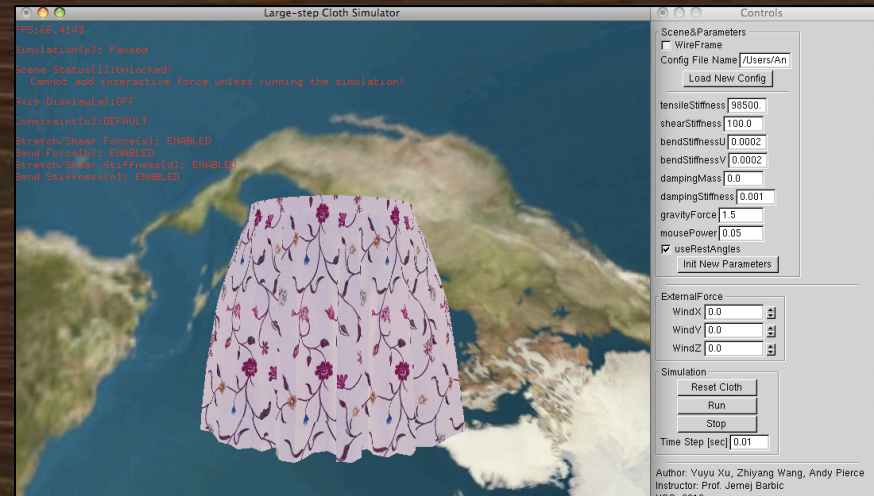
# Cloth Simulation Overview

- Problem of Interest
- Applications
- Challenges
  - Forces
  - Deformation



# My Project

- “Large Steps in Cloth Simulation” [Baraff and Witkin 1998]
- Preliminary Implementation
- Goals
  - Public Implementation
  - Extend Simulator




# Forces and Stiffness Matrices

- Cloth Forces

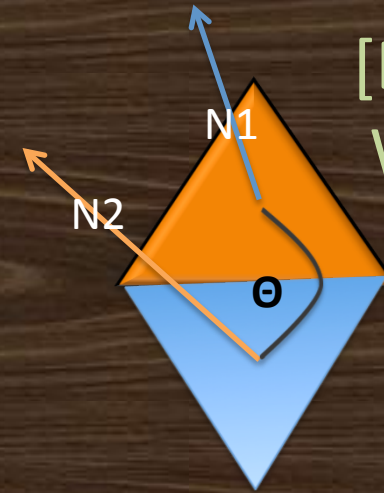
- Stretch 

- Shear 

- Bend 

- Bend Formula

- Force Derivatives



[Baraff and Witkin 1998]

$$\cos \theta = \mathbf{n}^A \cdot \mathbf{n}^B$$

$$\sin \theta = (\mathbf{n}^A \times \mathbf{n}^B) \cdot \mathbf{e}$$

$$C = \theta = \arctan \frac{\sin \theta}{\cos \theta}$$

# Timestepping the Forces

## Explicit

$$\begin{pmatrix} \Delta \mathbf{x} \\ \Delta \mathbf{v} \end{pmatrix} = h \begin{pmatrix} \mathbf{v}_0 \\ \mathbf{M}^{-1} \mathbf{f}_0 \end{pmatrix}$$

- Fast
- Unstable with large timesteps

## Implicit

$$\left( \mathbf{I} - h\mathbf{M}^{-1} \frac{\partial \mathbf{f}}{\partial \mathbf{v}} - h^2 \mathbf{M}^{-1} \frac{\partial \mathbf{f}}{\partial \mathbf{x}} \right) \Delta \mathbf{v} = h\mathbf{M}^{-1} \left( \mathbf{f}_0 + h \frac{\partial \mathbf{f}}{\partial \mathbf{x}} \mathbf{v}_0 \right)$$

- Must solve sparse linear system
- Can take large timesteps

[Baraff and Witkin 1998]

# Challenges

- Complexity of Formulas
  - 3<sup>rd</sup> order tensors
  - Large matrices
- Collapsing Triangles
  - Length of normal  $\rightarrow 0$
  - Explosions
  - Remedy

