Soft body physics and fracture generation

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What is a soft body?

What is not a soft body

- Rigid body
- Fluid
- Particle system

Soft body properties

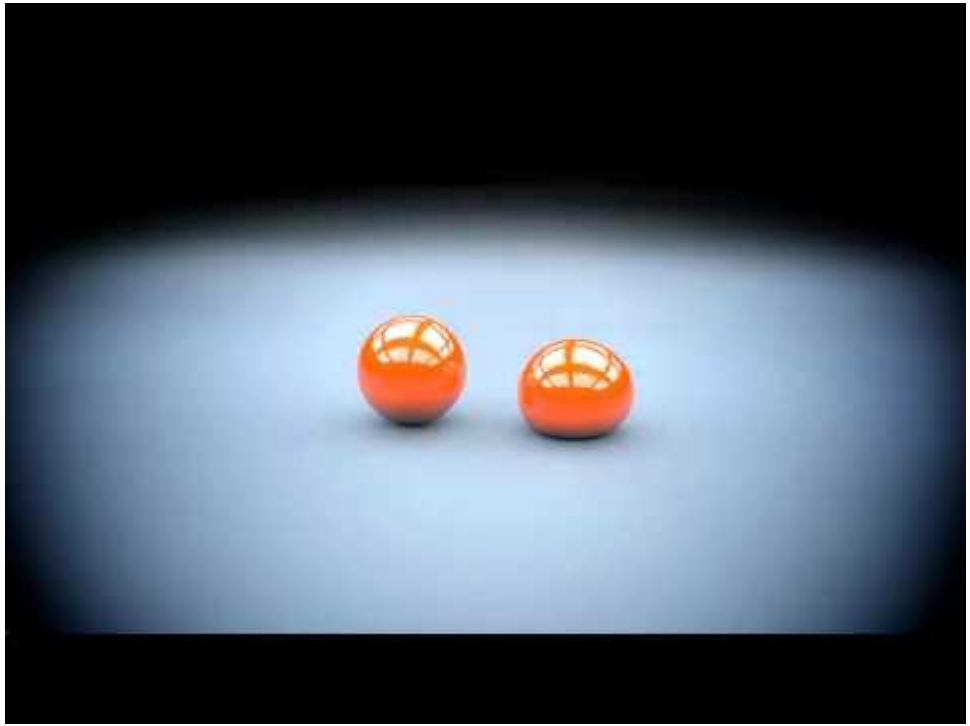
- Deformable
- Retains original shape
- Expensive to compute!

Types of soft bodies

- Rope (1D)
- Cloth (2D)
- Object (3D)

Examples

Example



So... How do they work?

- Dark Magic
- Sacrifices of innocent souls
- <Insert mom joke here>
- Mathematician tears

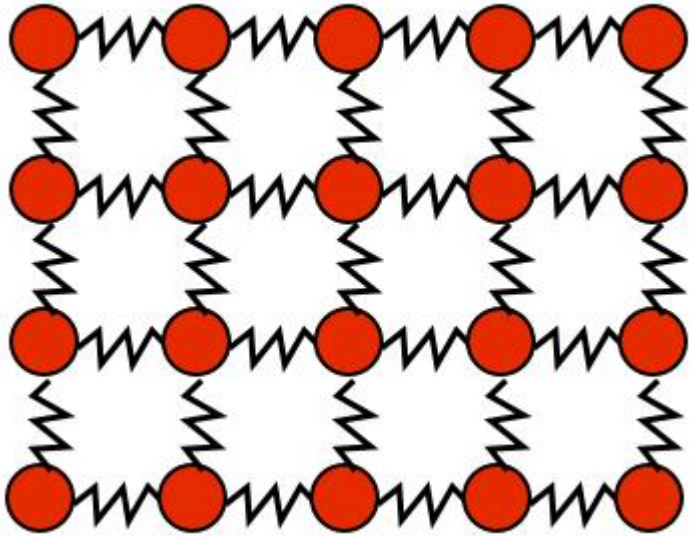
Models

- Spring-mass model
- Finite element simulation
- Shape matching
- .. apparently many others.

