CS 888: Recent Advances in Computer Graphics and User Interfaces

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- Workload

- Course topics

- How to give a talk

http://www.cgl.uwaterloo.ca/~smann/cs888-f03/

Workload

- Read papers
- Attend class (10%)
- Participate in discussions (10%)
- Give a talk (40%: 30,35,40)
- Project (written, implementation) (40%)

Audit credit: All but project

Analysis, not Recitation

Don't want reproduction of paper

- Talk: main idea, what was good, what was bad, how important, how to improve

  Not just their comments

  Let me know URL or give me hard copy 10 days before your talk

  Announce paper in class 1 week before your talk

- Project: research proposal, implementation, or research

Course topics

Recent papers in CG, HCI

- SIGGRAPH 2003 Conference Proceedings
- Graphics Interfaces 2003 Conference Proceedings
- ACM Transactions on Graphics, Volume 22 (2003)
- NPR 2002 Conference Proceedings
- EuroGraphics 2002 (2003) Conference Proceedings
- CHI 2003 Conference Proceedings

List not exclusive

Get okay from one of instructors

Sample BAD Talk

Simulating Fluid-Solid Interaction

Génevaux, Habibi, Dischler

GI 2003

- Previous work
- Liquid simulation
- Solid simulation
- Interfacing the two models
- Results

Previous Work (BAD TALK)

- Hand-crafted models — offloads the task of creating a convincing velocity field to an animator

- Physically based but not Navier-Stokes

  Able to exhibit realistic fluid beaviors without resorting to explicit description of motions

- Navier-Stokes models
  - Comprehensive fluid model
  - No restriction on properties of simulated fluid nor on motions
  - Expensive
  - Fluid/non-fluid boundaries (markers)

Liquid Simulation (BAD TALK)

- Navier-Stokes equations - 15-20 papers per week!

$$\frac{\partial \mathbf{u}}{\partial t} = -(\mathbf{u} \cdot \nabla)\mathbf{u} - \frac{1}{\rho}\nabla p + \nu \nabla^2 \mathbf{u} + \mathbf{F} \tag{1}$$

$$\nabla \cdot \mathbf{u} = 0 \tag{2}$$

  where ρ is fluid density, ν is viscosity, $\mathbf{u}$ is the velocity field, p is the pressure field, $\mathbf{F}$ is external forces.

- (1) expresses momentum conservation

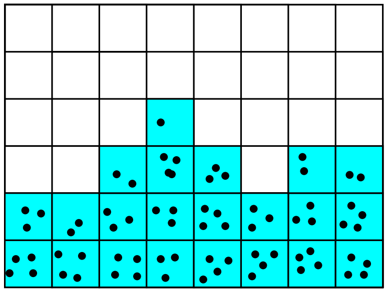
  (2) states that the liquid is incompressible

- Use equations to drive simulator

  Two problems:
  - Simulator must cope with liquid that does not fill space
  - 3D motions of liquid means we can't use height field

Markers and Cells (BAD TALK)

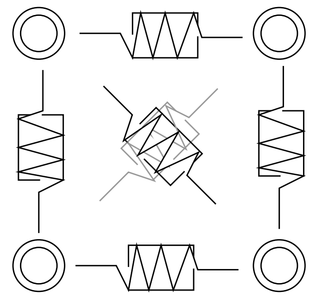
- Simulator must cope with liquid that does not fill space
- Make 3D grid, put markers in cells with liquid



- Use Navier-Stokes to update markers
  - Convection term handled by semi-lagrangian integration
  - Viscous term solved using direction differentiation
  - External force term handled by simple Euler integration
  - Mass conservation enforced by projection step inside target dirvergence free space
- Liquid visualization using Marching Cubes to extract surface

Solid Simulation (BAD TALK)

- Linked, viscous spring-mass model



- Intensity of force: $f = -k_{coh} \cdot (|\mathbf{x}_i - \mathbf{x}_j|) - z_{coh} \cdot \frac{d}{dt}|\mathbf{x}_i - \mathbf{x}_j|$.

