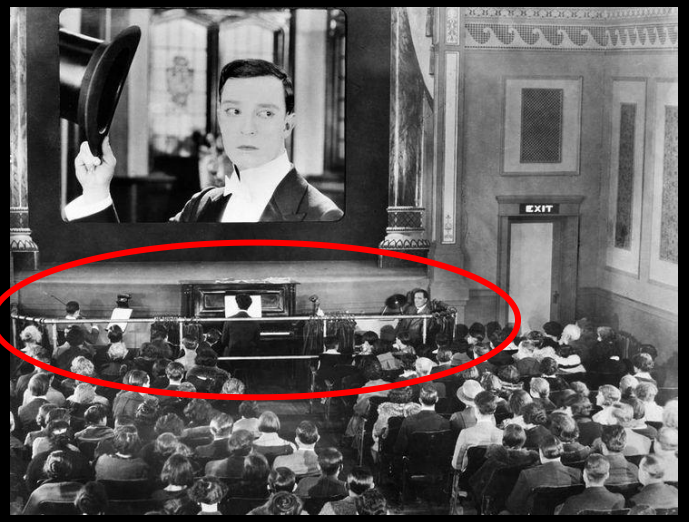
Technologies In Modern Film Production

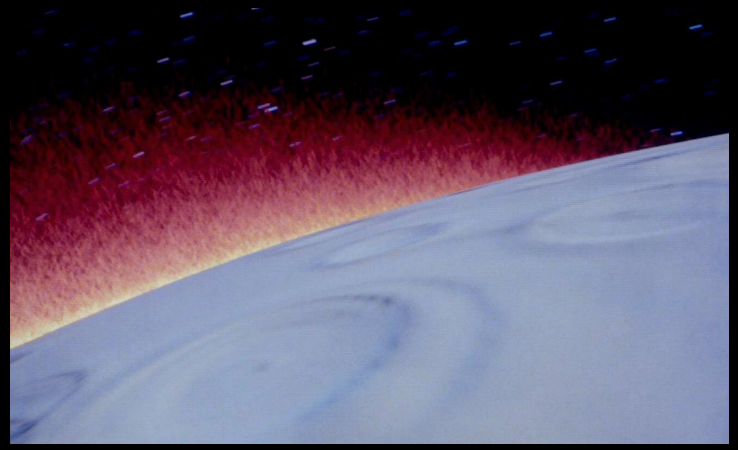
Technologies has been revolutionize film industry for centuries



Movies in 1920, with orchestra playing the musical

First Movie with sound, 1927

First True Color movie, by [Edward R. Turner] in 1899 and tested in 1902.



Star Trek II, 1982

First full length CG Anim, 1995

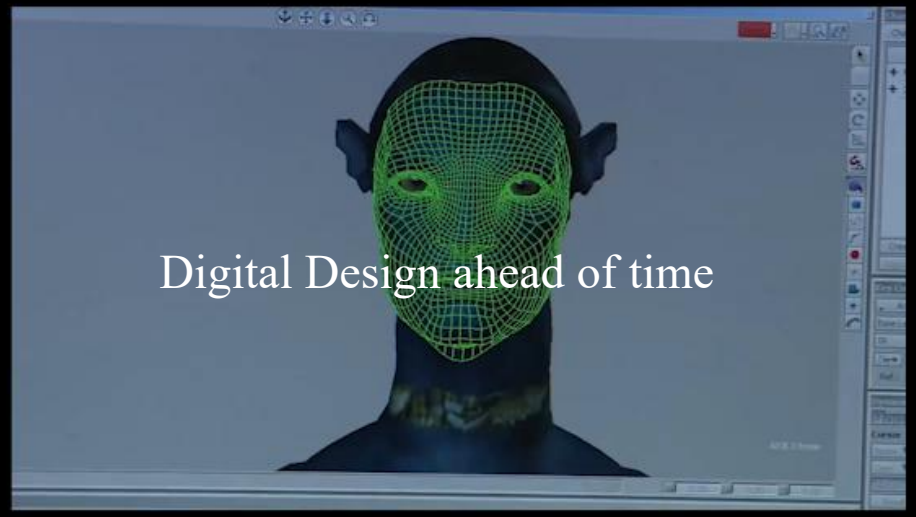
~$40 Billion/year Industry

Technology inspires art,
Art Challenges Technology.
– Pixar

During a Movie Production

- Computer Science's role:
  - Motion and Facial Capturing
    - Least Square Optimization
  - Camera Tracking
    - SLAM
  - Real-time Graphics
  - Off-line Graphics
    - Physically based Simulation and Rendering
    - Image Processing, AI driven graphics
  - Systematic integration with
    - Hi-speed network
    - Filming Hardware
    - Artists

Post-production now is Pre-production



Performing

Director's Monitor

+ Realtime Performance Capturing and Directing

Final-Cuts

What you thought “Real” are actually “Digital”

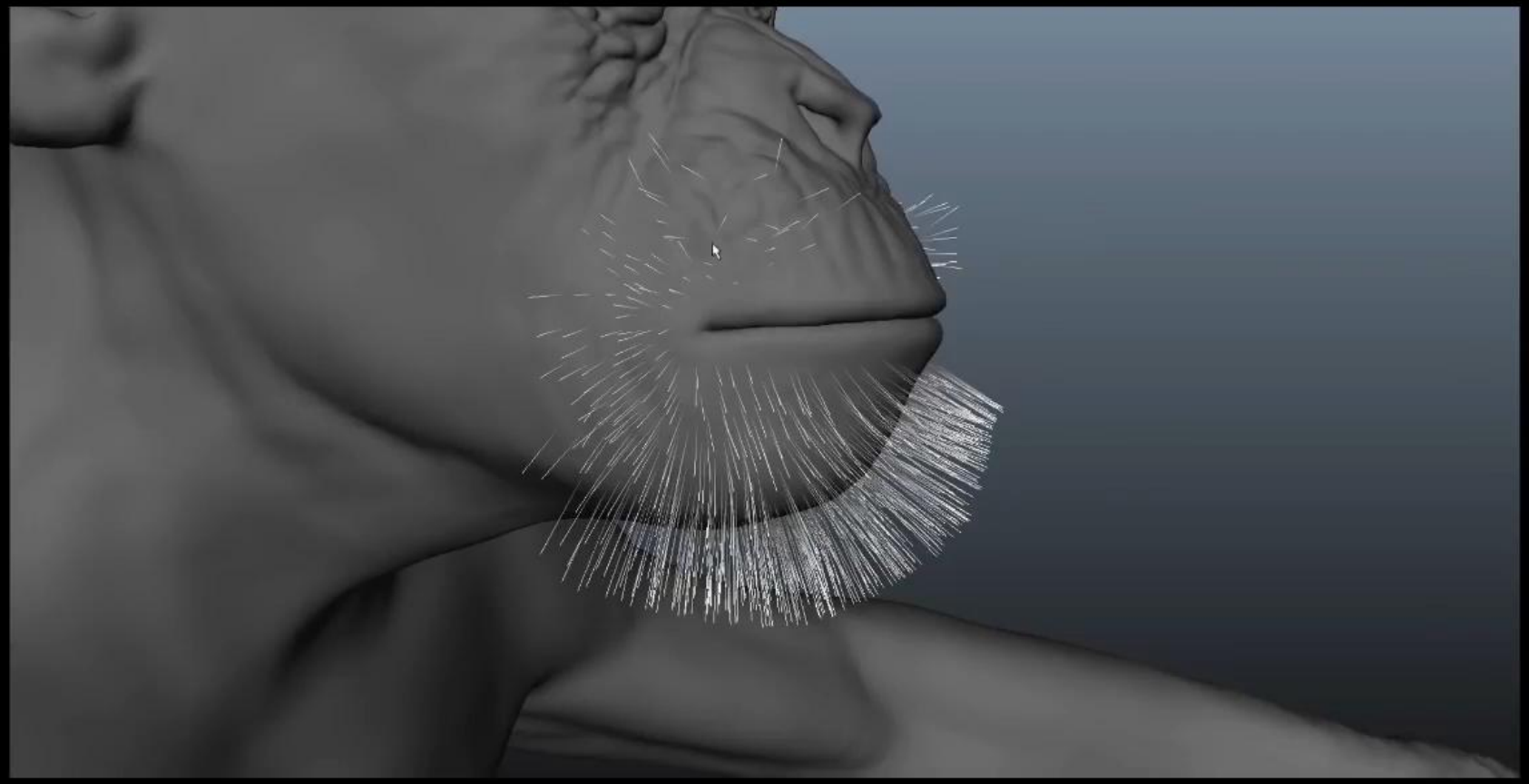
Dawn of the Planet of Apes

What you thought “Real” are actually “Digital”

Fast and Furious 7

How to achieve such quality?