Whatever model works on principle

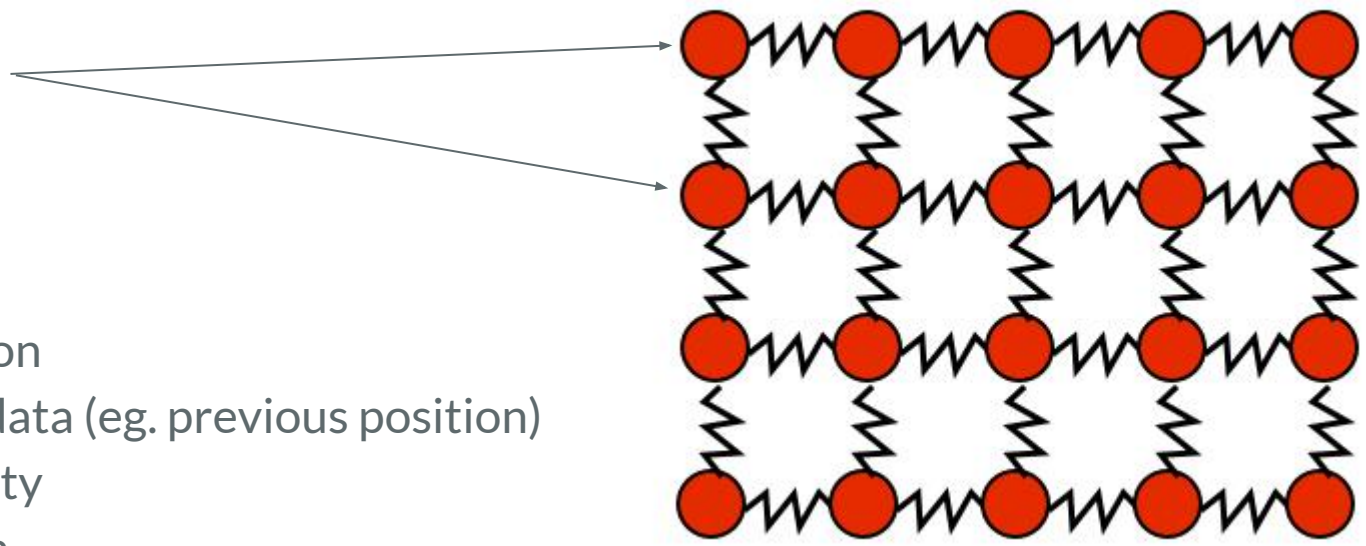
- A set of constraints- a equation system for each point
- A solver that iterates until constraints are satisfied
- A lot of parameters
  - For material
  - For solver

Lets focus on spring/mass model



Lets focus on spring/mass model

Point

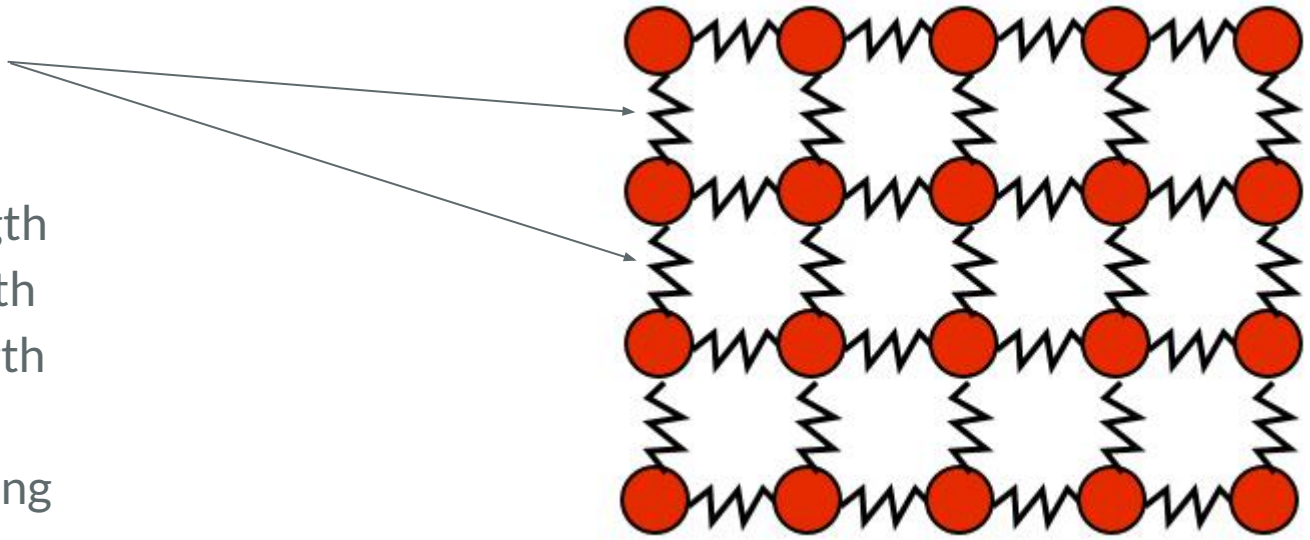


- Mass
- Position
- Metadata (eg. previous position)
- Velocity
- Inertia
- Angular Velocity
- ...and much more

