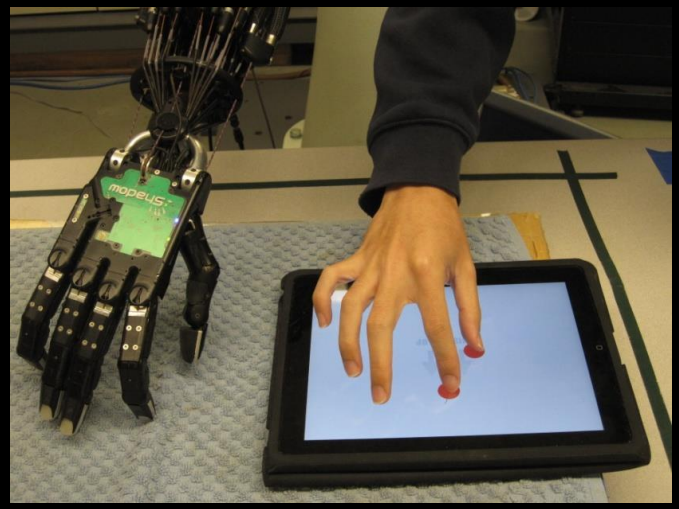


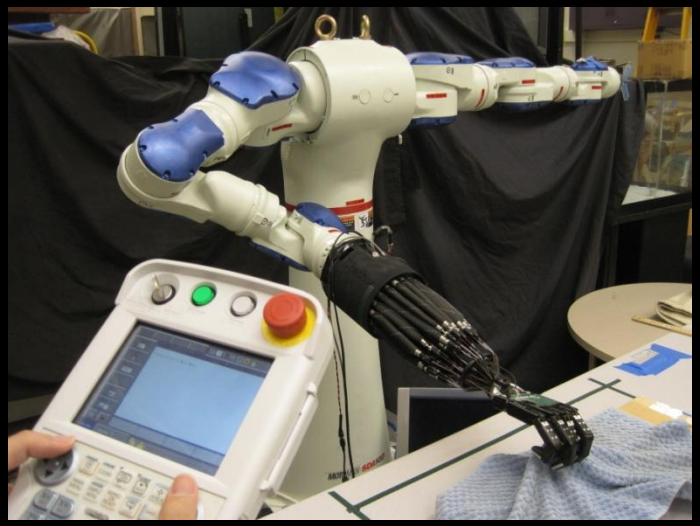
Sticky Finger Manipulation With a Multi-Touch Interface

Ken Toh MS Thesis

Motivation

- User interaction is a key feature in most graphical and robotic applications.

Manipulating virtual cloth



Teleoperating a robot with a multi-fingered hand

Motivation

- Traditional User Input Devices are effective for many simple high-level interaction tasks..

