FRIEDRICH-ALEXANDER
UNIVERSITÄT
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FACULTY OF ENGINEERING

Computeranimation

Lesson 5 – Mass-Spring-Networks

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Motivation

Topics

- Rigid Transformation
- Animation
- Collision
- Dynamic
- **Mass-Spring Simulation**
- Rigging and Skeletal Animation

Introduction

Mass-Spring-Systems

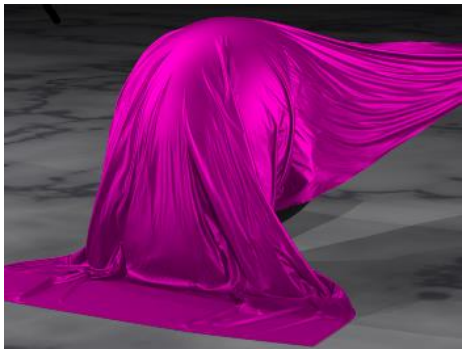
Mass-Spring-Networks

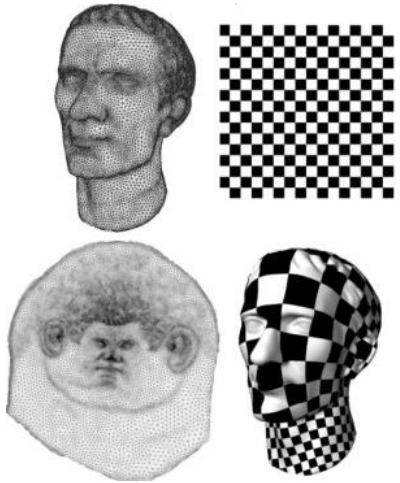
Application

Introduction

Basic Setup

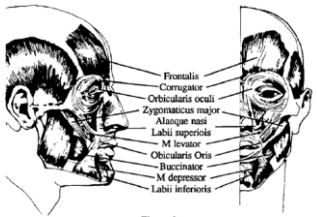
- Mass Spring Systems (MSS) can be used to represent e.g. soft deformable objects
- Most ***Cloth Simulation*** Systems are originated from MSS
- Similar applications can be found in ***parameterization***

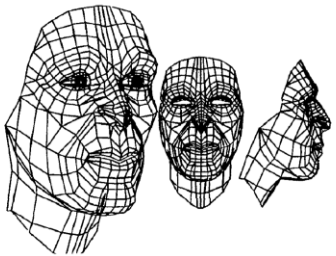




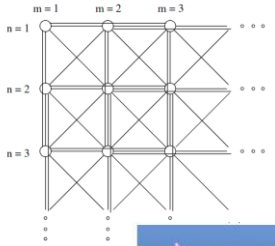
Introduction

A Brief History of Cloth Simulation





[Keith Waters87]



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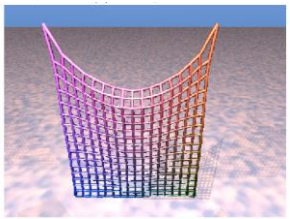
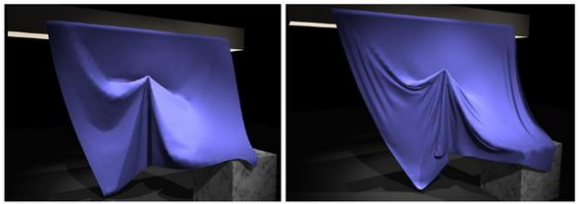


[Mueller07]



[Tyson13]

Introduction

Mass-Spring-Systems

Mass-Spring-Networks

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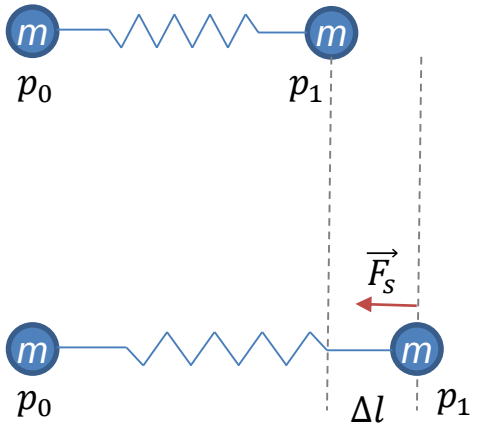
Mass-Spring-Systems

Basic Setup

- To simulate cloth we define a System consisting of
  - Particles with a mass m
  - A spring connecting the particles with stiffness coefficient k and rest length l_0

- When a Spring is elongated it induces a Force $\overrightarrow{F_s}$

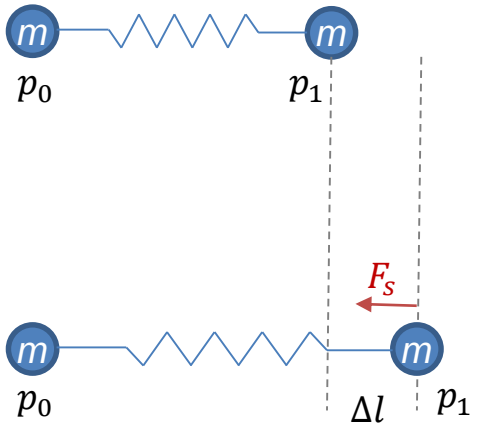


Mass-Spring-Systems

Hooke‘s Law

- The Force induced by a streched spring…
  - acts in the direction to force the spring in the rest state
  - depends *linearly* on the amount of stretch and the spring stiffness coefficient

$$\overrightarrow{F_s} = \frac{(\overrightarrow{p_1} - \overrightarrow{p_0})}{\|\overrightarrow{p_1} - \overrightarrow{p_0}\|} k \cdot \Delta l$$