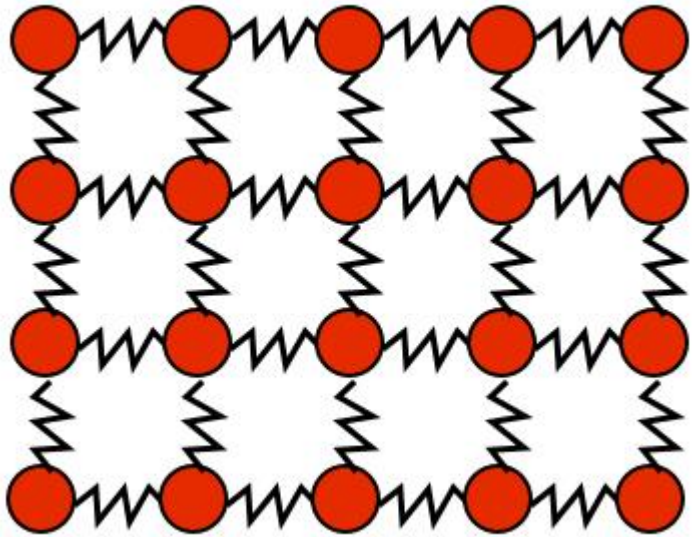
Lets focus on spring/mass model

Spring

- Rest length
- Min length
- Max length
- Force
- Dampening
- Stiffness



Lets focus on spring/mass model



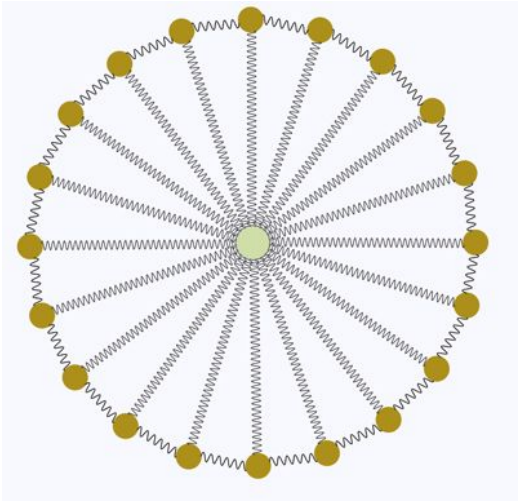
Example 1

Example 2

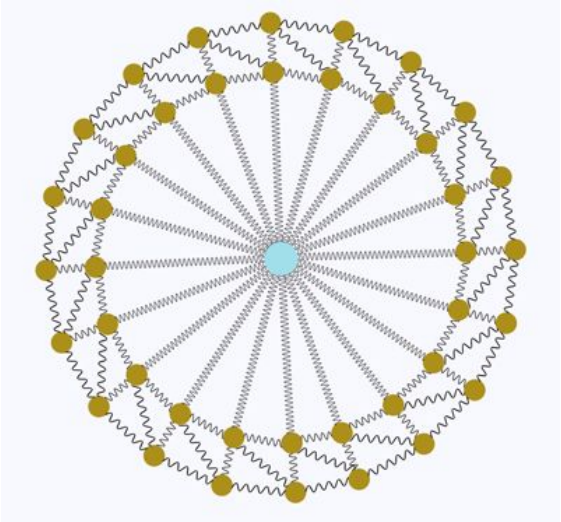
Example 3

Spring/Mass model issues

- How do you structure the object?