- Force aligned with direction implied by two positions:

$$F = f \cdot \frac{\mathbf{x}_i - \mathbf{x}_j}{|\mathbf{x}_i - \mathbf{x}_j|}$$

- Update over time (independently) with Newton's second law:

$$\mathbf{x} = \frac{1}{m} \int \int \sum_i F_i dt^2$$

Interfacing models (BAD TALK)

- Want to interface liquid, solid model

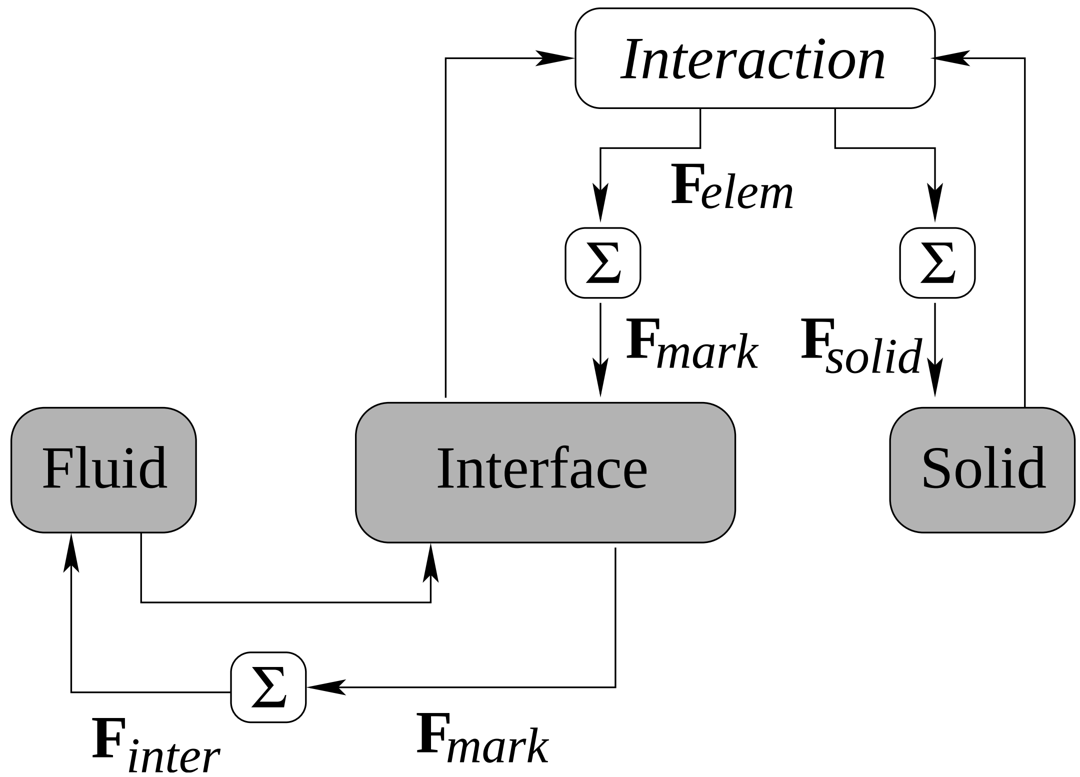
  Lagrangian, Eulerian

- Idea is to build Langrangian description of Eulerian model

- Liquid markers form the interface
  - No new entity is introduced in model, reducing complexity
  - Markers easily yet precisely determine where fluid is located
  - Trivial to define a restricted interface

- Interface has 3 logical components:
  - The eulerian Navier-Stokes based simulator
  - The lagrangian spring-mass solid's simulator
  - The interface that must be able to flow data between them

Coupling Scheme Overview (BAD TALK)



Final scheme is assymetric at a coarse level

- Connection between Interface and Solid Model is symmetric
- Connection between Interface and Fluid Model is assymetric

Interface / Solids Relationship (BAD TALK)

- Relationship between the interface and the solid's is handled by the use of a force exerted between each marker i of the interface and each nodal mass j of the solid.