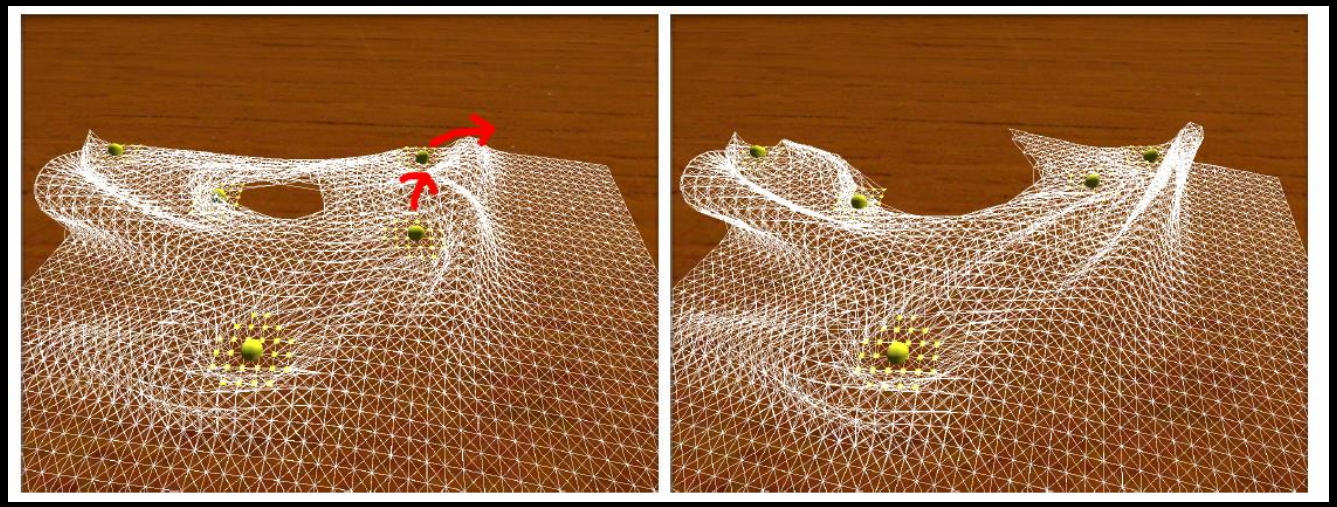
On/off

Up, down, left, right

Common user input devices with simple command spaces

Motivation

- *Dexterous manipulation* of simulated/real world objects with **high DOFs** can however be quite awkward to achieve with these existing input devices



Realistic cloth tearing requires more than a single cursor to execute

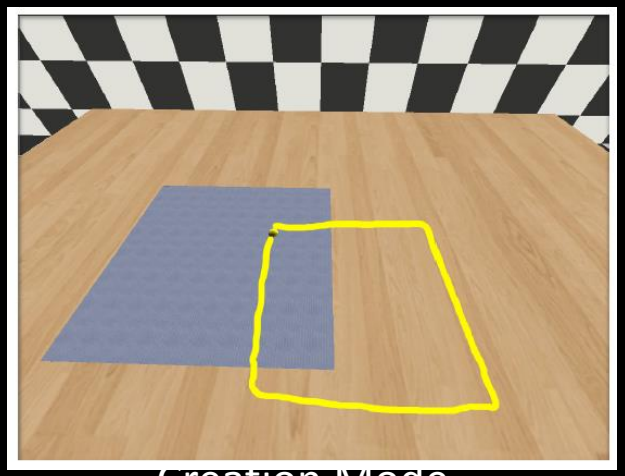
A panel of buttons is not the most intuitive interface for dexterous tele-manipulation

Motivation

- **Key Question:**

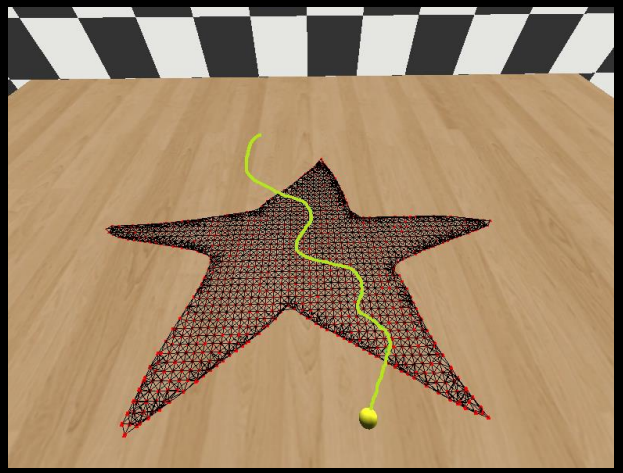
  Can we design an *intuitive* user interface that allows us to feel natural when manipulating objects by proxy, almost as though we are interacting with them directly?