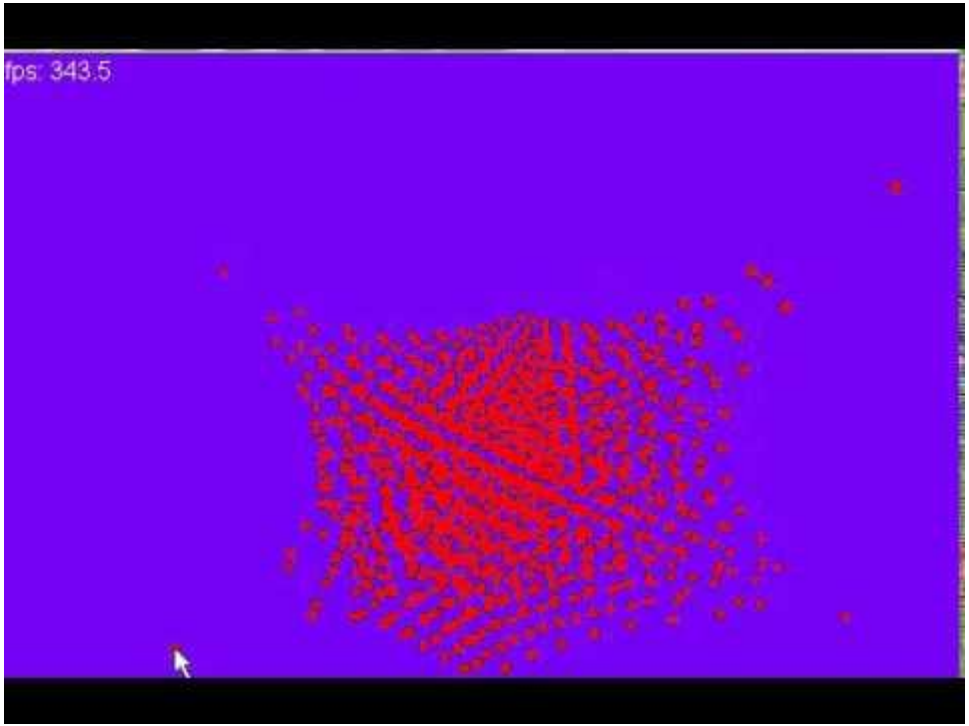


VS



- Issues with collision detection

Example of exhaustive approach



Achiements

Nvidia Flex

Fracture generation

Fracturing models

- Premade fractured model
- Fracture mapping
- Real-time fracture generation
  - Scientifically plausible
  - Rough approximation

