An Introduction to Computer Graphics

Ruigang Yang

- Education
  - PhD, UNC-Chapel Hill, 2003
  - M.S. Columbia Univ., 1998
- Research
  - Computer vision/graphics
  - Large display visualization
  - Tele-presence

Outline

- Definitions:
  - What is Computer Graphics?
- Coverage:
  - What does Computer Graphics study?
- Applications:
  - What is Computer Graphics good for?

Definitions

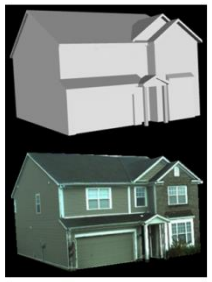
- The creation, display, and storage of pictures with a computer.
- The process associated with producing images by digital rendering of a picture model.
- Generation of (possibly realistic) images of virtual scenes using computer hardware.
- A human-oriented system that uses the capabilities of a computer to create, transform, and display pictorial and symbolic data.
- The synthesis of artificial images--the creation of pictures from descriptions.

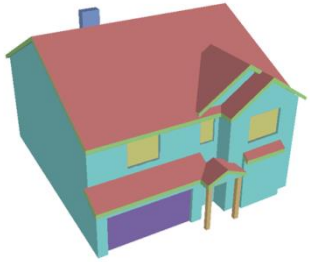
Covered Areas

- Imaging:
  - Representing and handling 2D images.
- Modeling:
  - Representing objects using 3D models.
- Rendering:
  - Generating 2D images from 3D models.
- Animation:
  - Simulating changes over time.

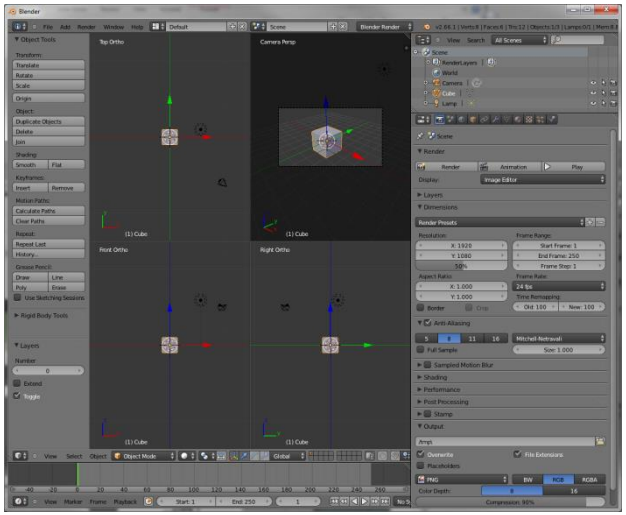
Modeling

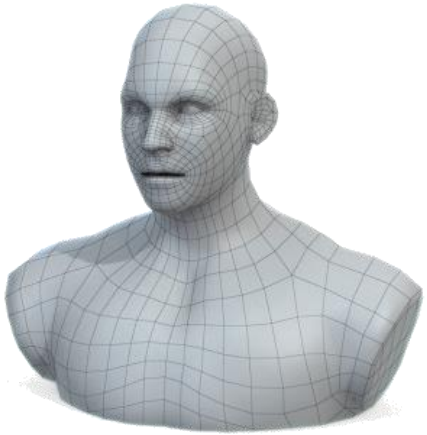
- How to represent complex objects in computer?
  - Human body
  - Mountain
  - Tree
  - Flower
  - …