- Develop new tools(Coding and Engineering)

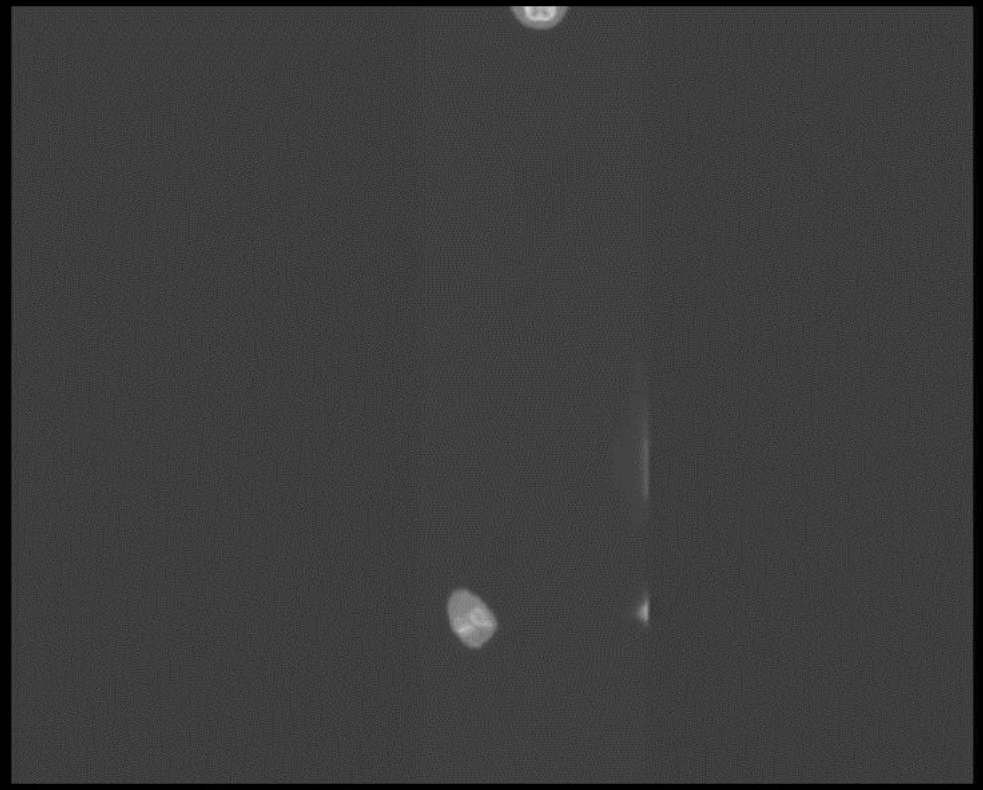


How to achieve such quality?

- Study the physics of light transporting models(Science)

How to achieve such quality?

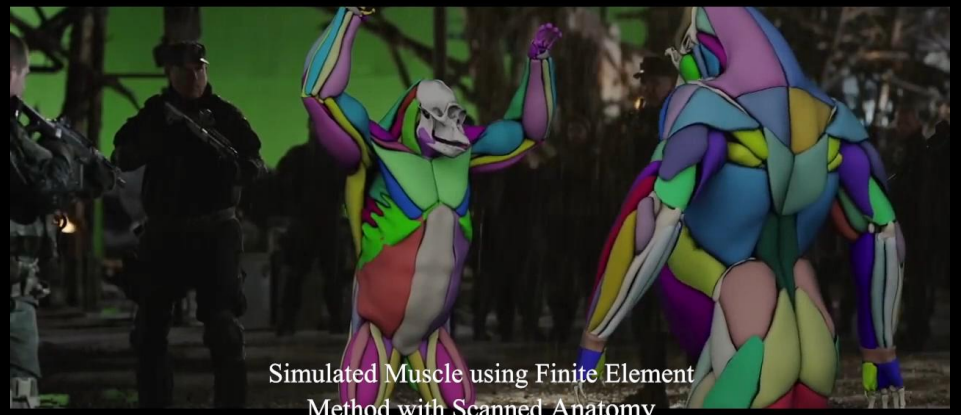
- Even Study the Anatomy of digital characters



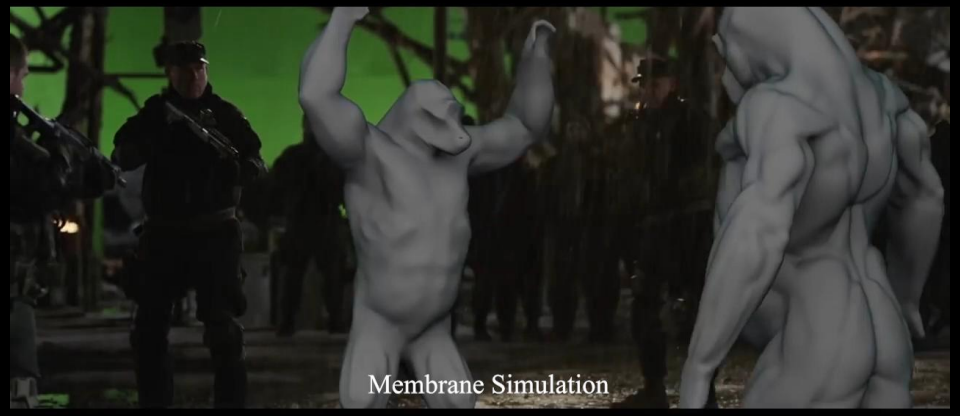
How to achieve such quality?

Put together: From Capture to Simulation and Rendering

Motion Capture



FEM Muscle Simulation



Membrane/Skin/Hair/Fur Simulation

Final Render(Lighting Simulation)

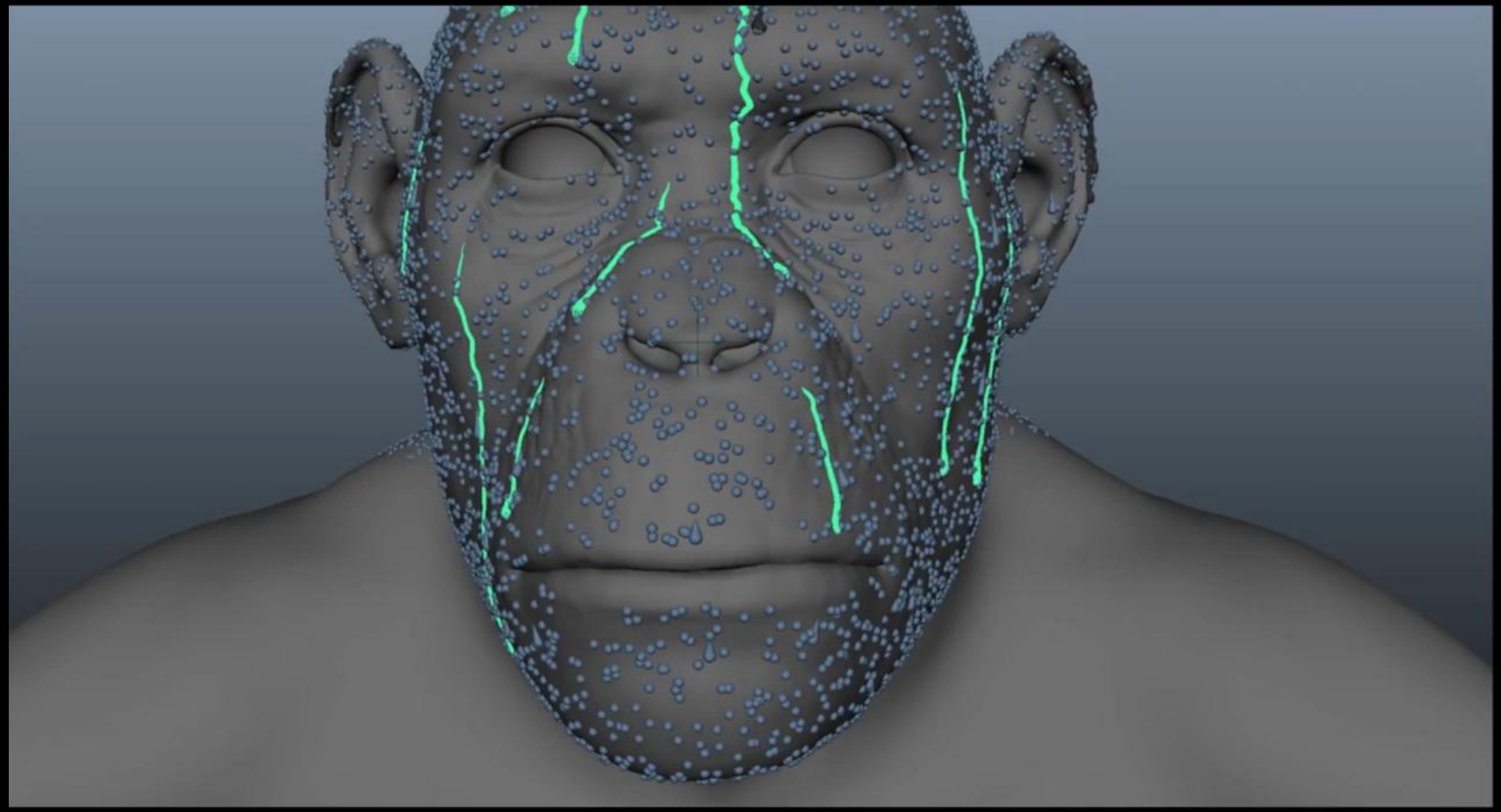
How to achieve such quality?