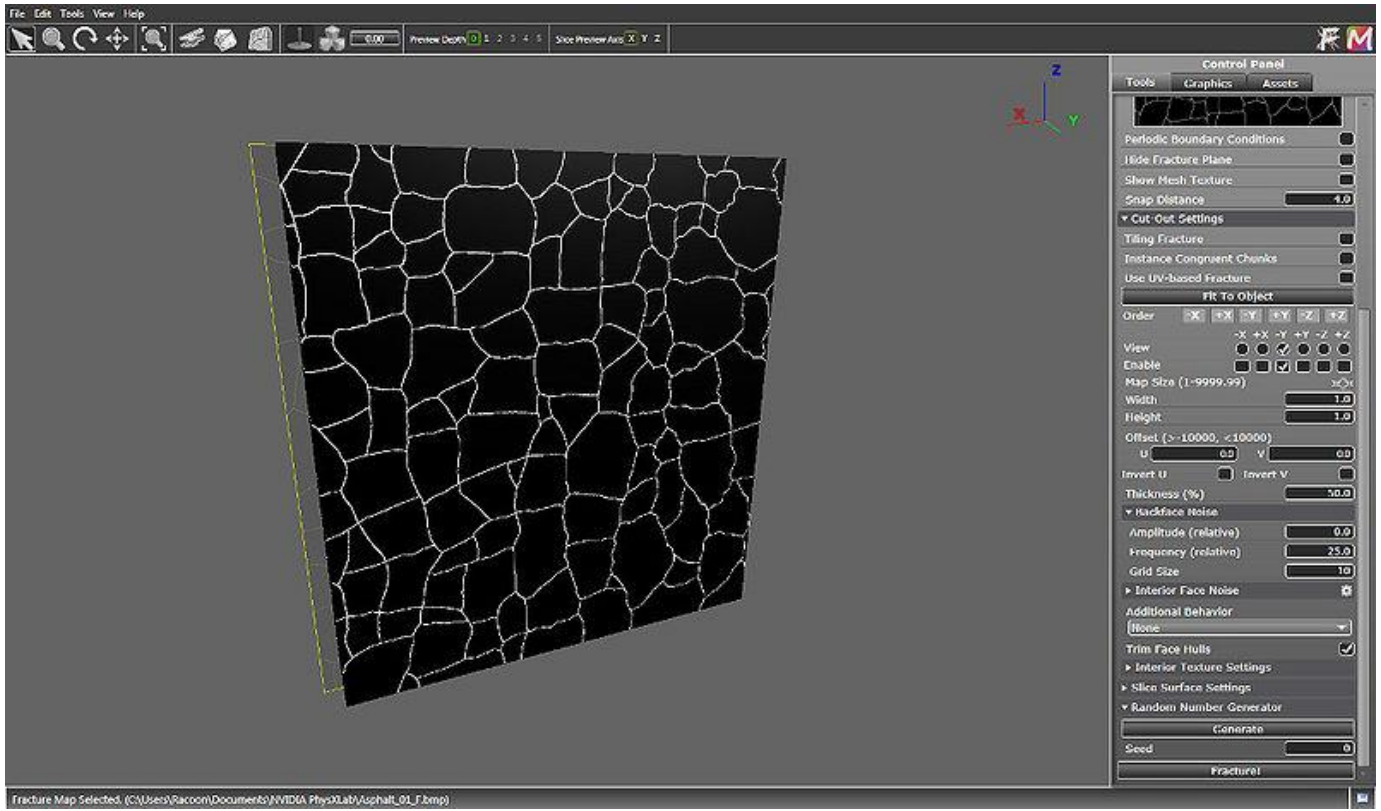
Premade fractured model

- Object comes as a collection of fractured pieces
- Pieces are glued together
- More mesh for graphics component to handle
- Less data needed for physics simulation
- Either ignore or take take into account point of impact

Fracture mapping

- Model comes with a fracture mapping