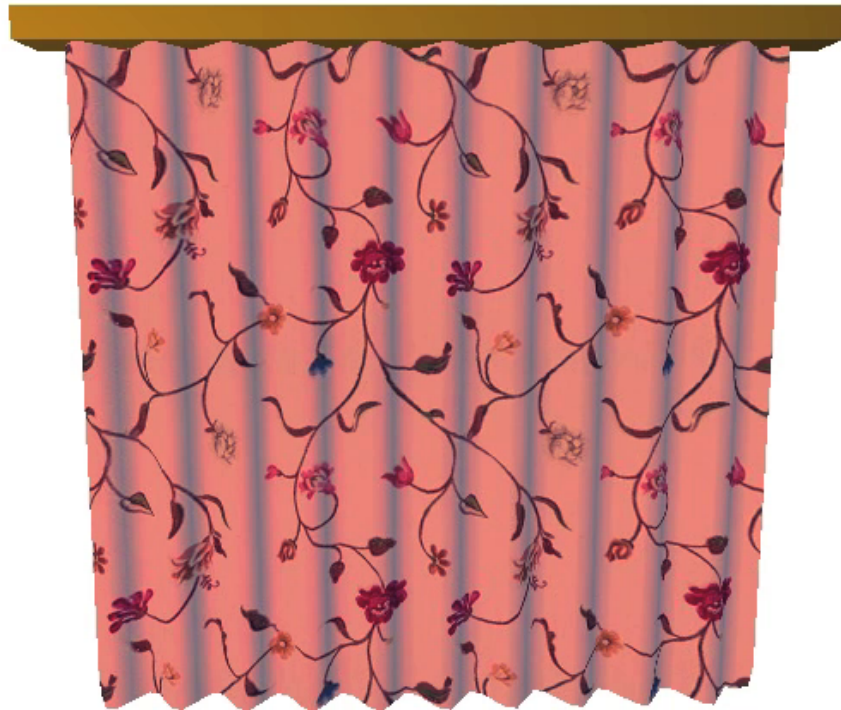


# Results



Model	Triangles	FPS	% Forces + Stiffness Matrix	% Solver
Curtain	2400	25	67	33





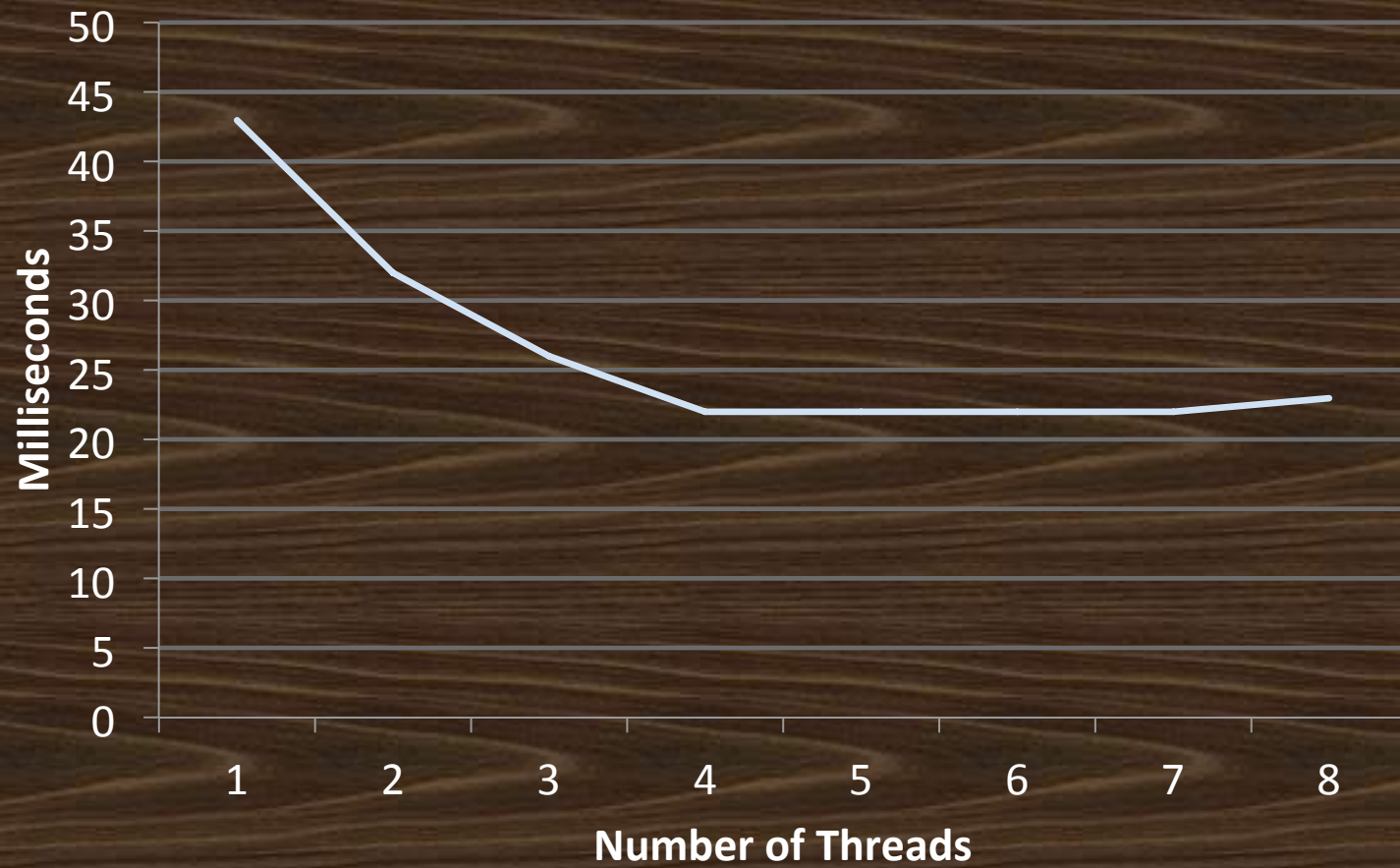
Model	Triangles	FPS	% Forces + Stiffness Matrix	% Solver
Curtain	2400	25	67	33



Model	Triangles	FPS	% Forces + Stiffness Matrix	% Solver
Skirt	4608	12	75	25

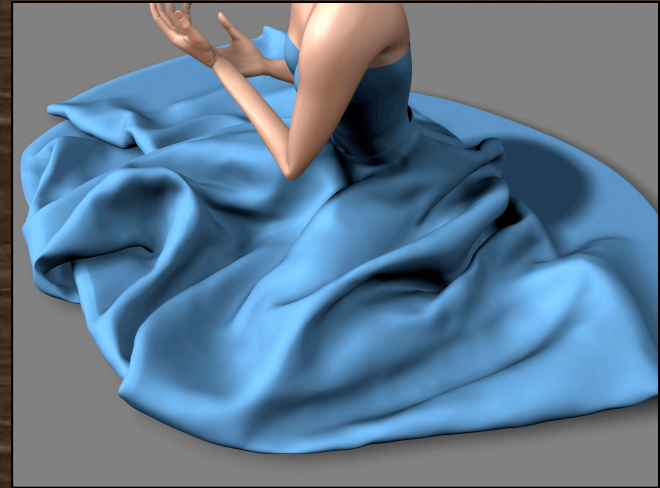
# Multithreading

## Force and Stiffness Matrix Computation



# Future Considerations

- Damping Forces
- Collision Detection  
[Bridson et al. 2002]
- Code Optimizations



[Govindaraju et al. 2005]

# Special Thanks

- Professor Jernej Barbic
- Yuyu Xu & Zhiyang Wang
- REU
- Baraff & Witkin
- David Pritchard

# Computer Specs

- Pentium Mac Pro, 2x66 GHz Quad Core
- Intel Xeon Dual Processor: 16 GB RAM