Cloth Manipulation: Modes



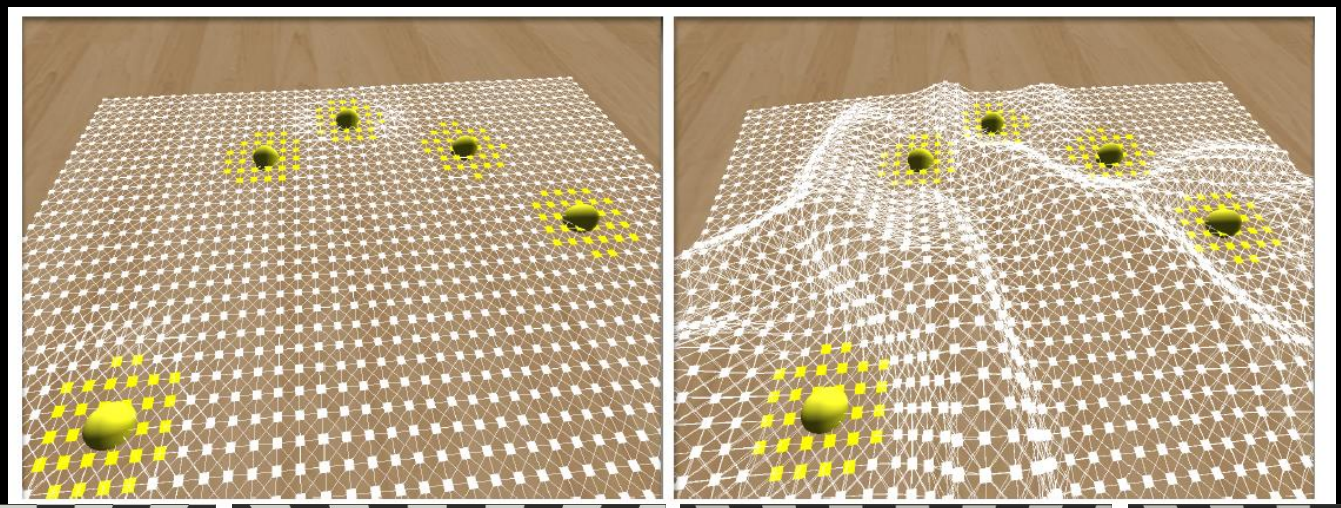
Creation Mode

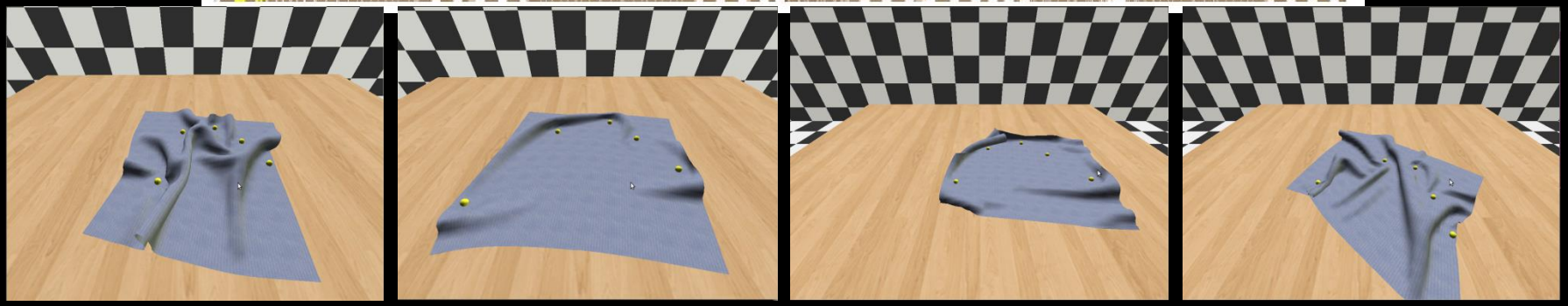