- Upon impact, fracture mapping is used to decompose object
- Most commonly used
  - Blender
  - Apex library
  - Unity

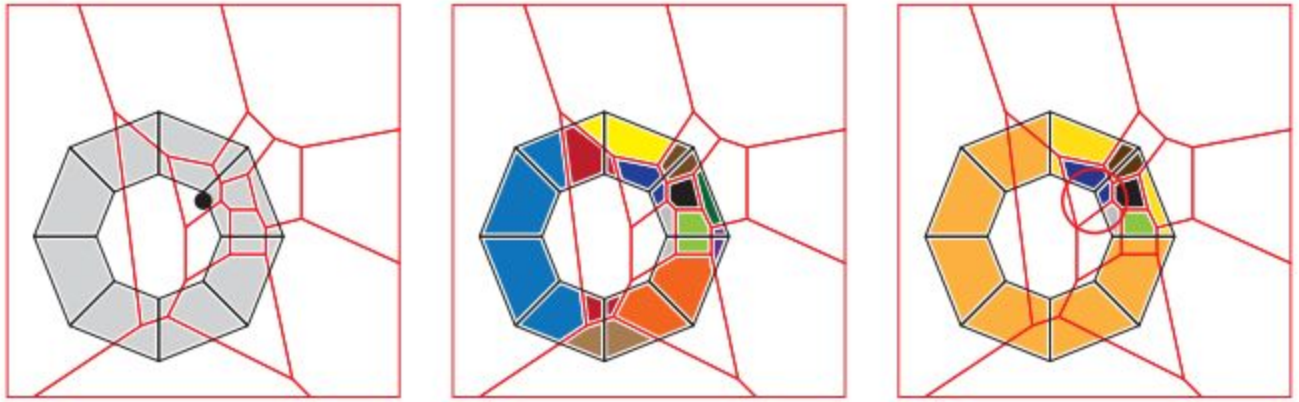
Fracture mapping



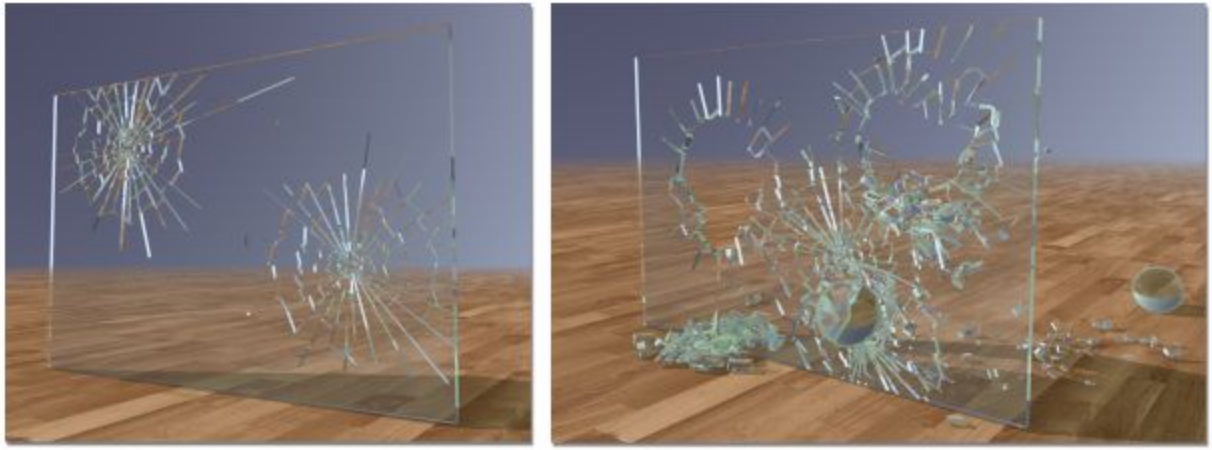
Real time fracture generation

- Ignoring point of impact vs taking it into account
- Some algorithm is used to iteratively generate fractures
- Most computationally expensive