Polish to even tiny details!

Modeling the Snow on the Fur

How to achieve such quality?

Don’t forge to run Physically Based Simulations!



How to achieve such quality?

Virtual Production + Performance Capturing brings Life Like Digital Characters!

How to achieve such quality?

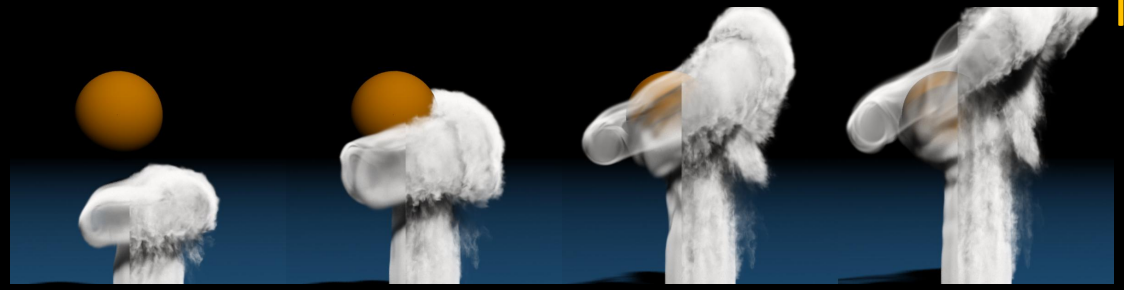
While apes use tools to act like human, human also use tools to act like apes.

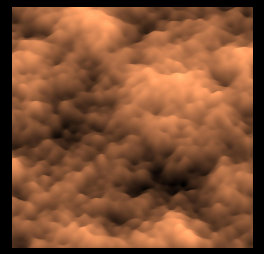
How to achieve such quality?

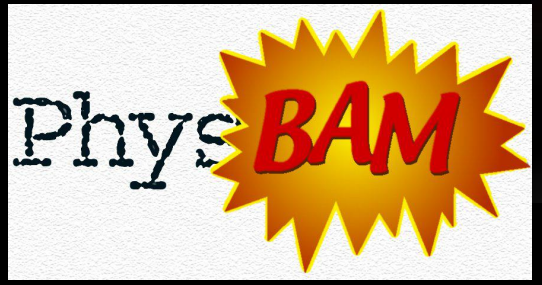
New Researches

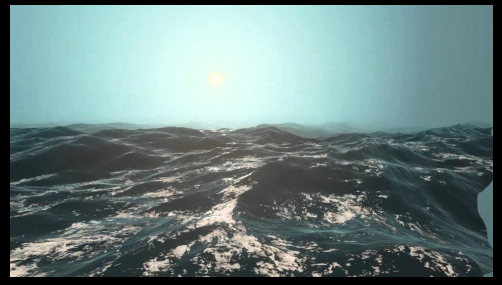
How to achieve such quality?

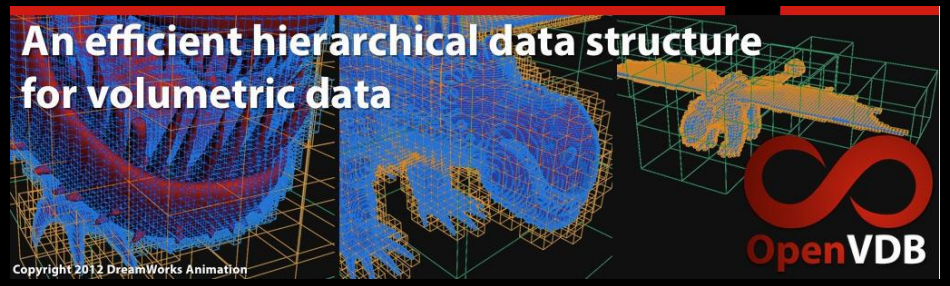
Award Oscar Statues to Comp. Scientist and Mathematicians!











How to achieve such quality?

Computer Scientists to get Oscar Statue!

- Wavelet Turbulence (Nils Thuerey, etc. TUM)
- Bullet Engine (Erwin Coumans, Google)
- PhysBam(Ron Fedkiw, Stanford)
- FFT based Ocean Simulation(Jerry Tessendorf, ClemsonU)
- Perlin Noise(Ken Perlin, NYU)
- OpenVDB(Ken Museth, Weta Digital)
- Sparse Voxel(Robert Bridson, UBC, Autodesk)
- Fast FEM Solver for Fracture(James O'Brien, UC Berkeley)
- ….. Too many names to put here(Columbia U, UCLA, Cornell, etc.).
- One of you guys!(PKU)