Sticky-Finger Mode



Cut Mode

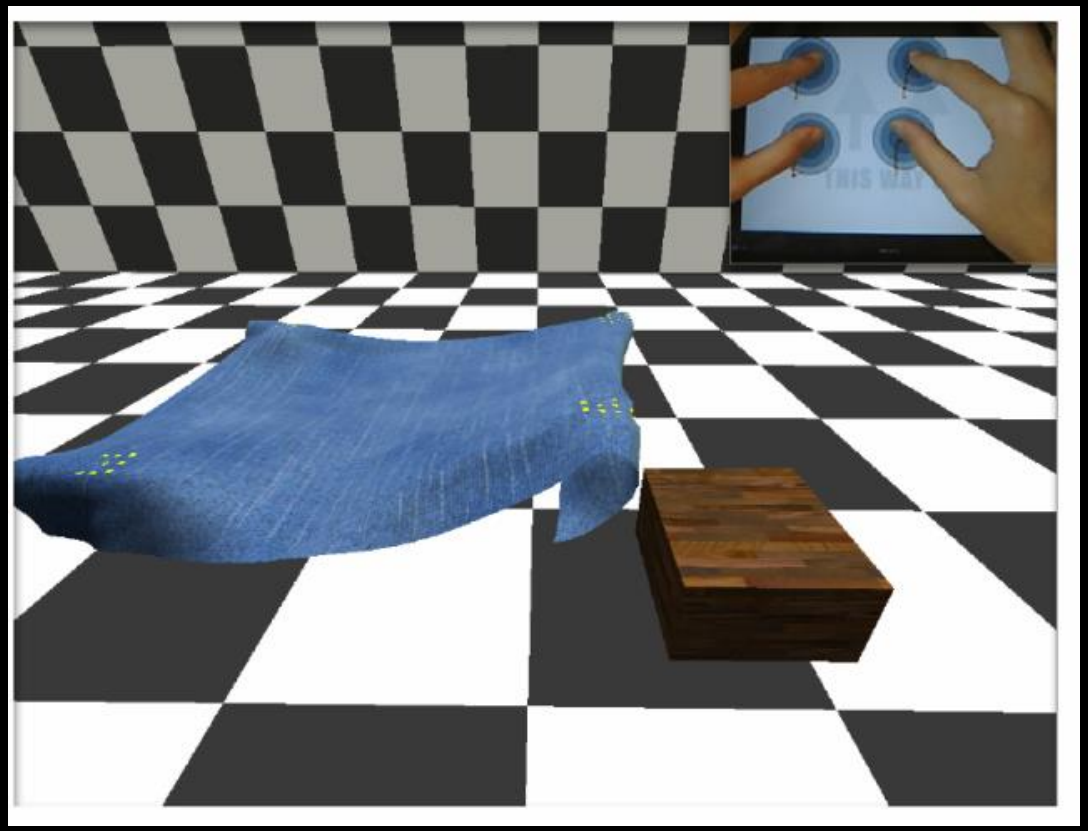
Sticky Fingers for Cloth Manipulation





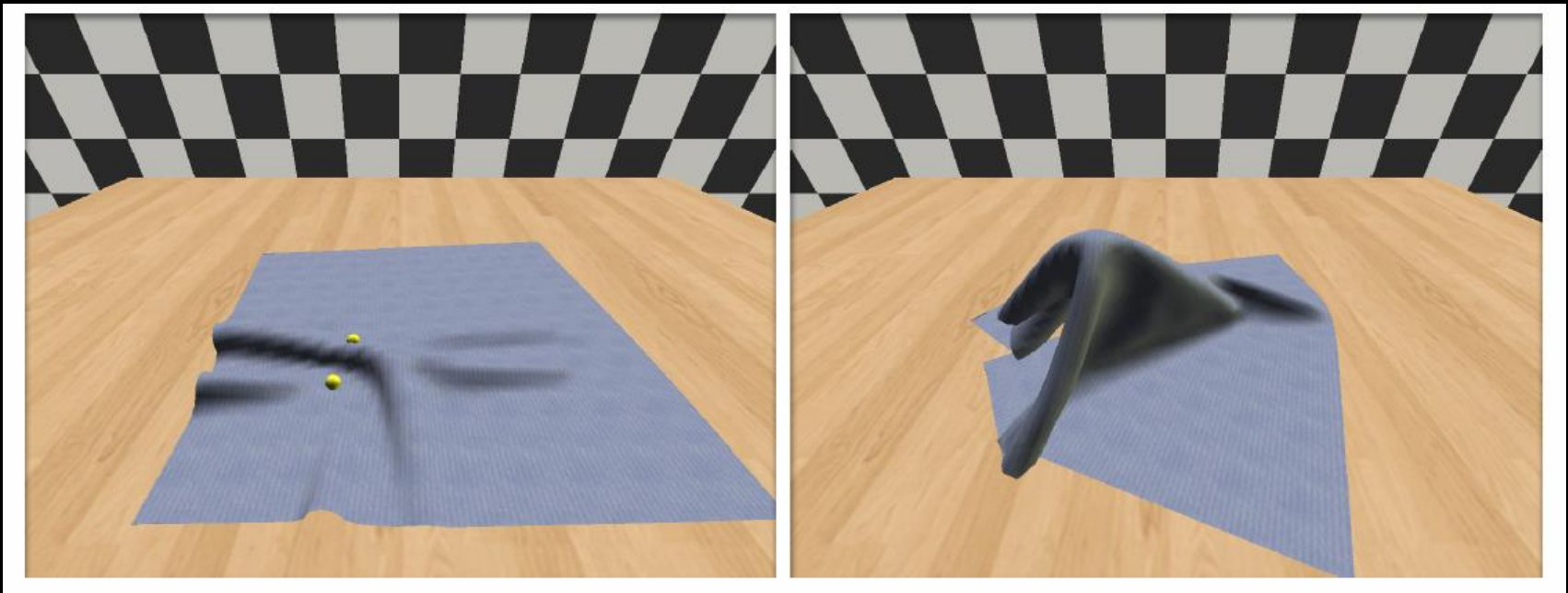
Underlying cloth particles within radius of each active fingertip center are stuck to that finger and moves with it