- Elementary force f_{elem} is visco-elastic, but of limited influence:

$$\bar{f}_{elem_{ij}} = -k_{int} \cdot (|\mathbf{x}_i - \mathbf{x}_j| - d_{int}) - z_{int} \cdot \frac{d}{dt}|\mathbf{x}_i - \mathbf{x}_j|,$$

$$f_{elem_{ij}} = \begin{cases} \bar{f}_{elem_{ij}} & \text{if } |\mathbf{x}_i - \mathbf{x}_j| \leq R \\ 0 & \text{if } |\mathbf{x}_i - \mathbf{x}_j| > R \end{cases}$$

  This way, solid's are naturally affected by the nearby interface, but objects are only affected by closely located liquid motions.

- Complete interaction force for each node and marker computed as

$$F_{solid} = \sum_j F_{elem_{ij}} \qquad F_{marker} = \sum_i F_{elem_{ij}}$$

Interface / Fluid's Relationship (BAD TALK)

- Solid interacts with Fluid via $\mathbf{F}$ term of Navier-Stokes equation. However, the interaction is spatially dependent, so the last term should be updated to $\mathbf{F}(x)$.

- Forces generated in Solid interface are stored in marker nodes, and summed on a per computational grid basis, inside each cell C:

$$\bar{\mathbf{F}}_{inter}(C) = \sum_{i \in C} F_{mark}$$

- Partially filled cells to not require special handling

- Once per-cell forces computed, can compute actual force:

$$\mathbf{F}_{inter}(\mathbf{x}_{(i,j,k)+\delta/2}) = \bar{\mathbf{F}}_{inter}(C_{i,j,k})/2 \cdot \delta + \bar{\mathbf{F}}_{inter}(C_{i,j,k} + \delta)/2 \cdot \delta$$

where $\delta = [\delta_{0n}, \delta_{1n}, \delta_{2n}]$

Example (BAD TALK)

Figure 11 from paper

Red cube five times heavier than yellow cube.

How To Give a Talk

- Bad talks are easy to give

- General guidelines apply to any talk

- Good talks are easy to give

- What's expected in talks for this course

Outline

- Designing your talk
- Making your slides
- Giving your presentation

Know Your Audience

- General Audience
- General Technical Audience
- Technical Audience
- Specialist Audience

- Classroom Lecture

Present below the technical level of audience.

Know Your Time Constraints

How to shorten your talk:

- High level results
- Not everything
- Few details

For this class, focus on contribution

Questions

At the end, the audience should know

- What was the talk about?
- Why was this interesting?
- What was new or novel?

Designing Your Slides

- Don't put too many points on a slide
- You should put points, and not sentences or whole paragraphs. Each point should be a separate idea. And only put three to six on a slide.
- Visually simple, uncluttered
- Visually appealing style
- Good colour combinations
- Large fonts Don't use small fonts
- Prooff-reed and spel chek
- Avoid acronyms
  - unless well known (RCMP)
  - used throughout

    Binary Space Partitioning Trees (BSP Trees)
- Use graphs, charts, and diagrams

Visual Simplicity

- Don't put too many points on a slide

- You should put points, and not sentences or whole paragraphs. Each point should be a separate idea. And only put three to six on a slide.

- Visually simple, uncluttered

Visually Appealing

- Visually appealing style, but not distracting
- Good colour combinations
- Large fonts

  Don't use small fonts

Little Things

- Proof-read and spell check

- Avoid acronyms
  - unless well known (RCMP)
  - used throughout
    Binary Space Partitioning Trees (BSP Trees)

- Use graphs, charts, figures, and pretty pictures

Equations

- Avoid equations
- Simple equations okay ($Ax = B$)
- For complex equations, say
  - What they mean
  - Why they are interesting
- **Illustrate each equation with a figure**

Equations

Two ways to overwhelm:

- Inadequate explanation

$$
\begin{aligned}
L^o(x,\theta_x^o,\phi_x^o,\lambda^o) = {} & L^e(x,\theta_x^o,\phi_x^o,\lambda^o) + \\
& \int_0^{\pi/2}\int_0^{2\pi}\int_{\lambda_{\mathsf{min}}}^{\lambda_{\mathsf{max}}} \rho_{bd}(x,\theta_x^i,\phi_x^i,\lambda^i,\theta_x^o,\phi_x^o,\lambda^o) \\
& \cos(\theta_x^i) L^i(x,\theta_x^i,\phi_x^i,\lambda^i)\, d\lambda^i \sin(\theta_x^i)\, d\phi_x^i\, d\theta_x^i
\end{aligned}
$$

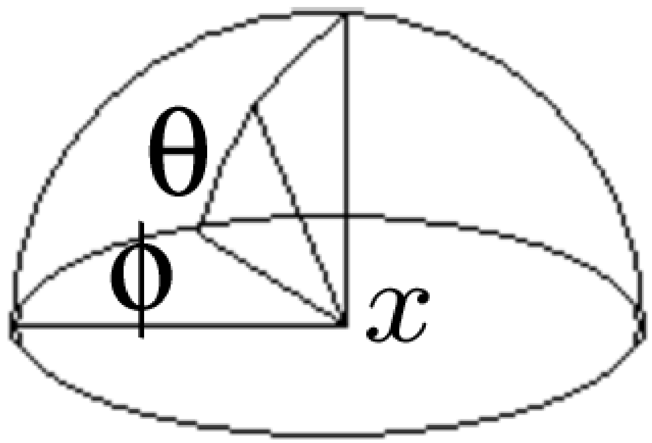
- A whole lot of equations

Equations

Two ways to overwhelm:

- Inadequate explanation

$$L^o(x,\theta_x^o,\phi_x^o,\lambda^o) = L^e(x,\theta_x^o,\phi_x^o,\lambda^o) + \int_0^{\pi/2}\int_0^{2\pi}\int_{\lambda_{\mathrm{min}}}^{\lambda_{\mathrm{max}}} \rho_{bd}(x,\theta_x^i,\phi_x^i,\lambda^i,\theta_x^o,\phi_x^o,\lambda^o) \cos(\theta_x^i)L^i(x,\theta_x^i,\phi_x^i,\lambda^i)d\lambda^i \sin(\theta_x^i)d\phi_x^i d\theta_x^i$$



- A whole lot of equations

Presentation Tips

- Stand near the projection screen

- Look at and talk to your audience

- Don't read your slides

- **Morgan McGuire:** "Geometric Algebra gives solutions to various physical situations on the level of elemental particles where general relativity breaks down or yields inconsistent results. Physicists hope that within a year experimental results will be able to confirm the theoretical findings. If this is indeed the case, Geometric Algebra may bring a new era of scientific discovery in addition to forming an interdisciplinary mathematical language. In short, Geometric Algebra will walk your dog, make you coffee in the morning, and is a desert topping and a floor wax."

Geometric Algebra

Morgan McGuire, on a SIGGRAPH Course in Geometric Algebra:

- Gives solutions to various physical situations where general relativity fails

- May bring new era of scientific discovery

- Interdisciplinary mathematical language

Geometric Algebra

Morgan McGuire, on a SIGGRAPH Course in Geometric Algebra:

- Gives solutions to various physical situations where general relativity fails

- May bring new era of scientific discovery

- Interdisciplinary mathematical language

...but also says...

> "In short, Geometric Algebra will walk your dog, make you coffee in the morning, and is a desert topping and a floor wax."

Presentation Tips

- Defer long questions to end

- Don't spend too much time on one slide
  + Split into two slides

- Put "throw away" slides near end

Practice

- Several times
- Out loud
- Until the words come naturally
- Until its the right length
- Before a live audience

Summary

- Design your talk
- Begin with overview and “flash”
- Good slide layout
- Practice your talk
- Summarize

  http://www.cgl.uwaterloo.ca/~smann/GSInfo/talk_guidelines.html

What We Expect From Your Talk

- NOT a recitation of the paper

  We can read, too!