Research aspects in Computer Graphics

- Computer Science's role:
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    - Least Square Optimization
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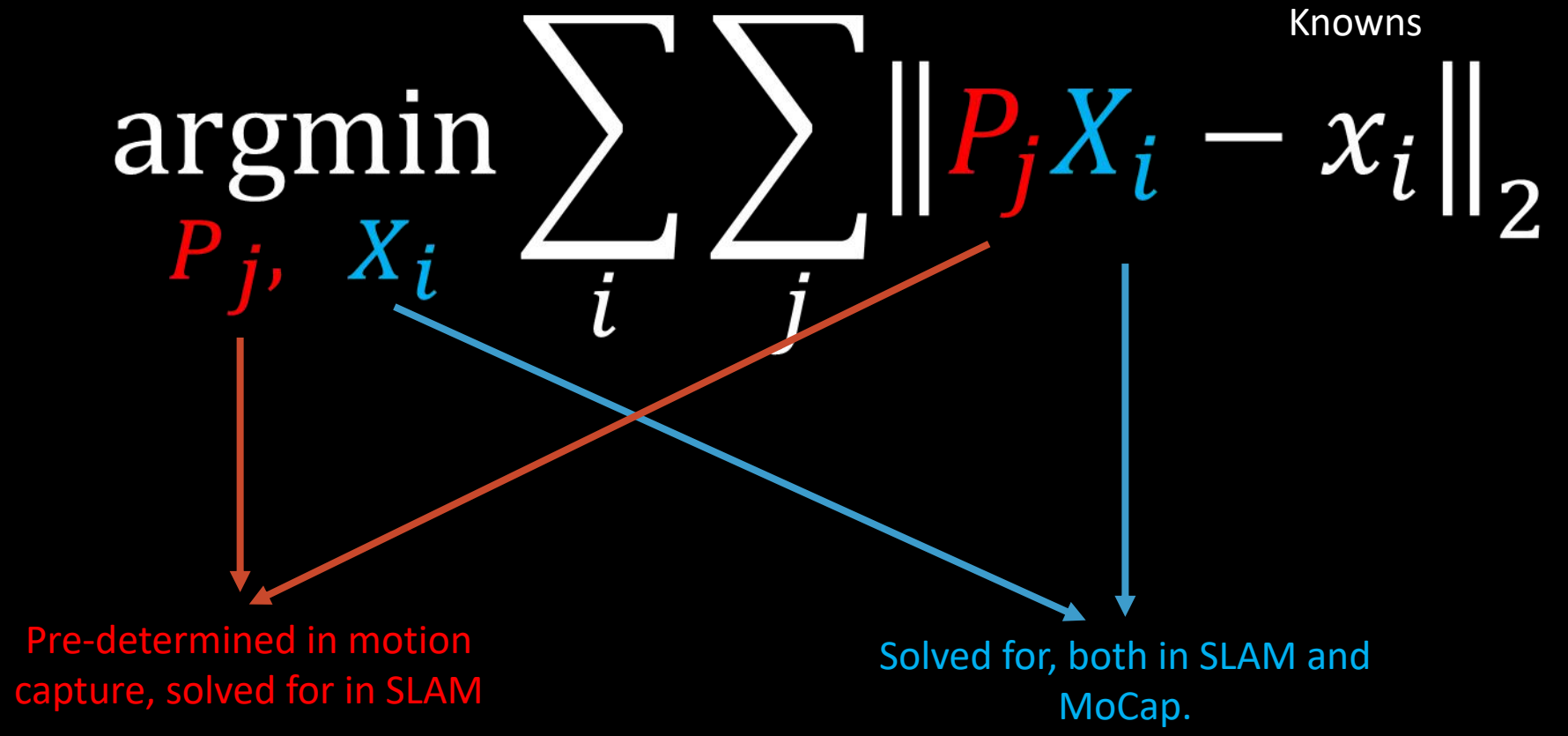
    - Filming Hardware
    - Artists

Same Equation



Different aspects

$$\underset{P_j,\ X_i}{\operatorname{argmin}} \sum_i \sum_j \left\| P_j X_i - x_i \right\|_2$$

Once P_j is Pre-determined, this is a **Linear System**,

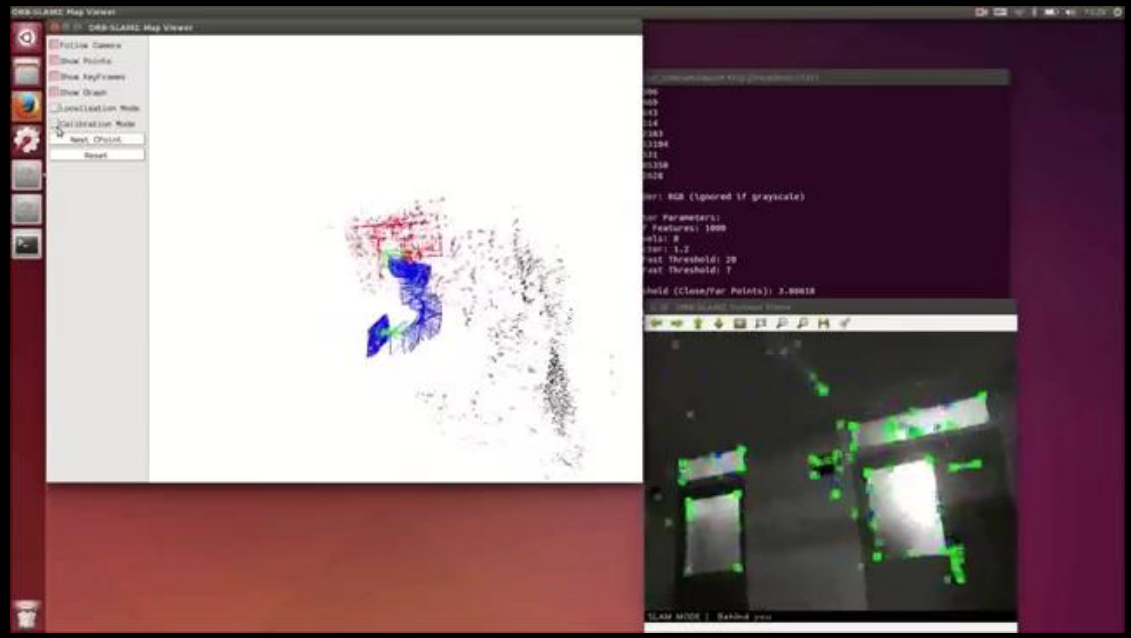
Linear Solvers – fast ☺

Once it is the Unkown, this is a **Non-linear Least Square**

Newton Solvers – slow ☹

Different aspects

Focus on locating the Object,
In A **Well-Conditioned** Evironment



Focus on locating the Observer,
In an **UnConditioned** Environment

Different aspects

Jitter is **Not Acceptable.**

Realtime Multi-Person 2D Human Pose Estimation using Part Affinity Fields, CVPR 2017 Oral

Jitter is probably **Acceptable.**

During a Movie Production

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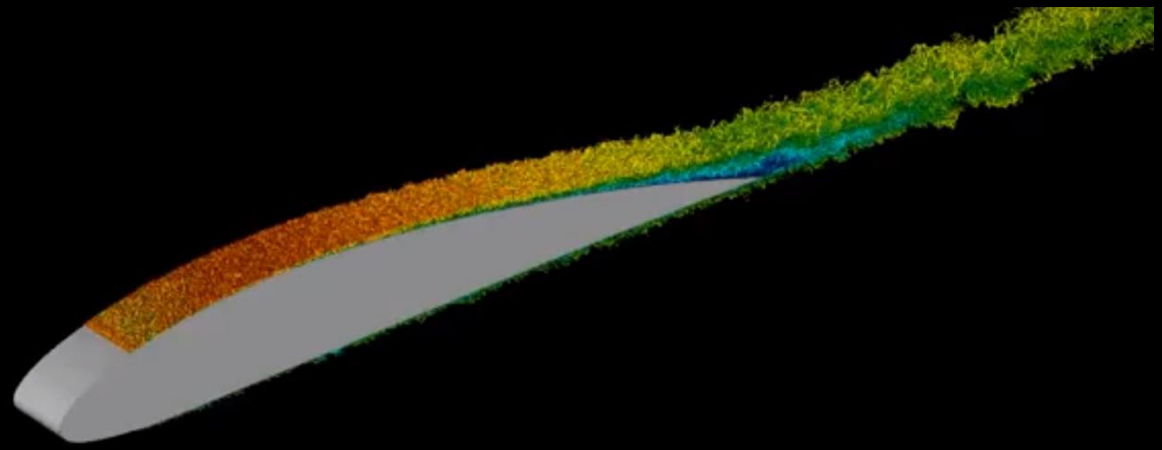
Same Equation

$$\frac{\partial u}{\partial t} + u \cdot \nabla u = -\frac{1}{\rho}\nabla p + \nabla^2 u + f$$