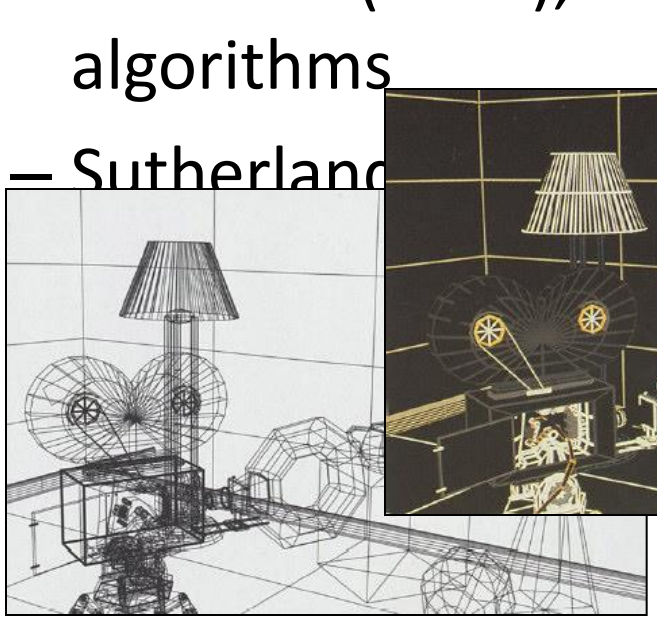
3D Modeling

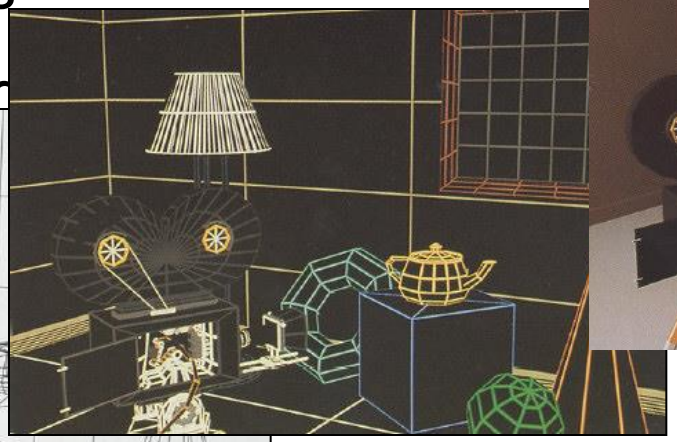


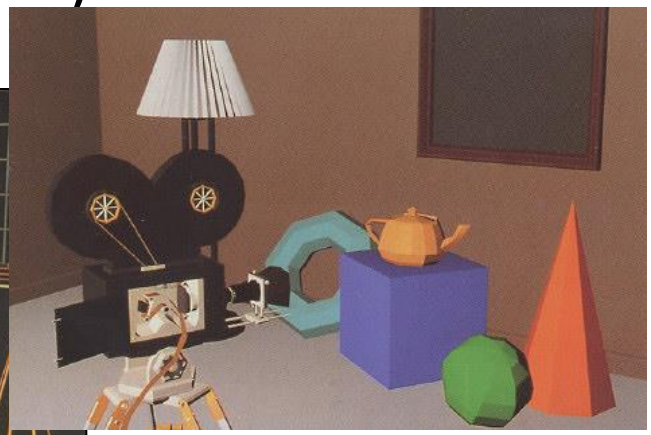


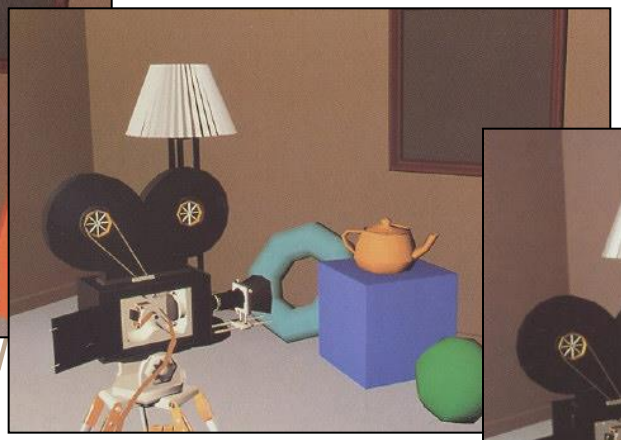
Rendering

- 1960s - the visibility problem
  - Roberts (1963), Appel (1967) - hidden-line algorithms
  - Warnock (1969), Watkins (1970) - hidden-surface algorithms
  - Sutherland





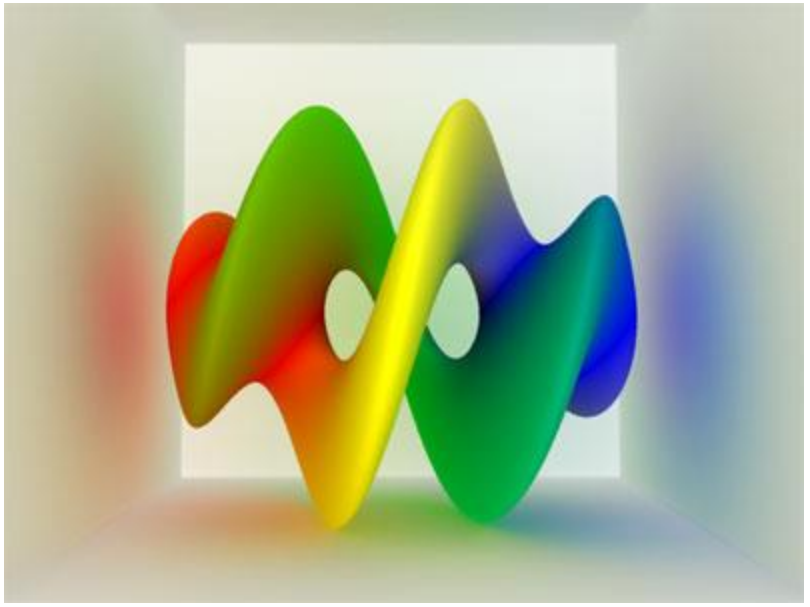


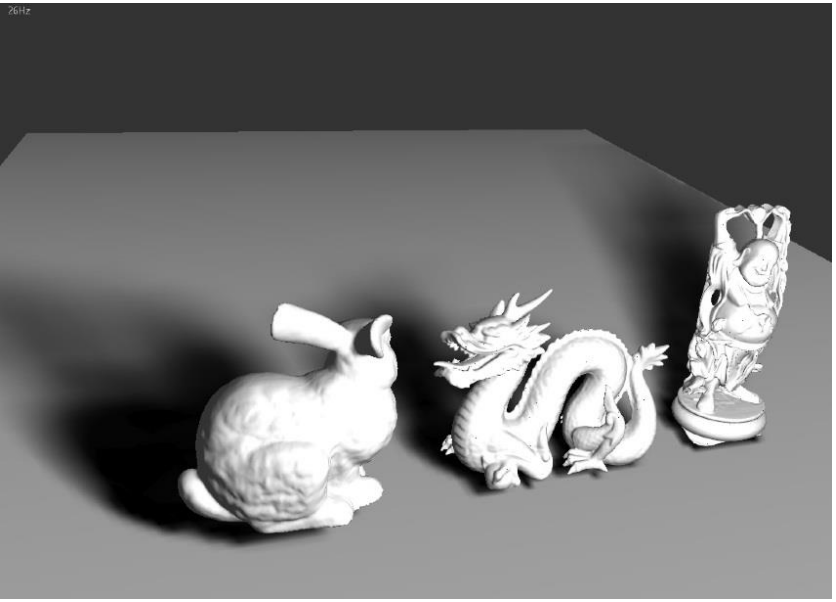



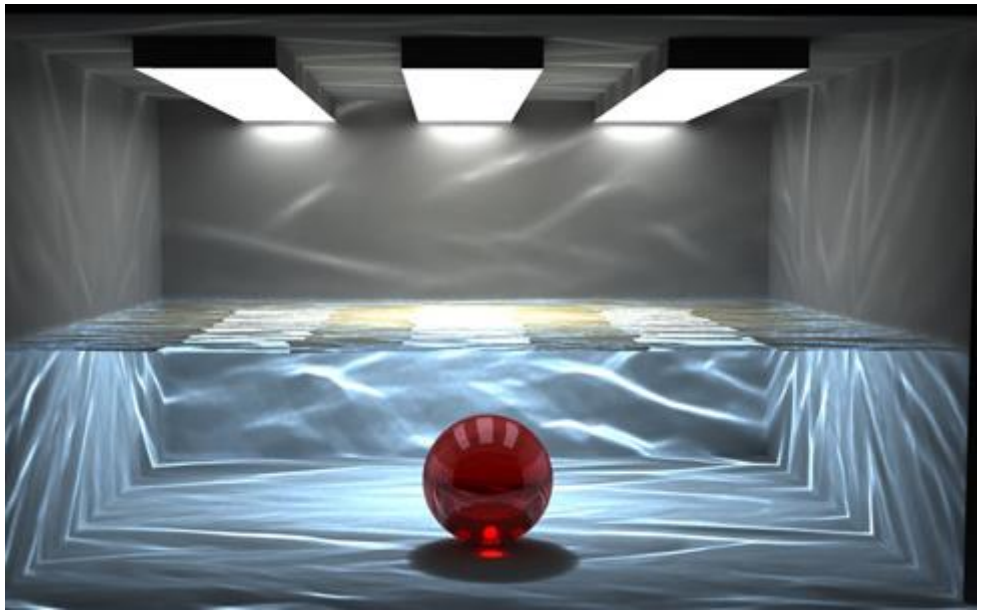

- 1
  - Warnock (1969), W
    algorithms
  - Sutherland (1974) - visibility = sortin
- 1970s - raster graphics
  - Gouraud (1971) - diffuse lighting
  - Phong (1974) - specular lighting
  - Blinn (1974) - curved surfaces, texture
  - Catmull (1974) - Z-buffer hidden-surface algorithm
  - Crow (1977) - anti-aliasing