- Brief summary of general idea

- Discussion of main contribution

  Good, bad, relation to previous work

- (Next step in research)

Ideally, stimulate discussion

Sample Talk

Simulating Fluid-Solid Interaction

Génevaux, Habibi, Dischler

GI 2003

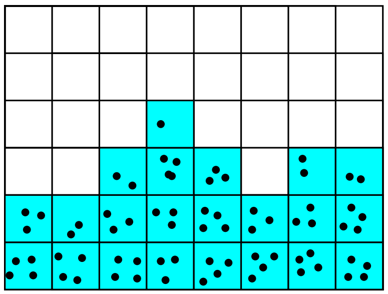
- Fluid-Solid Interaction
- Main Idea: Interfacing the two models
- Results
- Discussion

Overview

- Solids often simulated with spring-mass model (Lagrangian)
- Fluids often simulated by simulating Navier-Stokes (Eulerian)
- The paper looks at solids and fluids interacting
- Idea lifted from fluid mechanics

Fluid Simulation

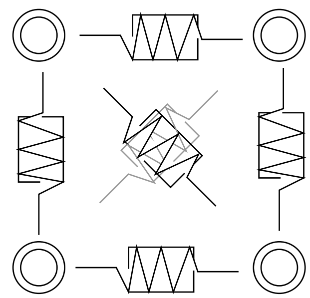
- Fluid simulator must allow "non-fluid" regions
- Fluid must be 3D
- Handle both issues using cells and markers



- Pressure and velocity evaluated on cells, markers moved as velocity dictates
- Navier-Stokes to handle fluid evolution

Solid Simulation

- Solids represented as set of masses, connected by springs

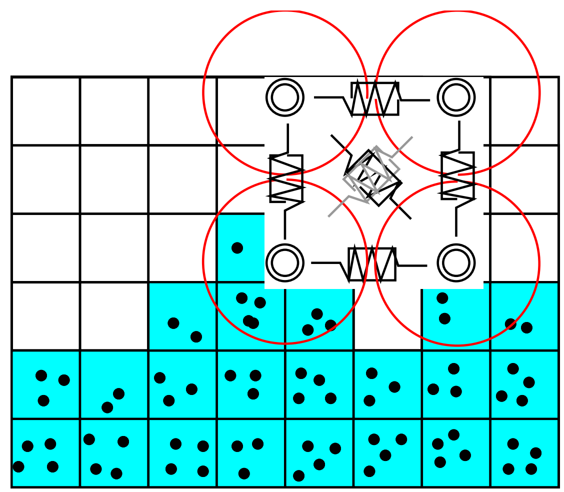


- At each time step, compute spring forces and external forces

Interfacing the Two Models

- Key interfacing ideas:
  - Convert fluid velocities into forces for use in Spring model