$$\nabla \cdot u = g$$

Different aspects



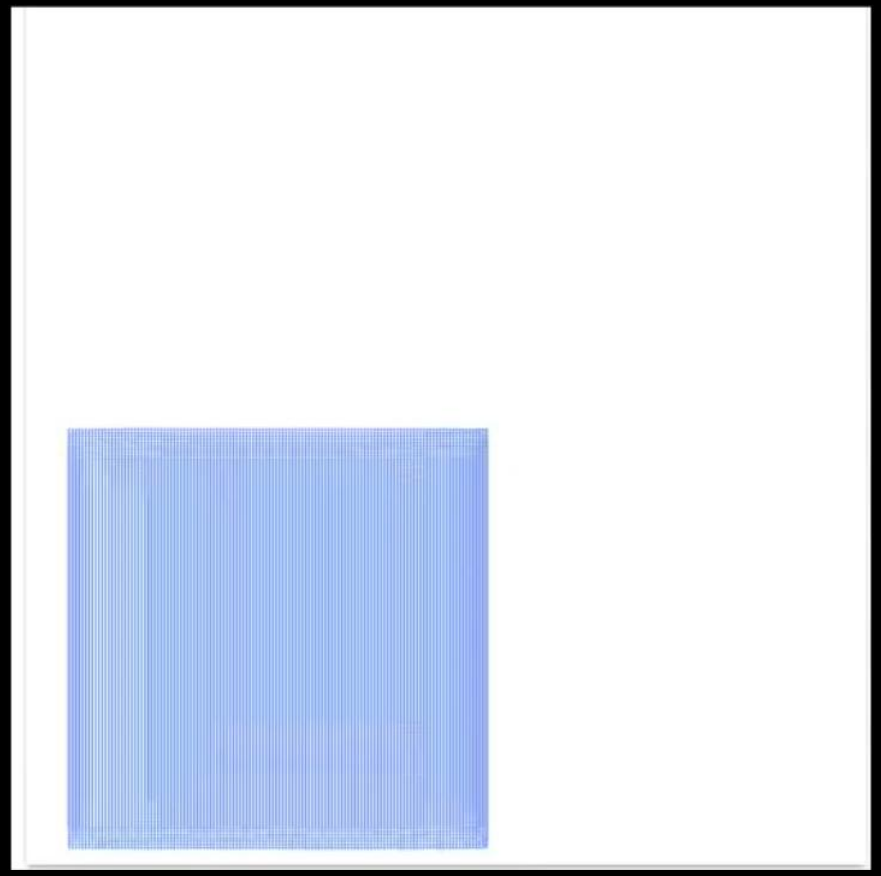
Stability of Numerical Integrator is more Important, Usually CFL>10, simulation done in hours.

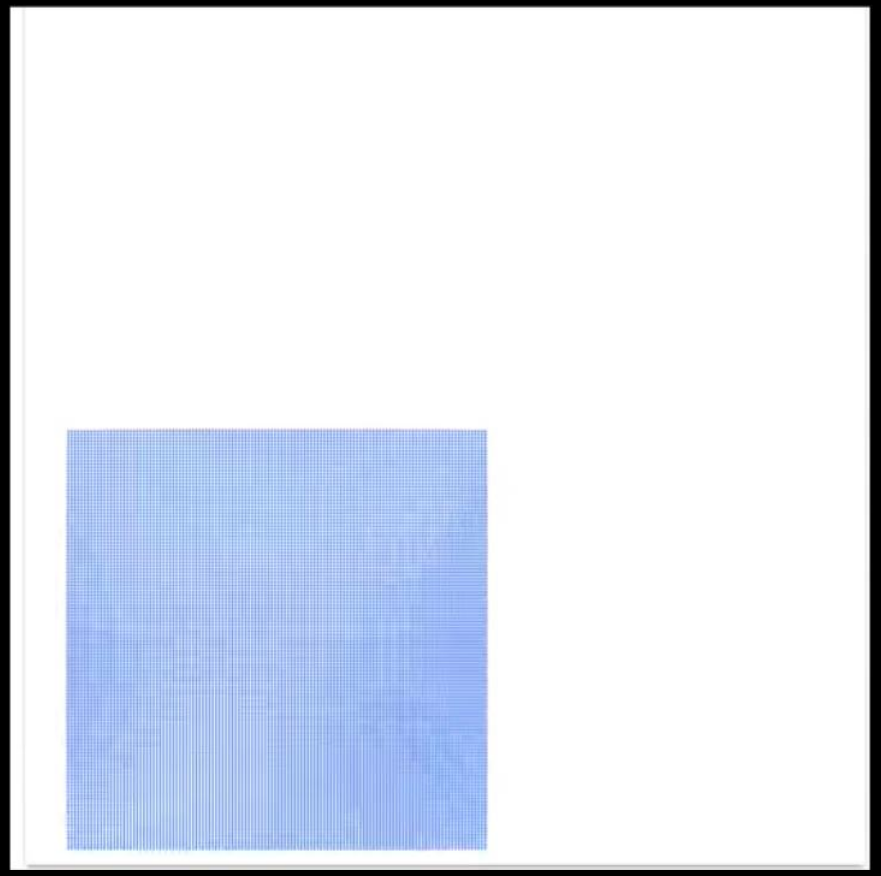
Accuracy of Numerical Integrator is more Important, Usually CFL<1, simulation done in Weeks.

Different aspects

Time is Money!!! -- faster Algorithm with better visual quality

Different aspects





But first it has to be correct!

Bigger Computing (Data) !

Big Visual Effects(Simulations) are done with Super Computers!!!

Hobbits 3: The Battle of 5 Armies

Same Equation

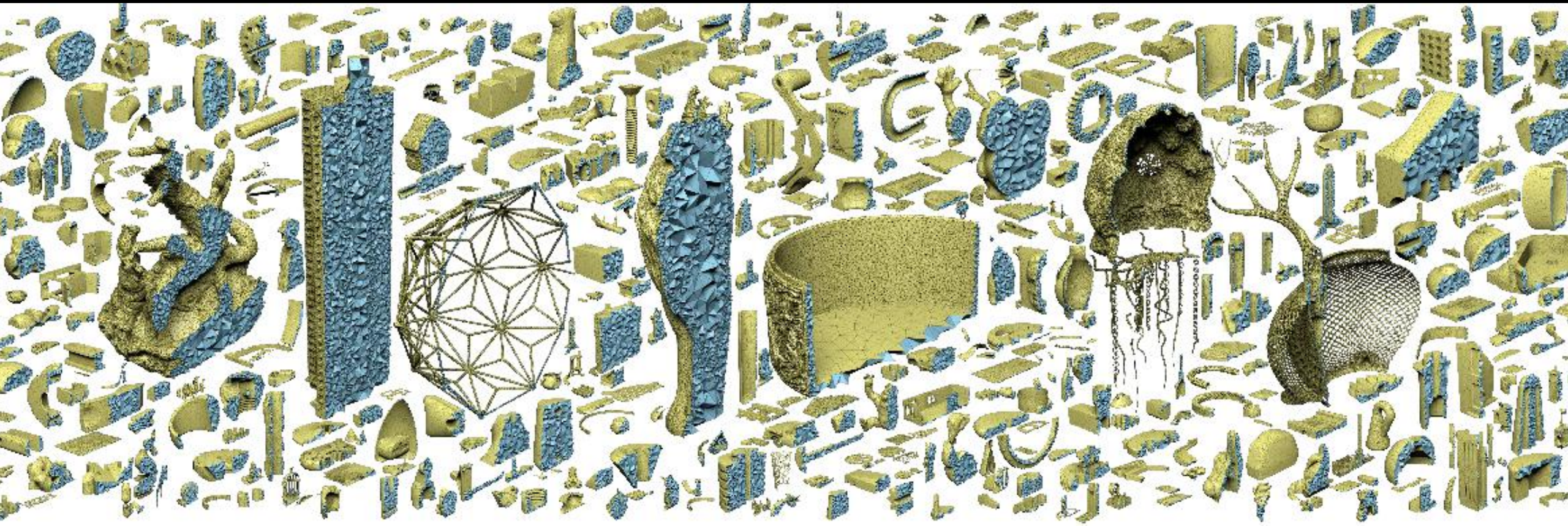
$$f_i = -\frac{\partial E}{\partial x_i} = \sum_e \left(\frac{\partial E_e}{\partial x_i} \right) = \sum_e f_i^e$$

Different aspects

Stability
15 CG

Efficient Elasticity for Character Skinning with Contact and Collisions, McAdams et al, ACM SIGGRAPH 2011