Rendering

- How to generate photorealistic effects?
  - Color bleeding
  - Soft shadow
  - Caustics







Animation

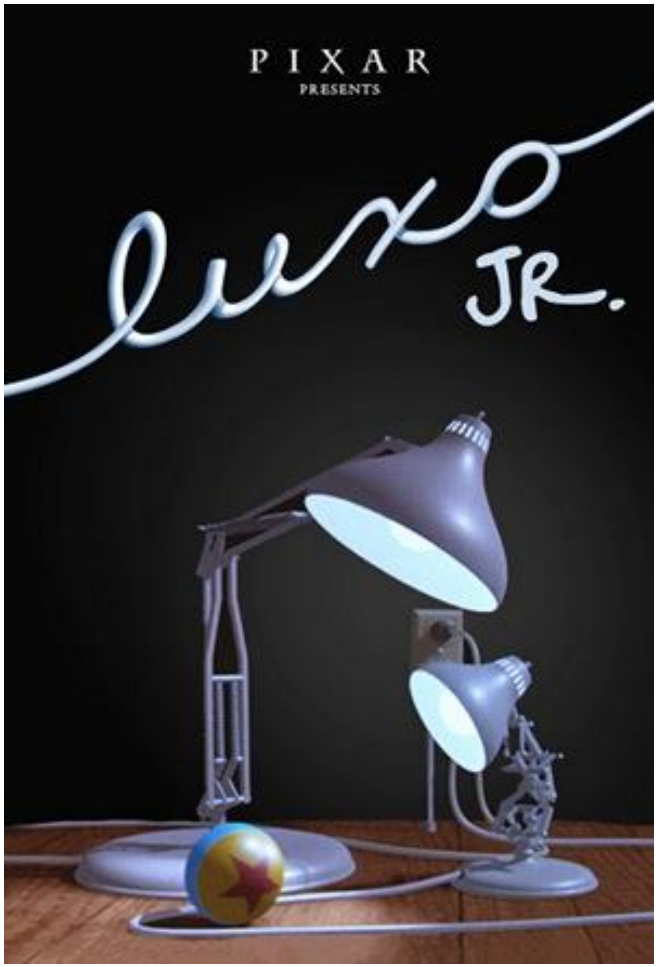
- How to simulate the movement of …?
  - Liquid
  - Human
  - Animal
  - Cloth
  - …

Applications

- Entertainment:
  - Movies
  - Games
- Scientific visualization:
  - Medical imaging
- Computer-aided design.
- Computer-aided education:
  - Training.

Movies

- Objectives:
  - Create special effects.
  - Make cartoons.
- Challenges:
  - High quality.
  - Photo-realistic.



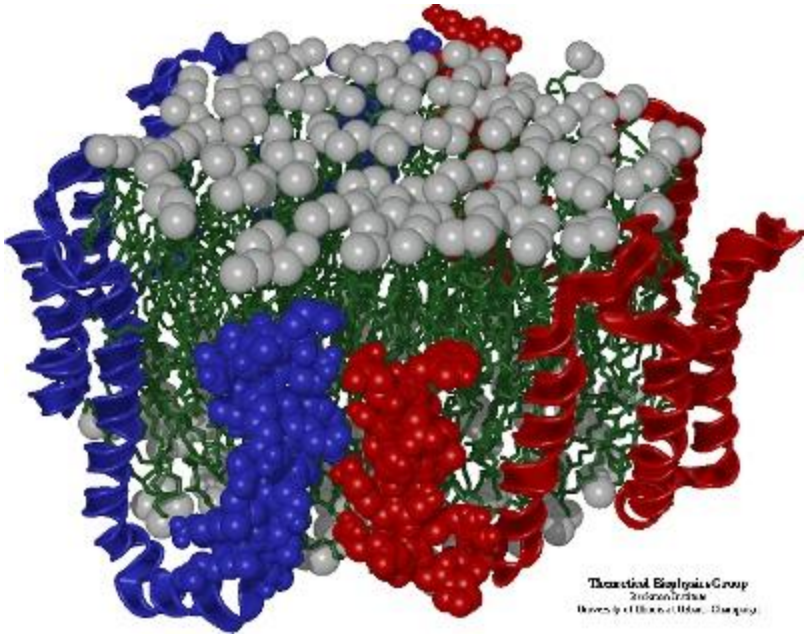
https://www.facebook.com/video.php?v=1244076069734

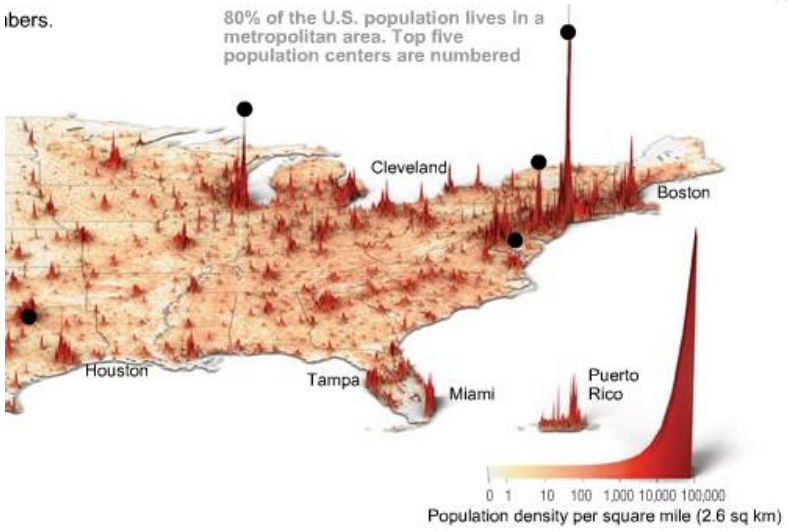
Games

- Objectives:
  - Fun games.
- Challenges:
  - Interactivity.

Data Visualization

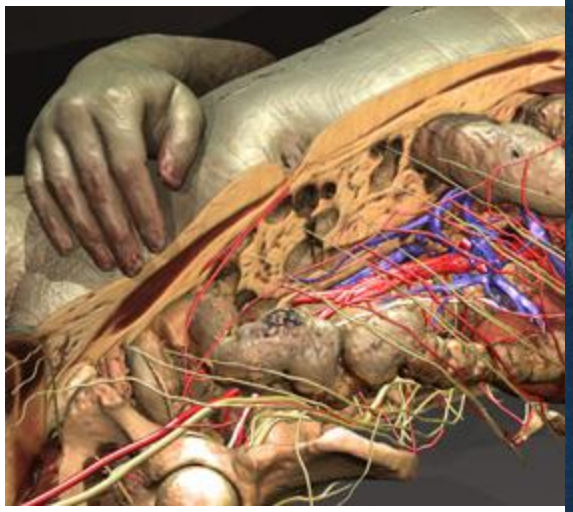
- Objectives:
  - Visualize data
- Challenges:
  - Huge datasets.





