Review continued
Next steps in Computer Graphics

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Today

- Announcements
  - This is the last class (as voted on Monday). You have Friday off!
  - Don’t forget to do the Course Evaluation (online). It will close on Monday.
  - Assignment Spotlights will be posted as videos after the end of term. Will let you know when it’s ready. Code will not be posted.

- Review continued
- Next steps in computer graphics
Beyond Pretty Pictures:

Fast and Accurate
Human Simulations

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“Before 2020, character animation will mainly be character simulation [of biomechanics and neural control]”

- In scare quotes because I’m on record saying this ca. 2010
  - I thought 10 years was far away…
  - I’m not the only one to believe this
- Yes, artists will control the animation, but at a high-level. Like directors, rather than as puppeteers
Could this work?

- Inspiration: the amazing success of physically based animation

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da Vinci’s fluid animations, ca. 1500
Fluid animations, ca. 2010

Could this work?

- Inspiration: the amazing success of physically based animation
  - Fluids
  - Cloth
  - Sound
  - Destruction
  - …
- With help from the usual suspects: Moore’s Law, Software is Eating the World, etc.
What about Character Animation?

Leonardo da Vinci, ca. 1500

What about Character Animation?

Avatar (2009)
A Physically Based Approach to Virtual Character Deformations [Siggraph 2010 talk]
The Pitfalls

Myth: Biomechanics is well understood

- Computer scientists just need to take these principles and make them faster, more scalable, and make prettier pictures
- This myth is believed by many in the field of biomechanics as well!

Chen & Zeltzer 1992

Lee, et al. 2010
Challenges of Biomechanics

- Constraints
- Contacts
- Large deformations
- Volumetric data

New Approach to Biomechanical Simulation

- Use Reduced Coordinates whenever possible

Most biological tissues are (or built from) thin structures, particularly
- 1D strands (proteins, muscle fibers, tendons, …)
- 2D sheets (skin, many muscles, aponeuroses, …)

- Use Eulerian discretizations

  - Pai, Levin, and Fan “Eulerian Solids for Soft Tissues, and more”, SIGGRAPH 2014 Course (plus original literature cited there)
Technology for modeling the mechanics of the human body

- Sueda, et al., “Large-Scale Dynamic Simulation of Highly Constrained Strands,” SIGGRAPH 2011

Example:
Eulerian Biomechanics in 1D (tendons and other fiber structures)

See [Sachdeva, et al, SIGGRAPH 2015]
Challenges

- Tendon sheaths: close contact and routing constraints
- Stiff tendon/ligament modeling
- Muscles: Material model and control

Lagrangian vs Eulerian Nodes

- Lagrangian Nodes
  - Fixed to strand material

- Eulerian Nodes
  - Allows strand material to pass

[Sueda et al. 2011]
Eulerian-on-Lagrangian Strands

- Node can be both Eulerian and Lagrangian

Finger Model (with simplified extensor hood) proof of concept
Controlled through muscle activation

- Controller learns from experience

Can simulate some deformities

- Swan neck deformity
- Boutonniere deformity
Simulating Skin

[Li, Sueda, Neog, Pai SIGGRAPH 2013]
[Neog, Cardoso, Ranjan, Pai Web3D 2015 (best paper)]
Standard Skinning

Too much skin motion

Simulation Challenges

Shared geometry
Simulation Challenges

- Shared geometry
- Skin mesh
- Body mesh

Non-conforming meshes!
Translating Ideas to Innovations

- Initially funded by NSERC I2I Phase 1 grant
- Spun off startup: Vital Mechanics Research Inc.
  - Currently in ICICS Hatch incubator
Simulation corrects unrealistic skin movement around joints.
VitalSkin used in Fantastic Beasts

Skin Capture: Estimating the Physical Properties of Human Skin

Austin Rothwell, Pearson Wyder-Hodge, + many others in Sensorimotor Systems Lab
Motivation

- Human Tissue is a heterogeneous, anisotropic, viscoelastic, non-linear material making it difficult to model
- Being able to accurately model human tissue is important:

Clinical
- Surgery
- Diagnosis of disease
- Biomedical device design

Graphics
- Virtual surgery
- Gaming
- Cinema

Measurement Based Model Fitting

Pai et al., 2001
Other projects in the lab

- Data-driven modeling of skin movement around the eyes
- Scientific Computing for human body simulation
- Perception of motion in VR
  - Oculus Rift DK2 with SMI eye tracker built in

Simulating Skin Around the Eyes
Neog, Cardoso, Ranjan, Pai, Web3D 2016 (Best Paper Award)
You can try the application in a browser at
http://www.cs.ubc.ca/research/eyemoveweb3d16/

To learn more

- Get involved in projects in research labs
  - Contact me if you’re interested in getting involved in current topics
- CS offers both 4th year and grad courses in graphics
- Huge Opportunity: SIGGRAPH is coming to Vancouver!!
Term 2 Grad Course

- CPSC 530P Sensorimotor Computation
  MW 13:30-15:00 Dempster 101
- Focus on modeling and simulation of biomechanical systems (soft tissues, musculoskeletal systems, skin, etc.).
- Also a (gentle?) introduction to physically based modeling and numerical simulation methods that are useful in computer animation and robotics

In Lecture 1, I said:

- The following are essential for success
  - good grasp of linear algebra
  - exposure to calculus; “mathematical maturity”
  - programming experience in C++
- This is not an easy course!
Yet, you chose to stick with it :-)

All the best for the finals
and
Happy Holidays!