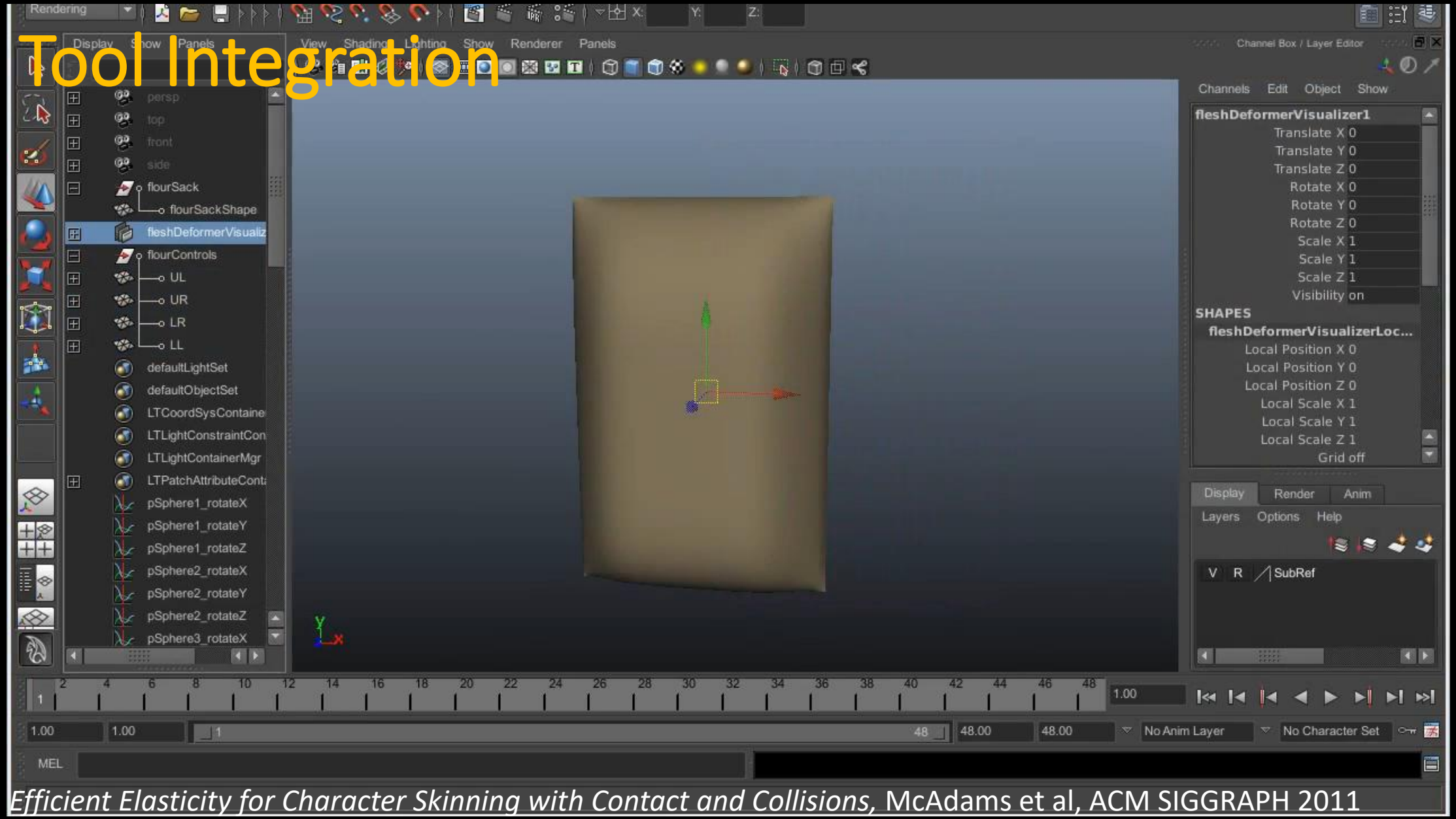
Different aspects



Tetrahedral meshing in Wild, Yixin Hu, et. al., SIGGRAPH 2018.

Computer Graphics industry often has the requirement to deal with extremely bad mesh inputs.(Degenerated mesh, non-manifold mesh, self-intersection meshes, etc.)

Tool Integration



Efficient Elasticity for Character Skinning with Contact and Collisions, McAdams et al, ACM SIGGRAPH 2011

Tool Integration

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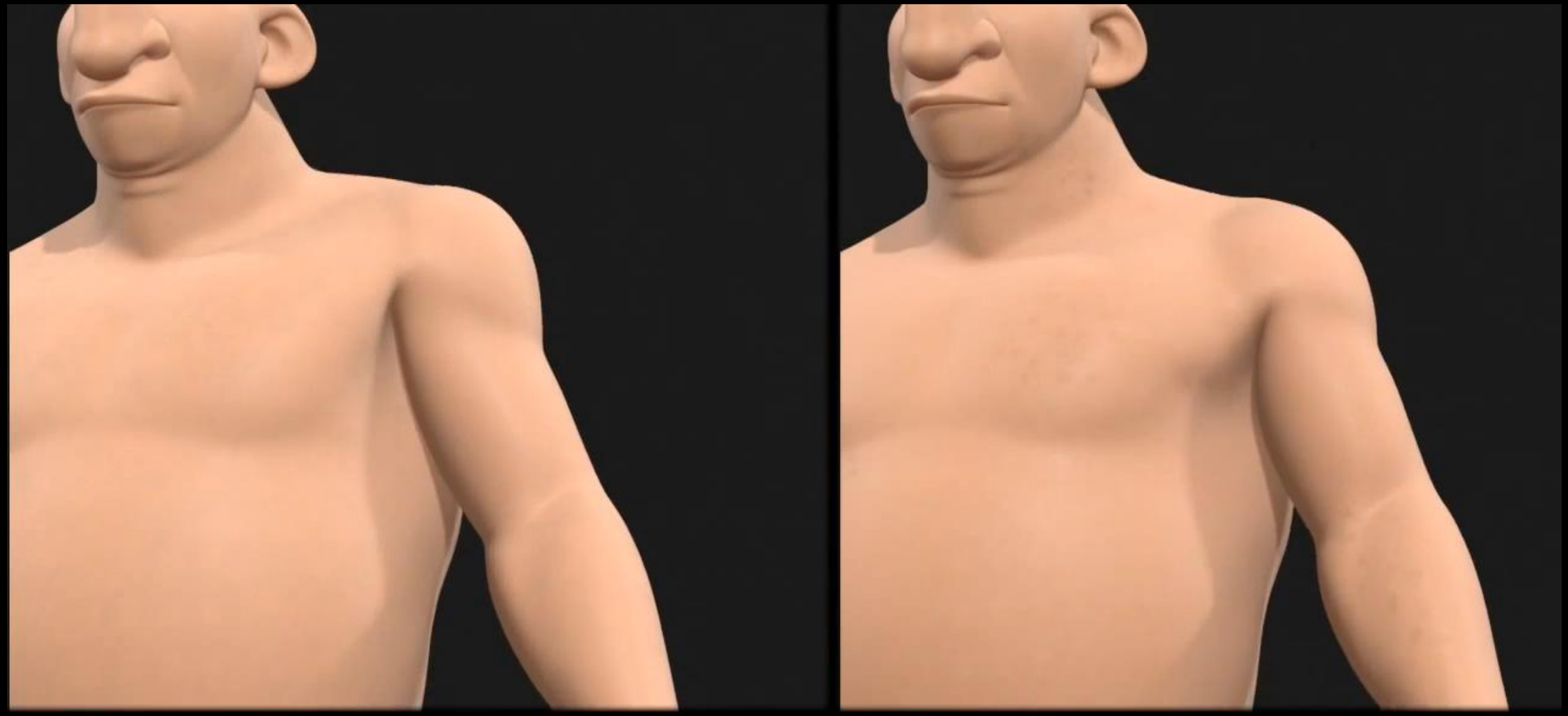
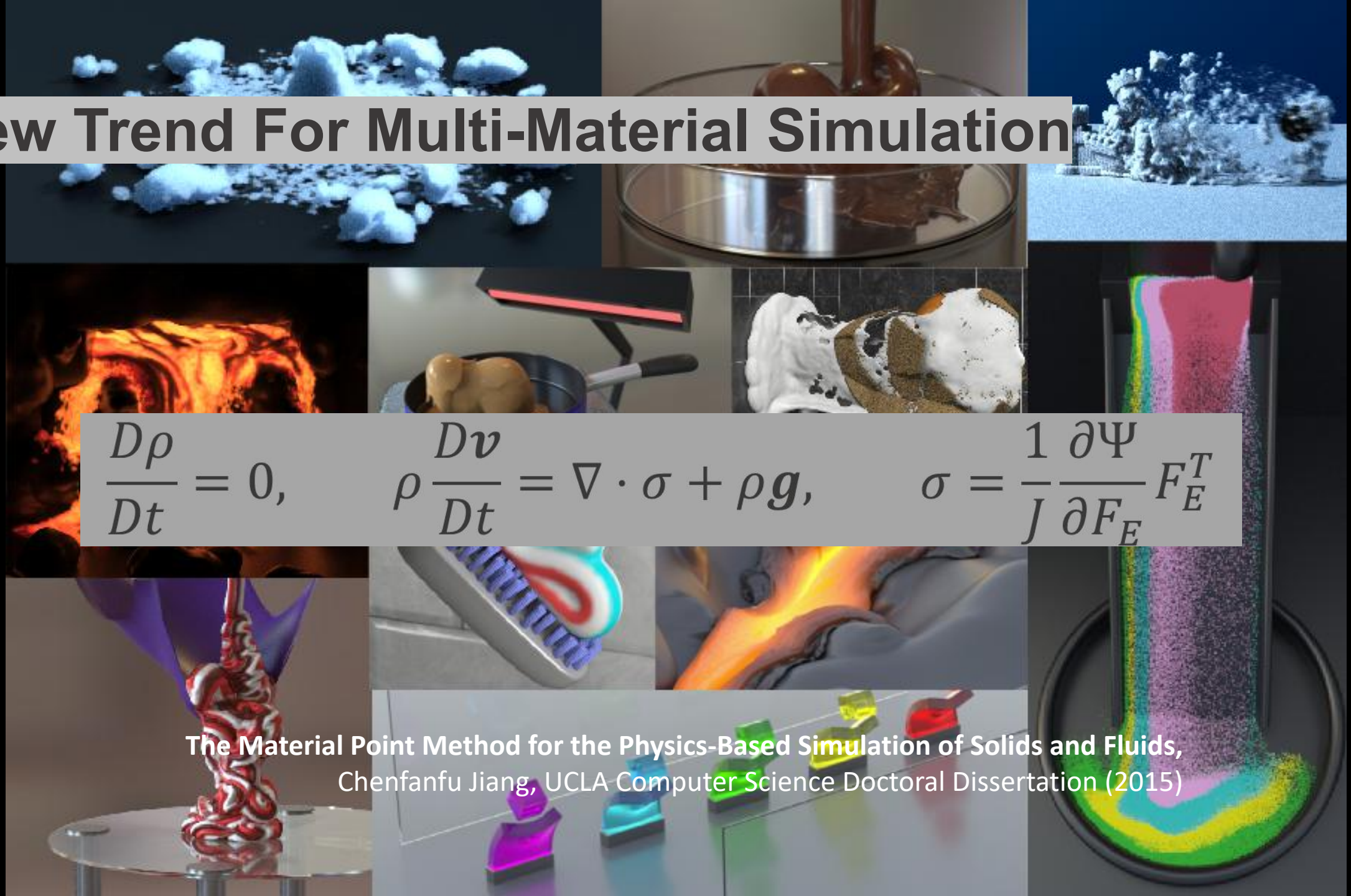