Medical Imaging

- Objectives:
  - Represent the measuring results visually.
  - Help to diagnose.

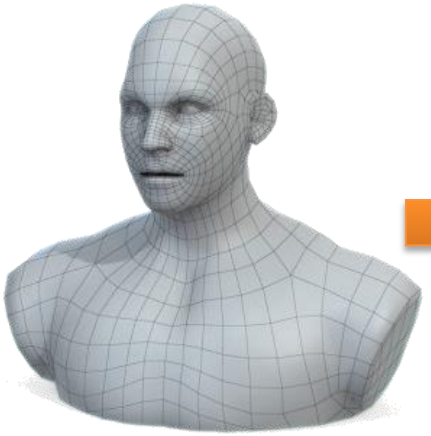


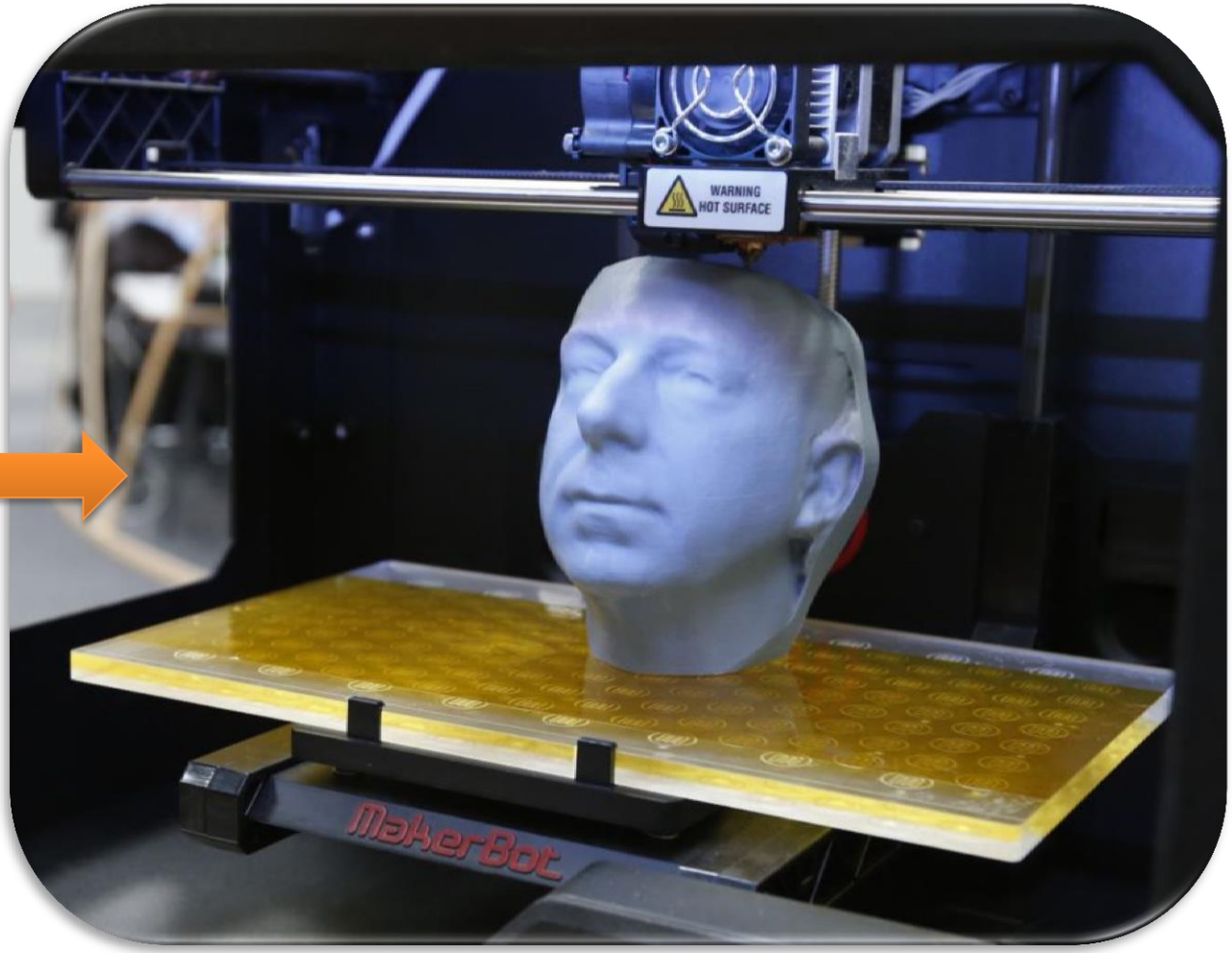
The visible human project

Computer-aided Design

- Objectives:
  - Shorten the design circle.