Introduction

Mass-Spring-Systems

Mass-Spring-Networks

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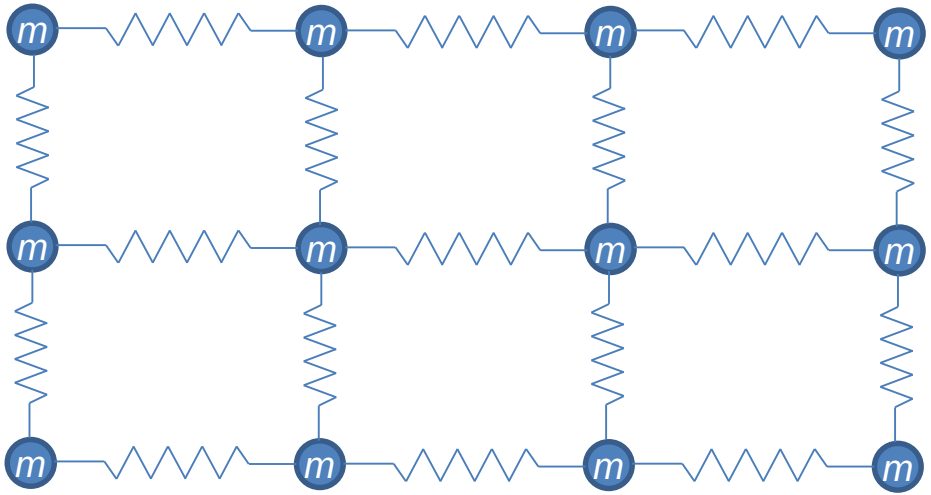
Mass-Spring-Networks

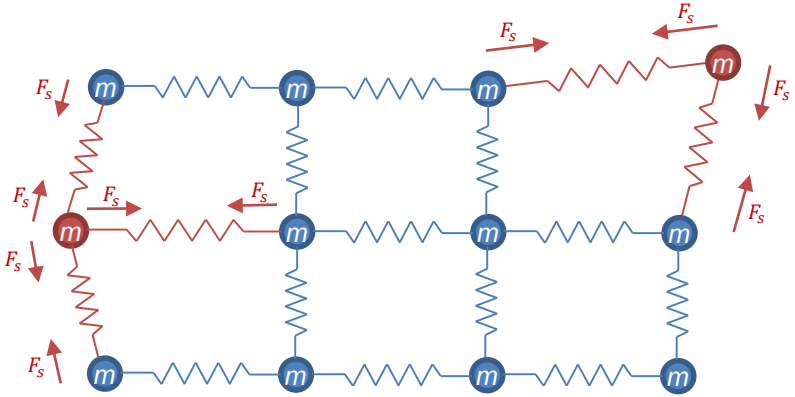
Basic Setup

- To simulate a deformable surface, a network of mass particles and springs is created



Mass-Spring-Networks

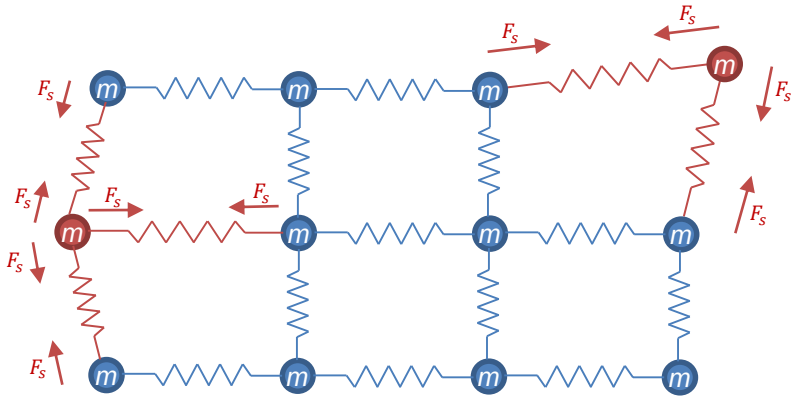
Over-Elongated Springs



Mass-Spring-Networks

Simulation

- For each Particle the sum of spring Forces are added to $\overrightarrow{F_{ext}}$
- Subsequential the integration is done as known:



Linear

$$\mathrm{F}_{\mathrm{ext}}(t) = \sum_i F_i(t)$$

$$p(t + \Delta t) = p(t) + \Delta t \cdot F_{ext}(t)$$

$$v(t + \Delta t) = \frac{p(t + \Delta t)}{m}$$

$$x(t + \Delta t) = x(t) + \Delta t \cdot v(t + \Delta t)$$

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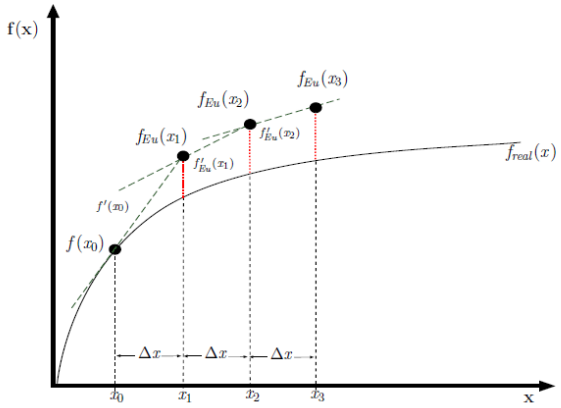
Mass Spring System

A note on stability

- The integration scheme depends on the time-step Δt
- This causes an error in the system which highly suffer, if the system is able to oscillate
- Cloth simulations are highly unstable against high time steps



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