Efficient Elasticity for Character Skinning with Contact and Collisions, McAdams et al, ACM SIGGRAPH 2011

New Trend For Multi-Material Simulation



$$\frac{D\rho}{Dt} = 0, \qquad \rho\frac{D\boldsymbol{v}}{Dt} = \nabla\cdot\sigma + \rho\boldsymbol{g}, \qquad \sigma = \frac{1}{J}\frac{\partial\Psi}{\partial F_E}F_E^T$$

The Material Point Method for the Physics-Based Simulation of Solids and Fluids,
Chenfanfu Jiang, UCLA Computer Science Doctoral Dissertation (2015)

MPM Algorithm Overview

A. Stomakhin, C. Schroeder, L. Chai, J. Teran, A. Selle,
B. *A Material Point Method for Snow Simulation*, ACM Transactions on Graphics (SIGGRAPH 2013)

Art “Directablility” and Automate in Film Production

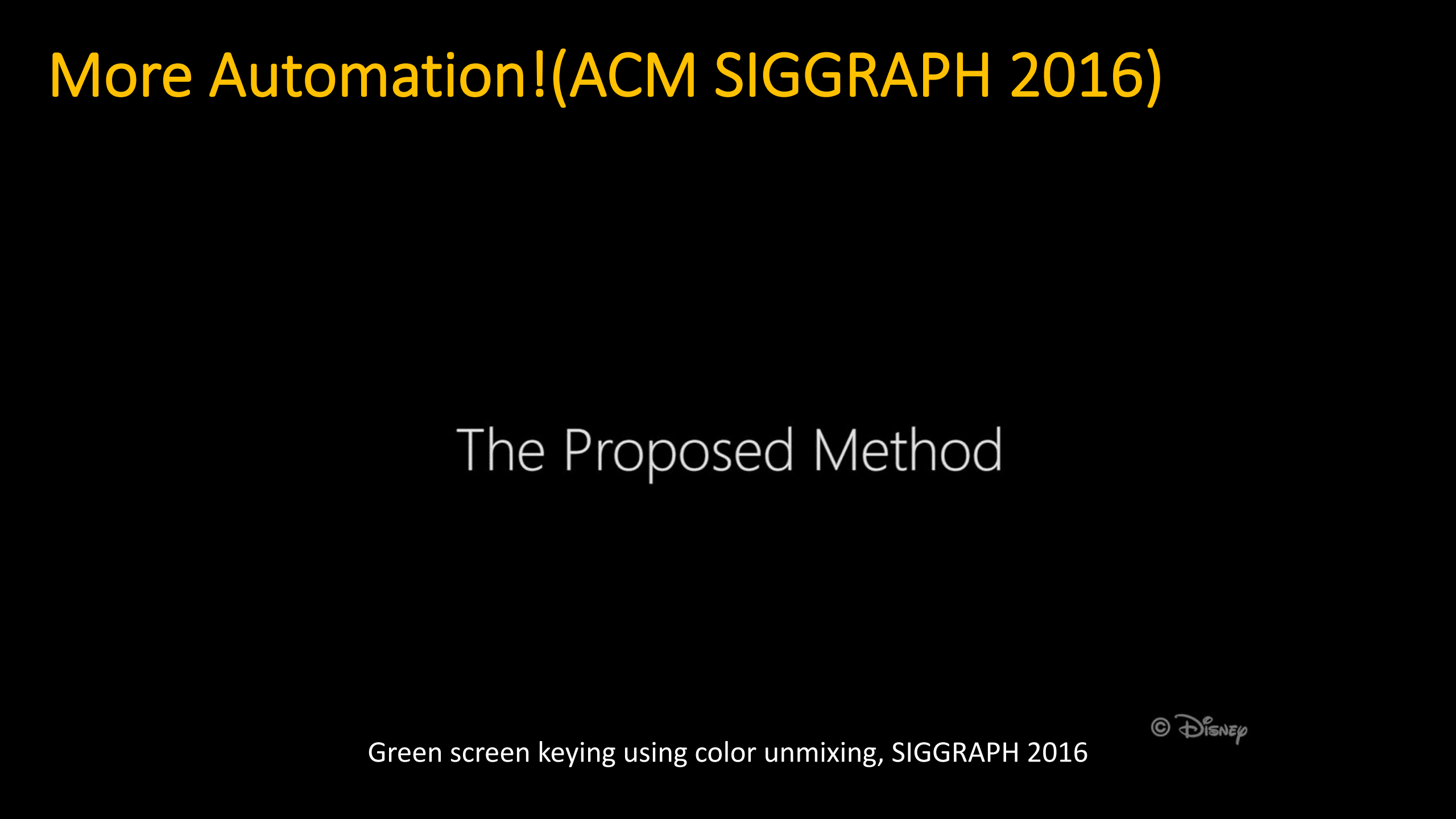
Art Directability

A. Stomakhin, A.Selle. Fluxed Animated Boundary Method, SIGGRAPH 2017

Art Directability

Ongoing research

More Automation!(ACM SIGGRAPH 2016)



Green screen keying using color unmixing, SIGGRAPH 2016

More Automation!(ACM SIGGRAPH 2018)