Real time fracture generation: Voronoi

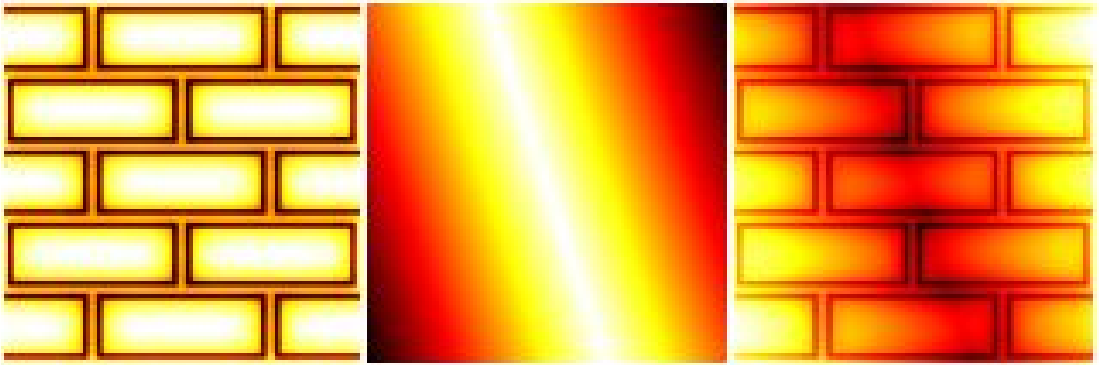


Another example



Real time fracture refinement

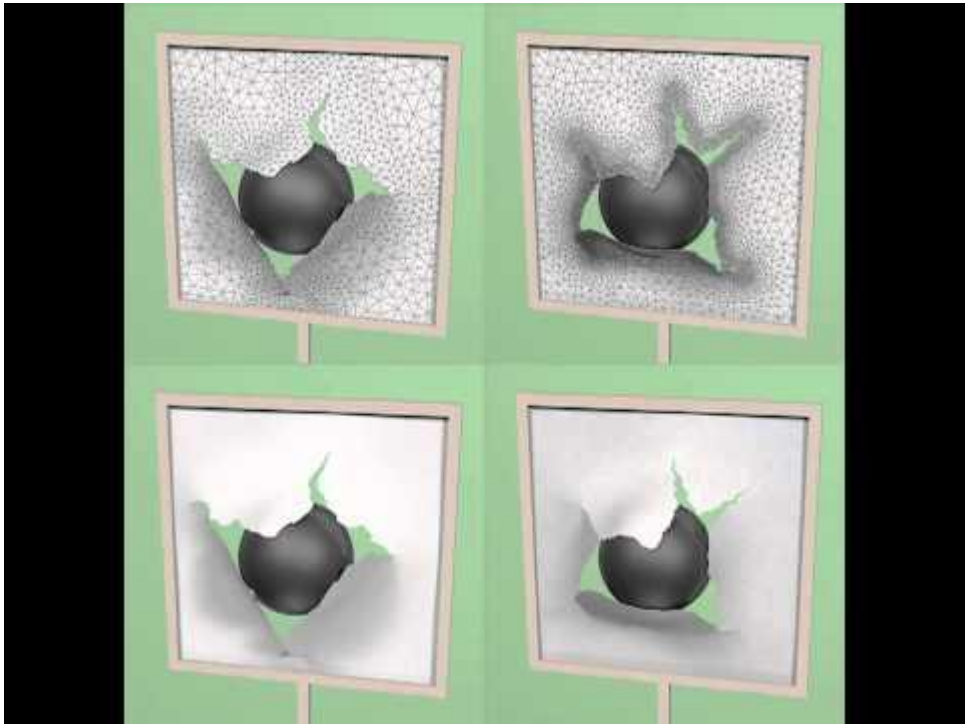
Real time fracture refinement



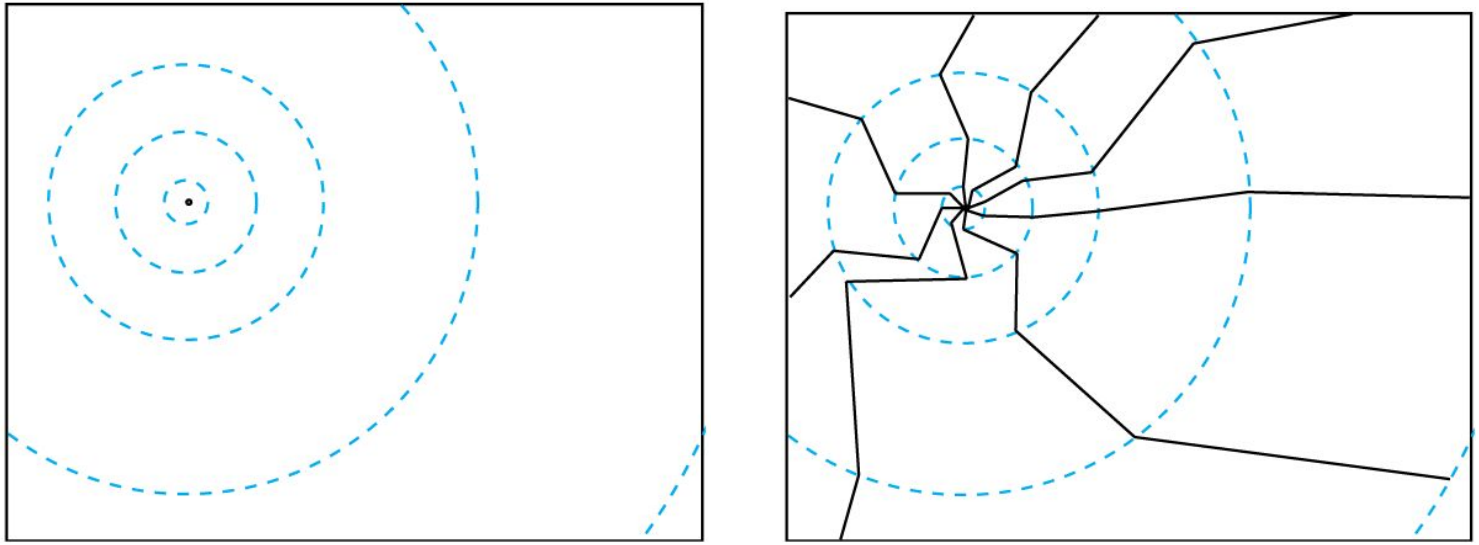
(a) Strength Field (b) Stress Field (c) Modified Strg. Field

Figure 4: *Modified material strength field. By subtracting an estimated stress field in (b) from a procedurally generated strength field in (a), we generate a modified material strength field in (c) to model the fractures of a collapsing brick wall.*