    Force of each marker has limited radius



  - Use Spring-Mass forces as external forces in Navier-Stokes

    Need position dependent external force term

    Save and reuse forces from previous step

Examples

Figure 7 from paper

Ball starts on bottom, motionless, floats to top

Examples

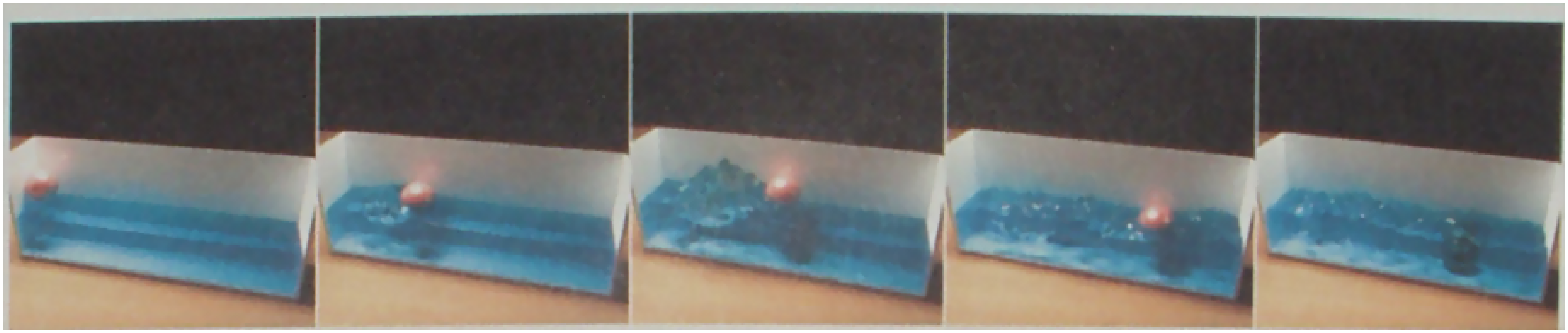


Figure 8 from paper

Ball thrown into tank

Examples

Figure 9 from paper

Cube hit by high speed water jet

- Cube is $1000 = 10^3$ nodes in cube lattice
- Noisy water not part of simulation

  Mesh too complex to render well (???)
- Cube deforms, then “reforms”