Semantic Soft Segmentation, SIGGRAPH 2018， Adobe

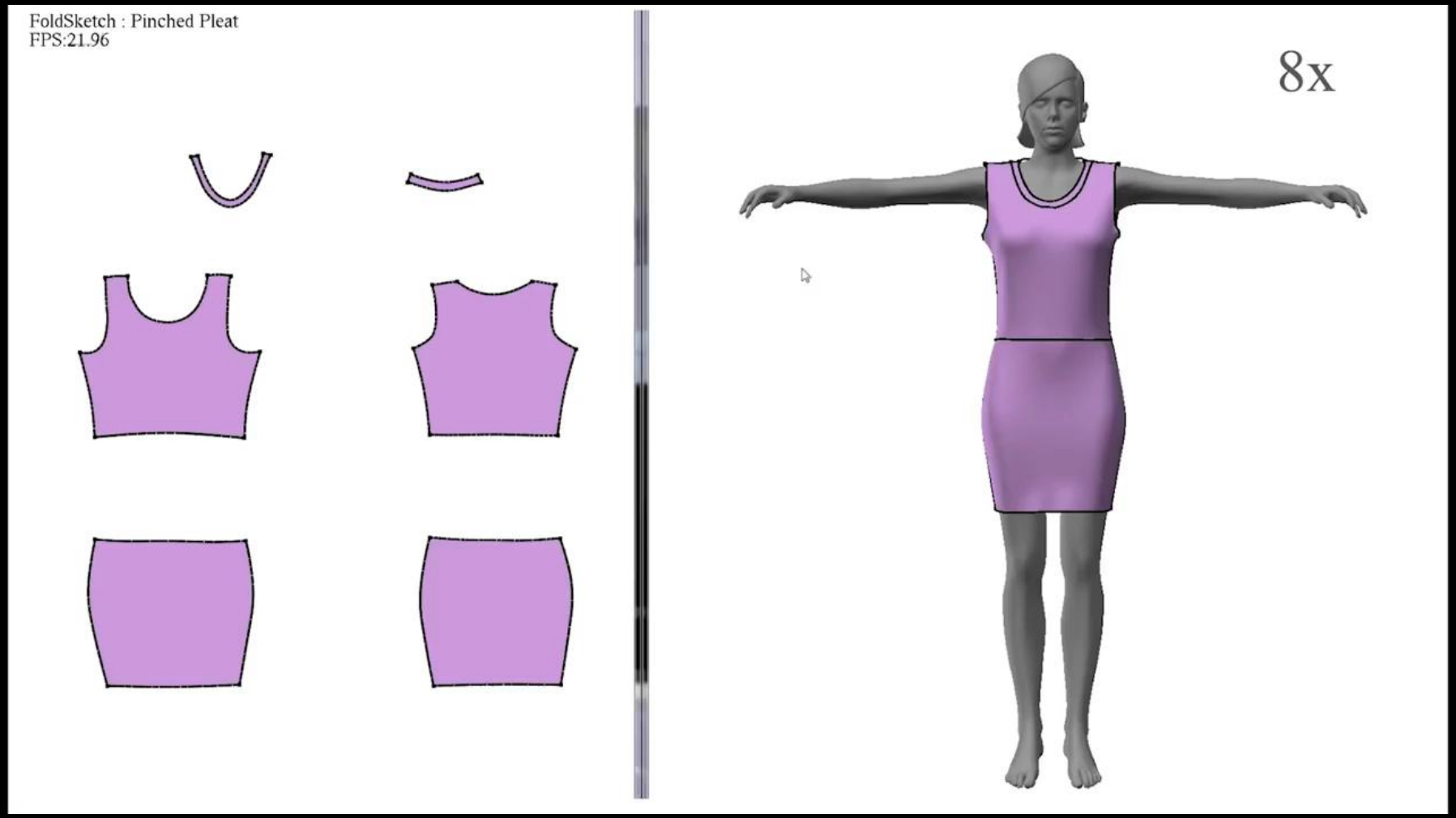
More Automation!(ACM SIGGRAPH 2018)

Optimizing for Different Target Speeds

Flexible Muscle-Based Locomotion for Bipedal Creatures,
Thomas Geijtenbeek, SIGGRAPH 2013

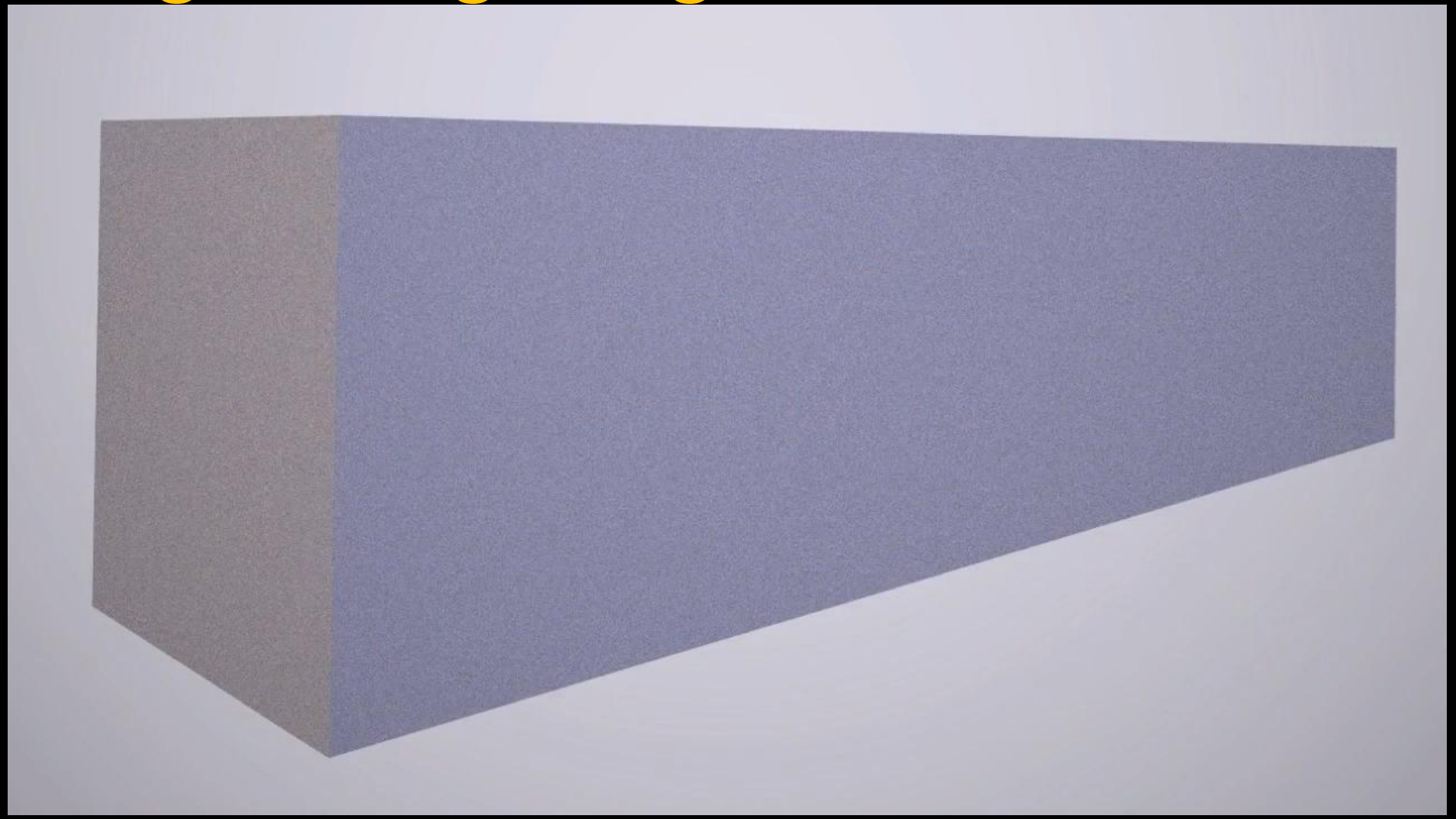
Creative Manufacturing

CS For Fashion Design!



FoldSketch: Enriching Garments with Physically Reproducible Folds, Minchen Li et. al., SIGGRAPH 2018

CS For Engineering Design!



Narrow-band Topology Optimization on a Sparsely Populated Grid,
Haixiang Liu et. al., SIGGRAPH Asia 2018