3D Printing





Give 3D Printer Color

Computational Hydrographic Printing

Yizhong Zhang, Chunji Yin, Changxi Zheng, Kun Zhou

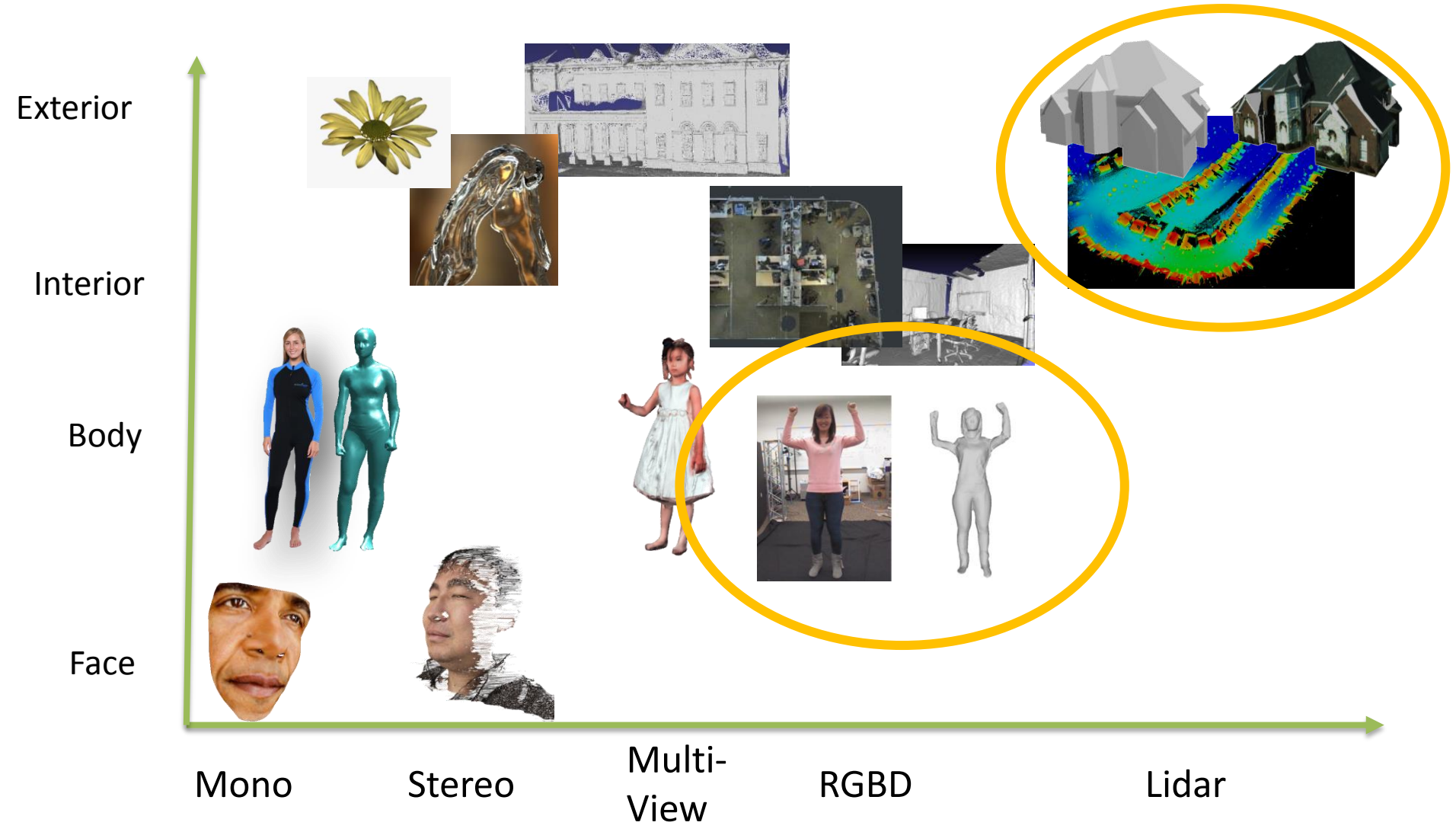
http://gaps-zju.org/hydrographics/index.html

Computer-aided Education

- Objectives:
  - Create virtual environments.

GRAPHICS/VISIO RESEARCH @ GRAVITY

My 3D Research



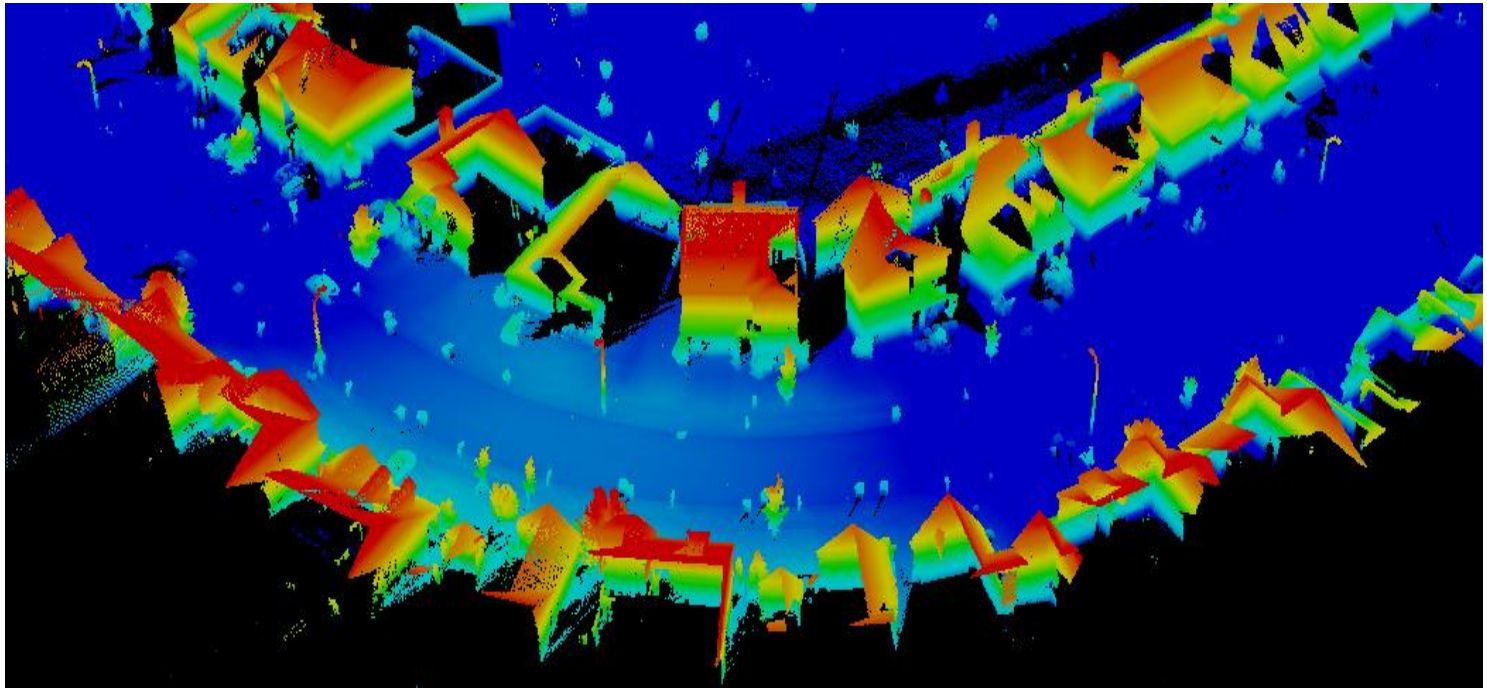
3D Reconstruction of Water

Residential Scene Modeling

- Receives little attention but equally important!
- They are everywhere!