Sticky-finger Lifting



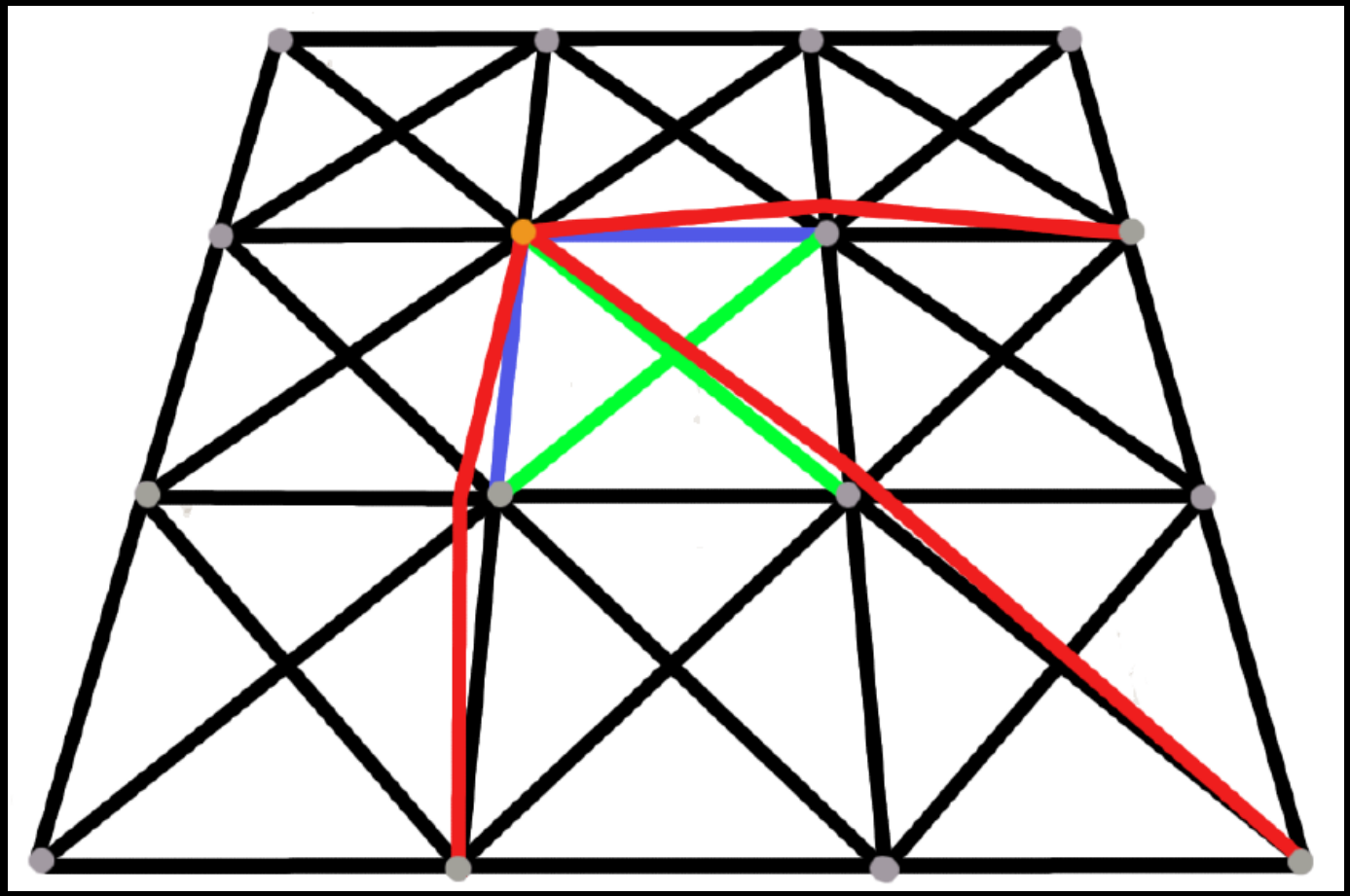
- User activates toggle which changes the plane of control from the **x-z** plane to **x-y** plane.

Pinch-lifting



- Automatic detection of pinch event when two finger touches are close together.

Cloth Simulation Model



A mesh of particles connected by bend, shear and stretch constraints

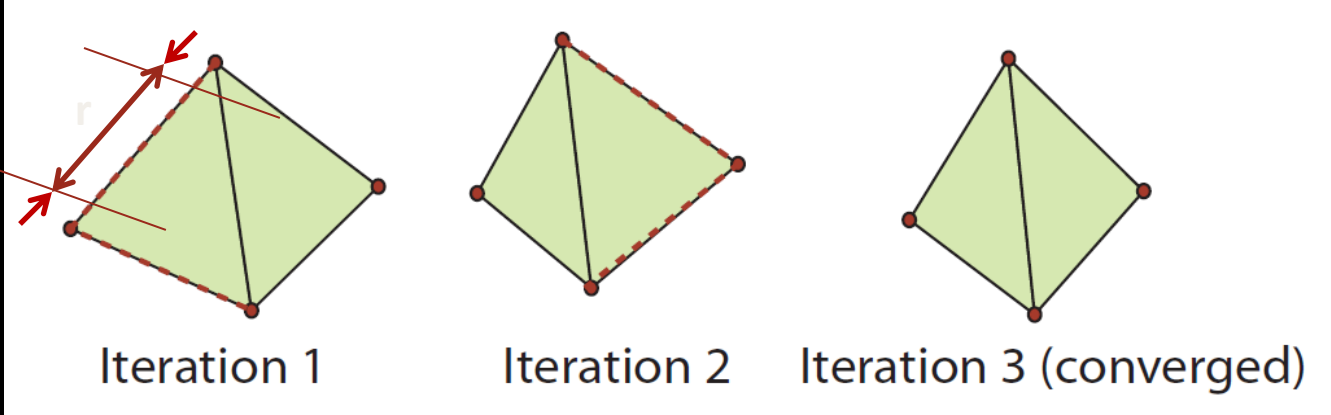
Verlet Integration

- **Key:** Position-based dynamics essential because we need to stick particles kinematically to fingers (ie. modify positions directly)