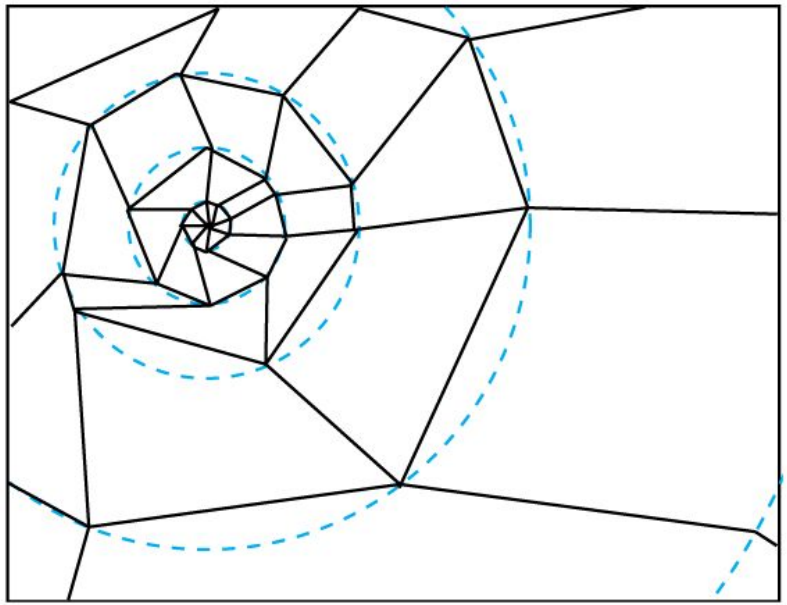
A cool approach

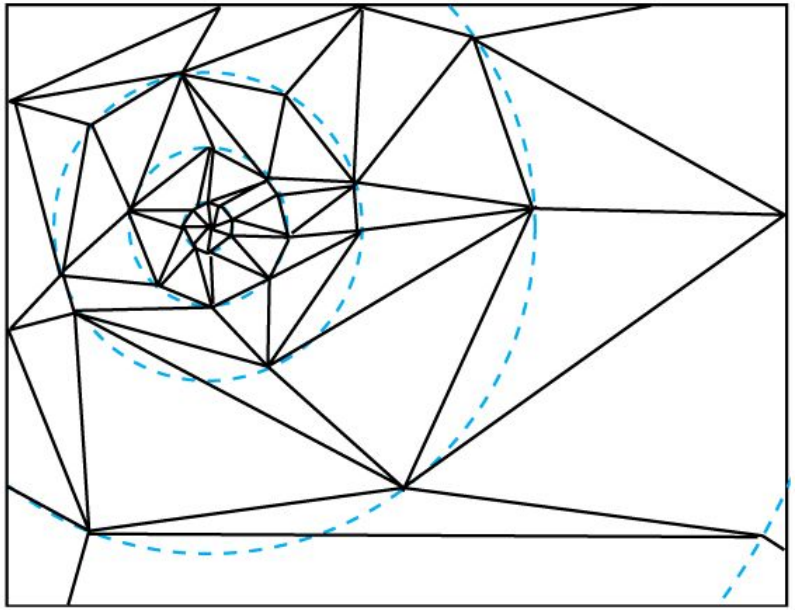


Another cool approach

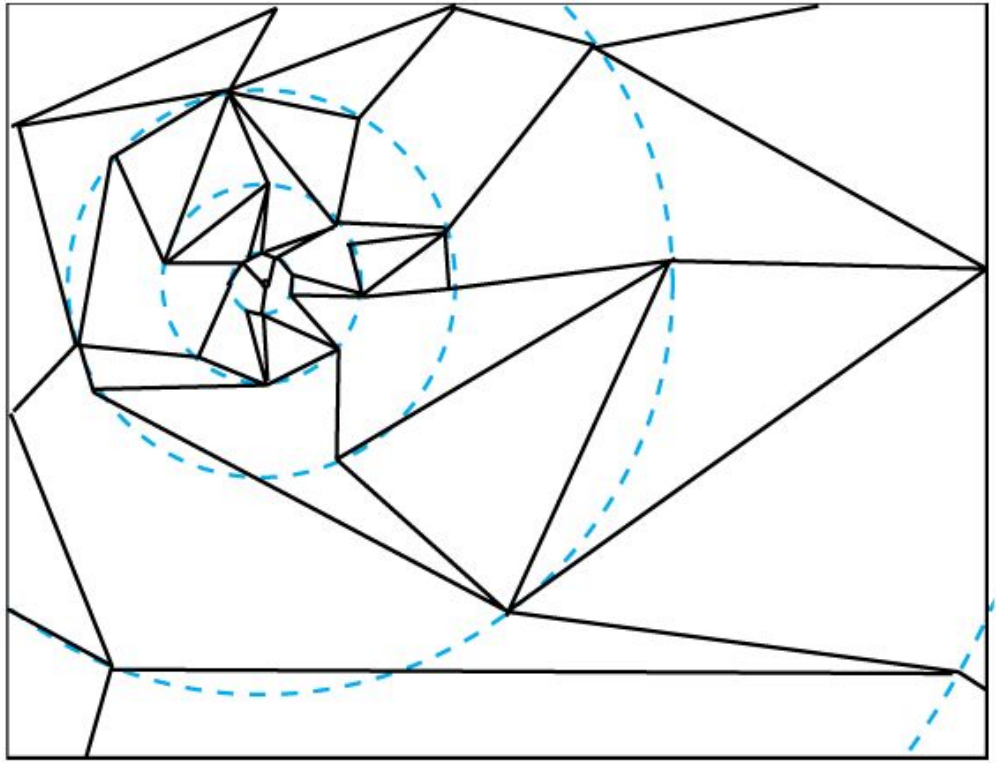


Another cool approach (2)





Another cool approach: Result



Boiling it down

- Detect impact
- Figure out how to fracture (mapping or some algorithm)
- Use fractures to split mesh into parts
- Add the parts to the scene
- Calculate velocities, inertia, mass etc.
- Do it in a single render cycle or several.

Cluster Trucks

Discussion