Residential Scene Modeling

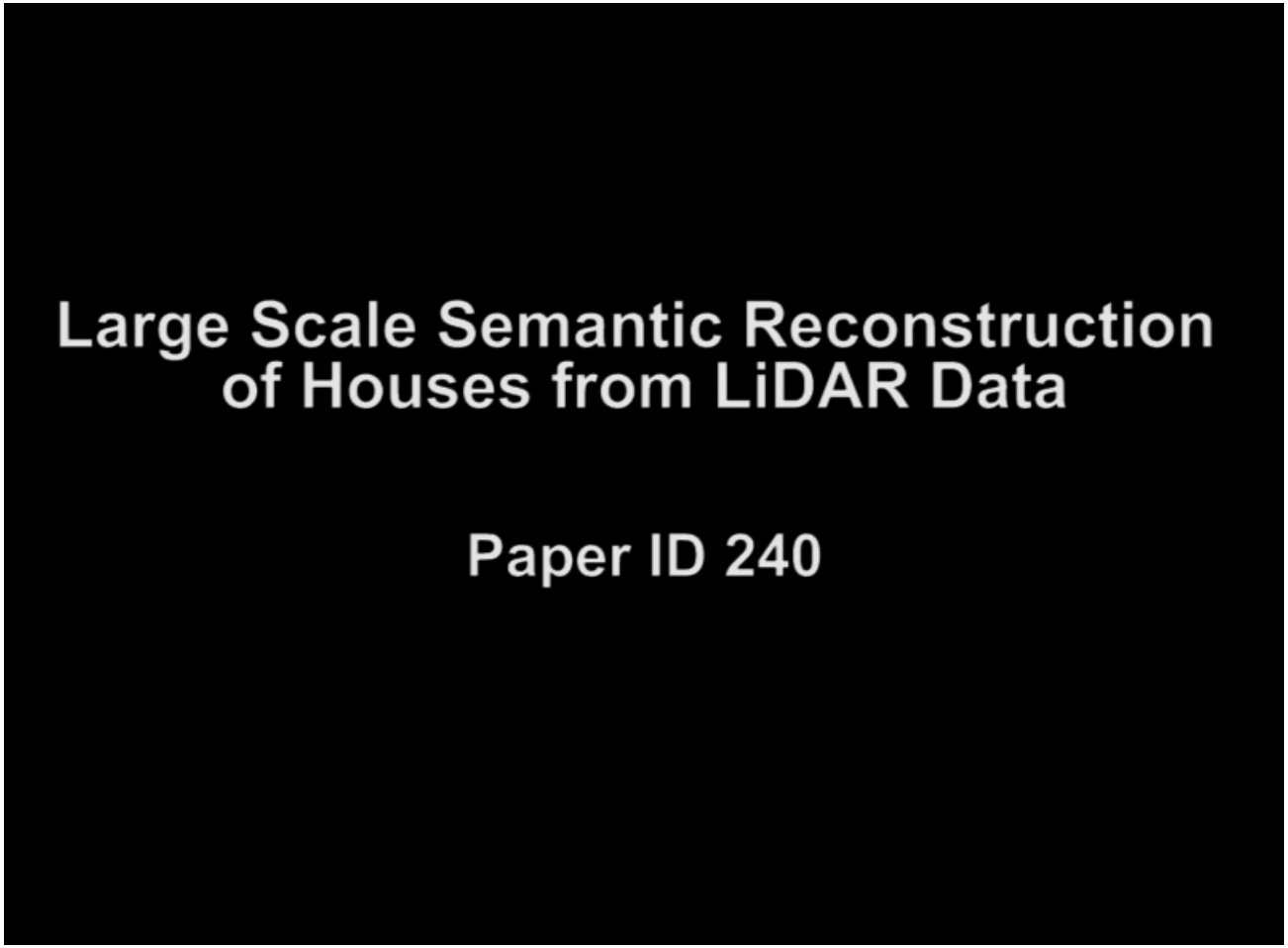
- Input: ground-based LiDAR point clouds with geo-registered images



Residential Scene Modeling

- Output: ***complete*** 3D models with textures of common objects in a residential scene