$$\mathbf{x}_{new} = 2\mathbf{x}_{cur} - \mathbf{x}_{old} + \mathbf{a}\Delta t^2$$

$$\mathbf{x}_{old} = \mathbf{x}_{cur}$$

Iterative Constraint Satisfaction



- Must handle cases with stuck fingers

$$\Delta \mathbf{x}_2 = -\Delta \mathbf{x}_1$$

Correction vector

$$\Delta \mathbf{x}_1 = \frac{1}{2}\left(|\mathbf{x}_2 - \mathbf{x}_1| - r\right)\frac{\mathbf{x}_2 - \mathbf{x}_1}{|\mathbf{x}_2 - \mathbf{x}_1|}$$

Case (a): $\mathbf{x}_1$ and $\mathbf{x}_2$ not stuck

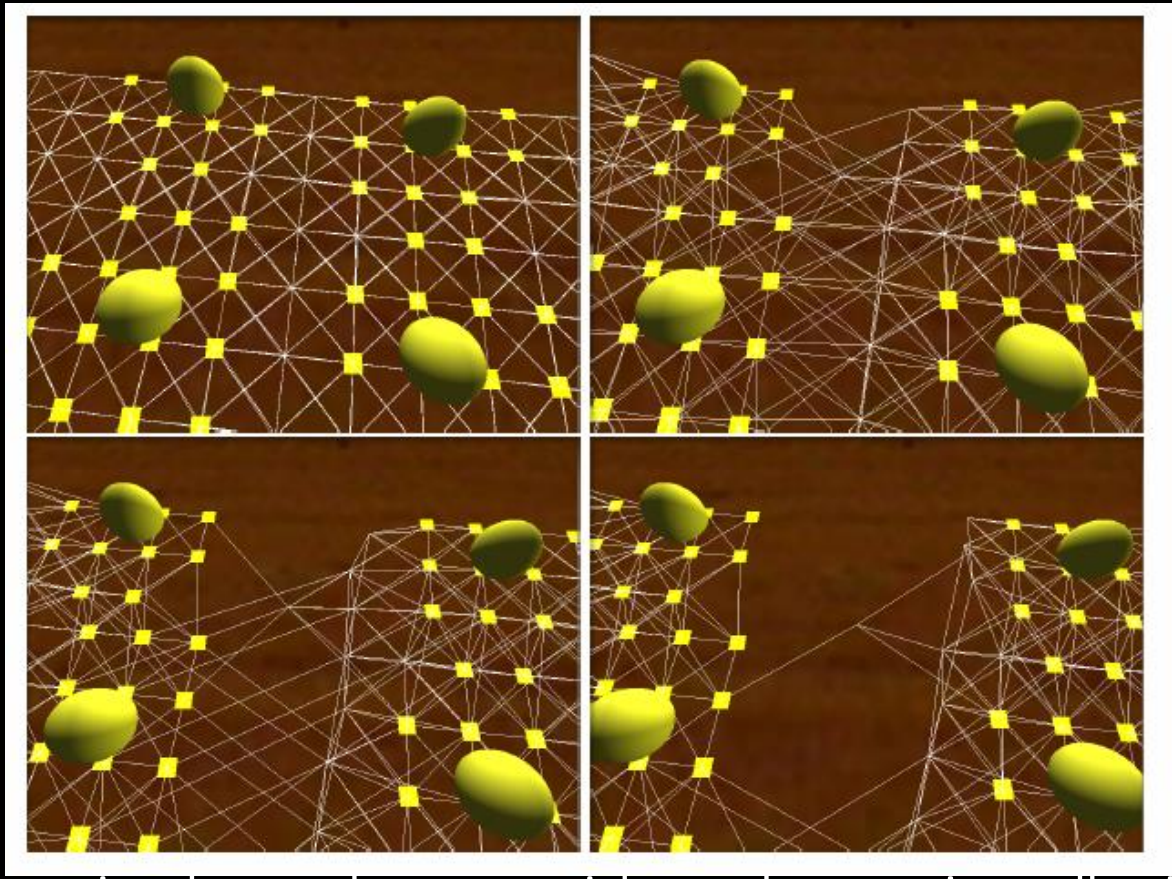
$$\Delta \mathbf{x}_1 = 0$$