Examples

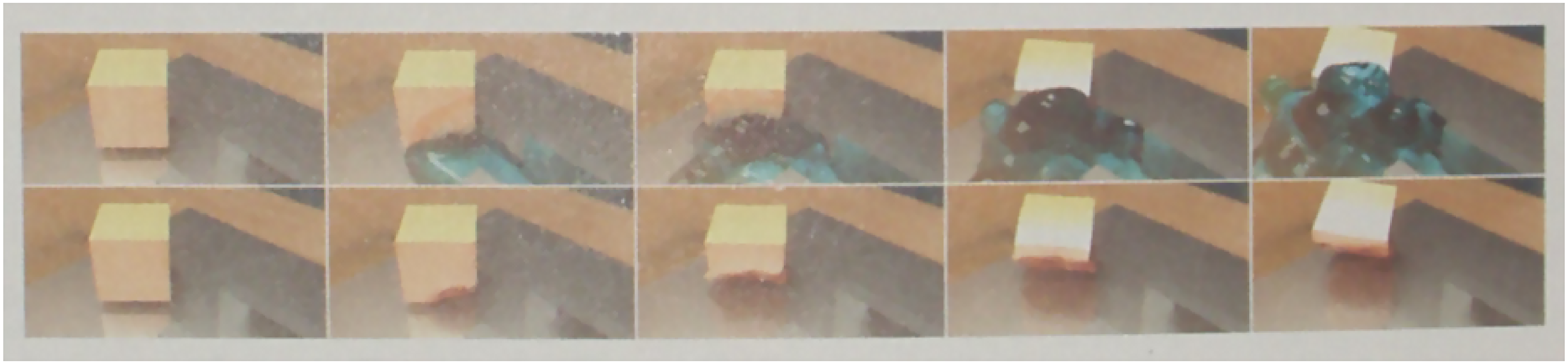


Figure 10 from paper

Close-up of cube from previous example, with and without water

Shows deformation of cube

Examples

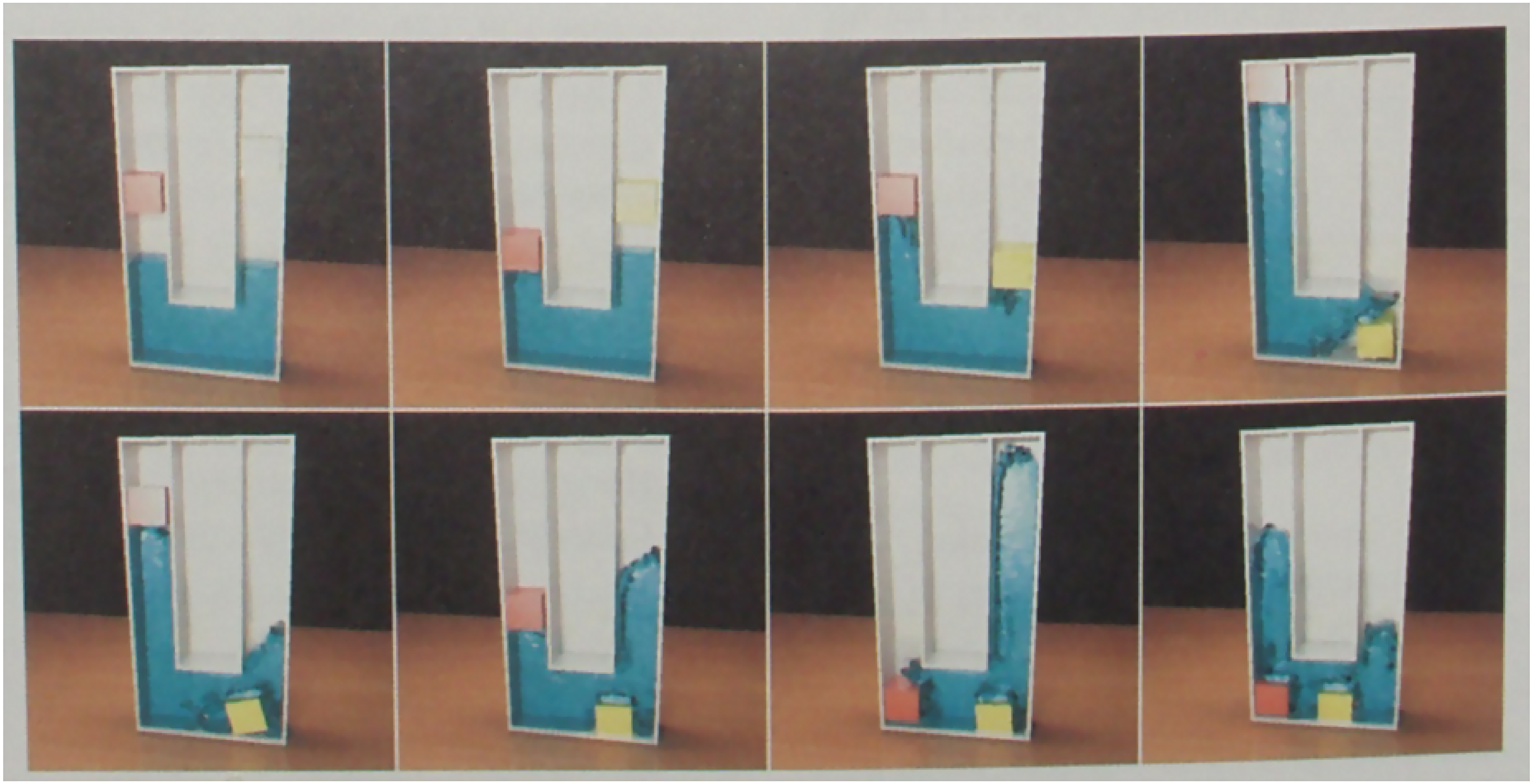


Figure 11 from paper

Yellow cube five times heavier than red cube.

Timings

- Athlon XP 1800+, 512GB RAM.

- From 8 to 45 seconds per frame

- Complex examples took less time — fewer particles

- Time steps 1/240 second, one frame every 1/24 second

  Small time steps needed to avoid instabilities

Evaluation

- Parameter nightmare

  "multiple interlocked parameters need to be devised"

- No guidelines from many parameters other than vague statements

  "k_{int} must be stiff enough to repel water markers from interior of solid"

- Videos looked good, but hard to evaluate realism

- A reasonable first attempt, but much work remains

Evaluation/Comparison of Talk

- Shorter

  Less on details of background material

- More examples

- An evaluation of their method

- No equations