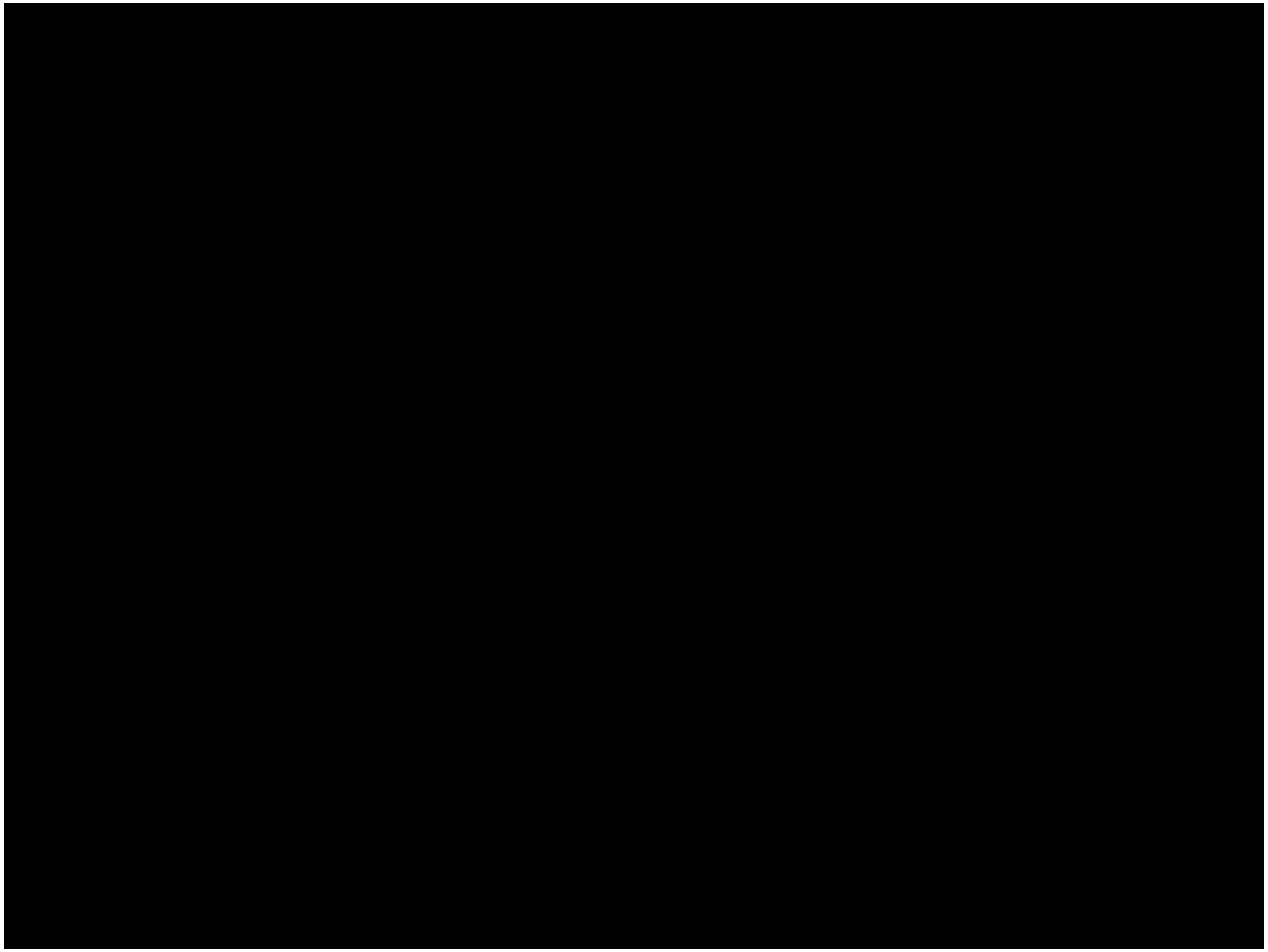
Show Video


Large Scale Semantic Reconstruction
of Houses from LiDAR Data
Paper ID 240

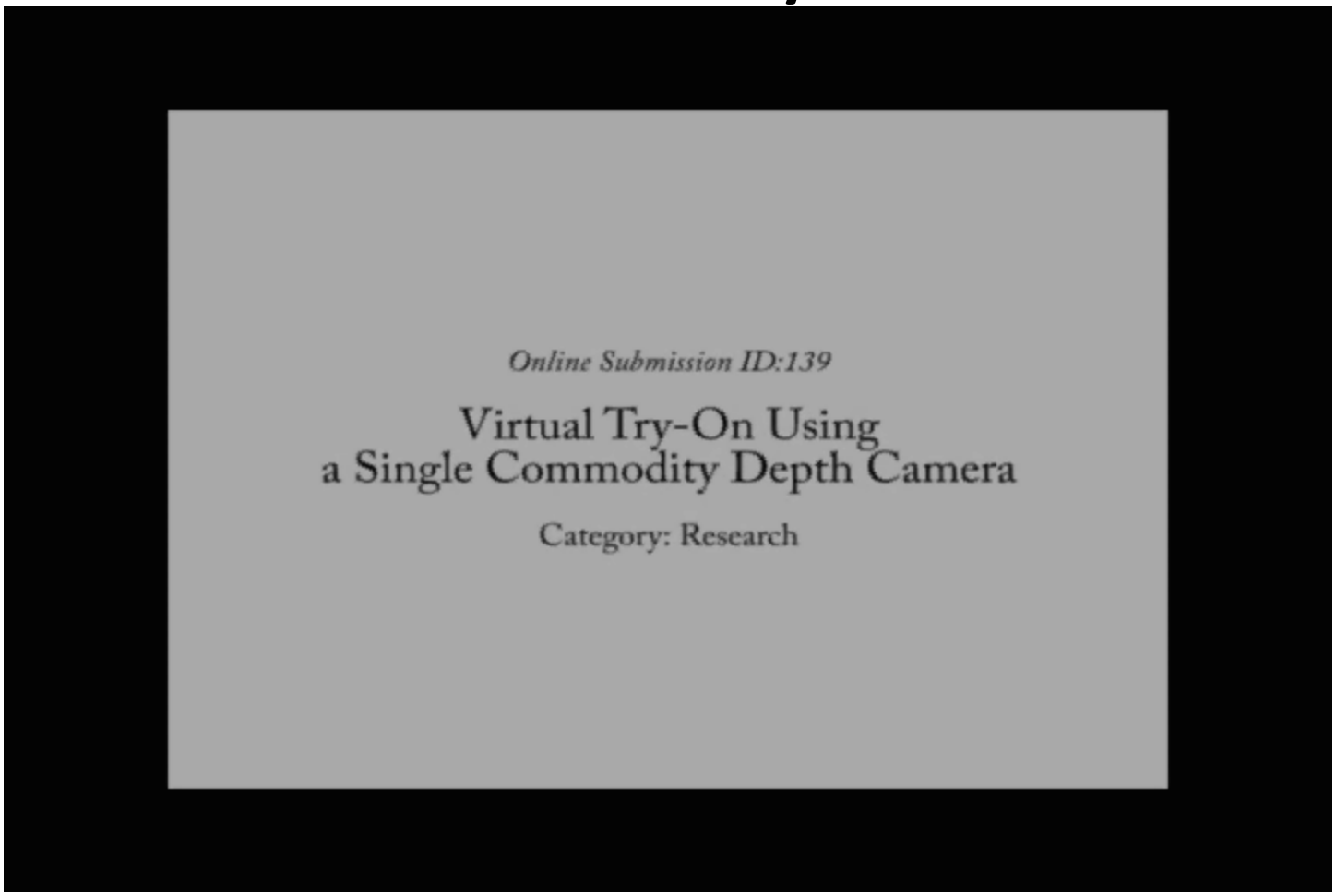
3D Body Scanning

- Play

Pose Tracking

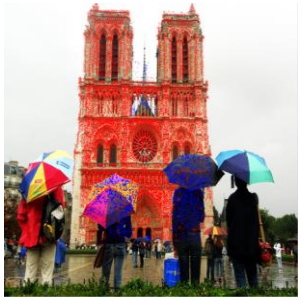


Virtual Try-on



Automatic Segmentation

Image with bounding box for Grabcut (4th Column)