$$\Delta \mathbf{x}_2 = -\left(|\mathbf{x}_2 - \mathbf{x}_1| - r\right)\frac{\mathbf{x}_2 - \mathbf{x}_1}{|\mathbf{x}_2 - \mathbf{x}_1|}$$

Case (b): $\mathbf{x}_1$ stuck, $\mathbf{x}_2$ not stuck

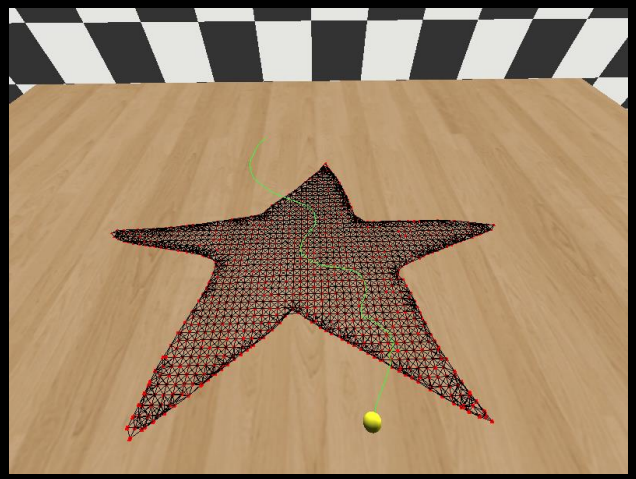
Case (c): if both are stuck, both = 0

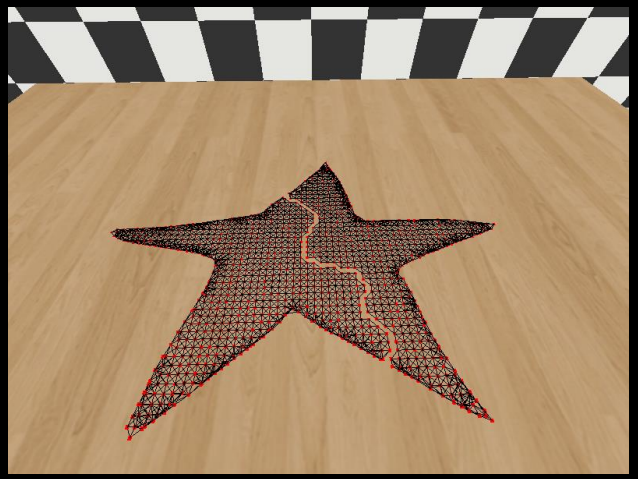
Tearing

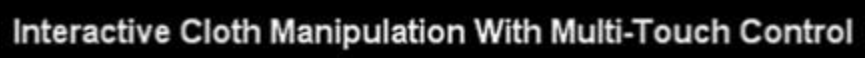


- Sticky finger pins down relevant particles and constraints, allowing unconstrained regions to elongate and eventually tear. Finger size matters too.

Cutting





Similar to tearing but in a more controlled fashion

Direct Cloth Manipulation