Background (red) color seeds
Foreground (blue) color seeds

Results of our automatic algorithm

Results of Grabcut

Stereoscopic Conversion

Original Image

Stereo: Red-Cyan Anaglyph

Stereoscopic Conversion

Original Image

Stereo: Red-Cyan Anaglyph

FOV Expansion

Original Image

FOV Expanded

FOV Expansion

Original Image

FOV Expanded

FOV Expansion

Content aware resizing case

Original Image

FOV Expanded

FOV Expansion

Original Image

FOV Expanded

FOV Expansion

Original Image

FOV Expanded

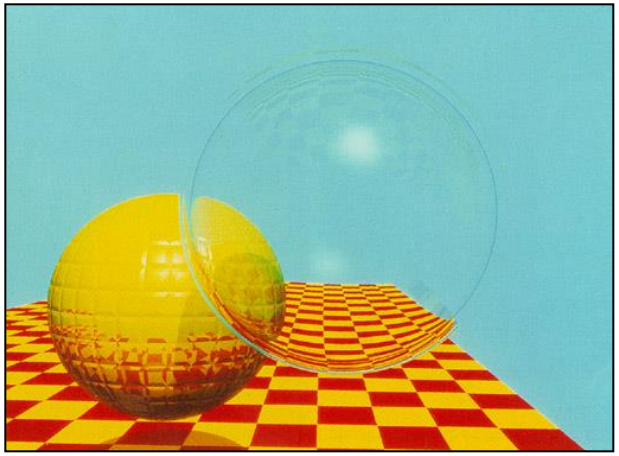
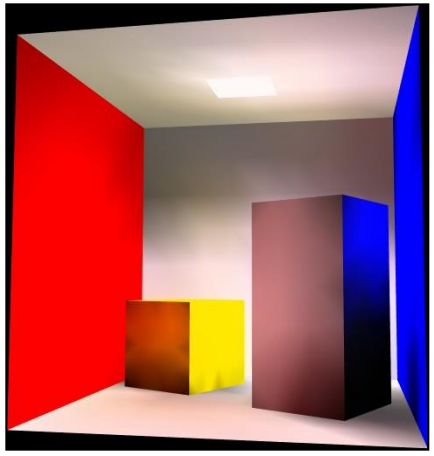
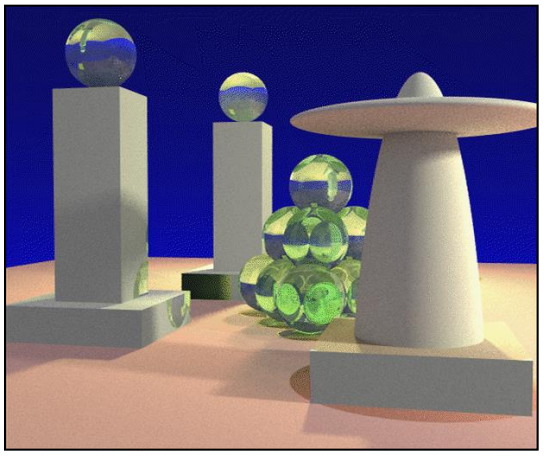
Thank you

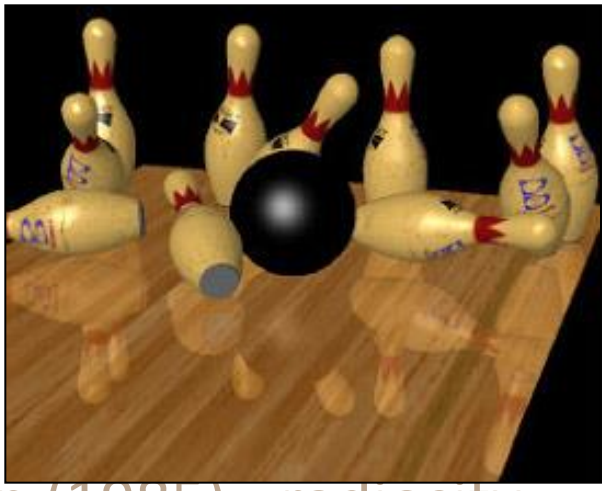
Random Cool Stuffs

The Evolution of Computer Graphics

Sketchpad ,
1963 Ivan Sutherland

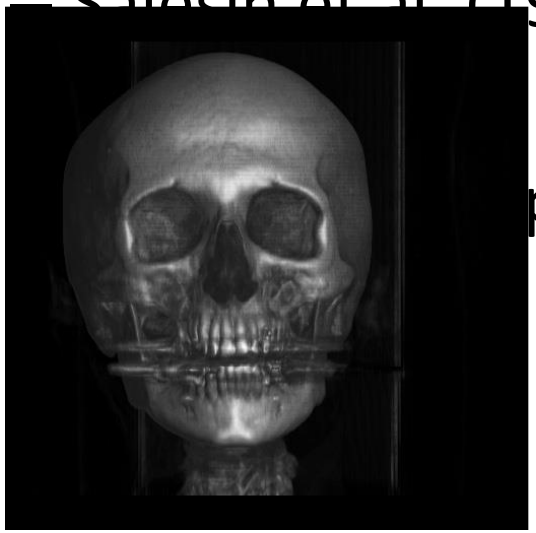
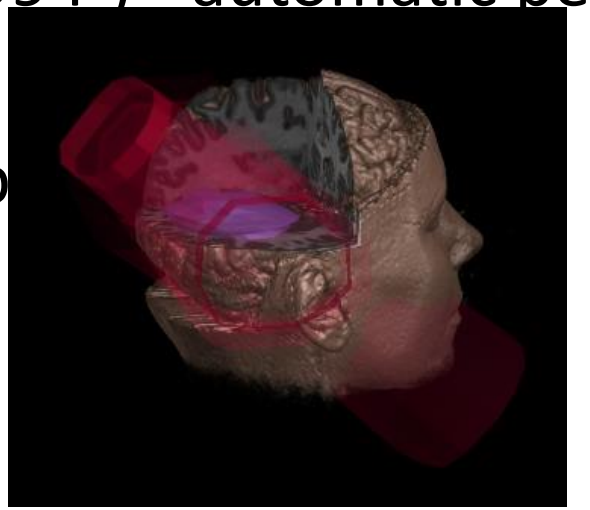
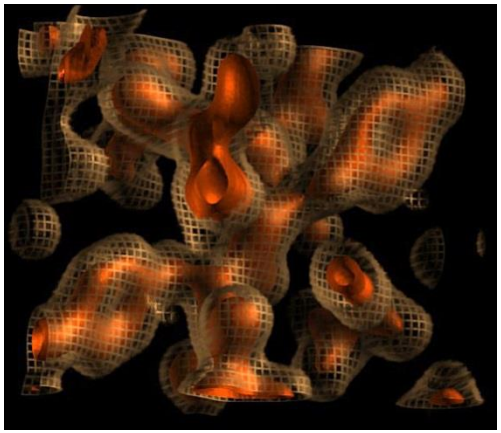
- early 1980s - global illumination
  - Whitted (1980) - ray tracing
  - Goral, Torrance et al. (1984), Cohen (1985) - radiosity
  - Kajiya (1986) - the rendering equation



- e[illegible]ba[illegible]n
  - r[illegible]
  - Goral, Torrance et [illegible]en (1985) - radiosity
  - Kajiya (1986) - the [illegible]ation
- late 1980s - photorealism
  - Cook (1984) - shade trees
  - Perlin (1985) - shading languages
  - Hanrahan and Lawson (1990) - RenderMan

- early 1990s - non-photorealistic rendering
  - Drebin et al. (1988), Levoy (1988) - volume rendering
  - Haeberli (1990) - impressionistic paint programs
  - Salesin et al. (1994-) - automatic pen-and-ink p

The Evolution of Computer Graphics

What is Reality

Safari File Edit View History Bookmarks Window Help (0:57) Fri 2:16 PM

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http://www.nvidia.com/content/nvision2008/tech_presentations/Technology_Keynotes/NVISION08-Tech_Keynote-GPU.pdf

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CoreDataTutorial

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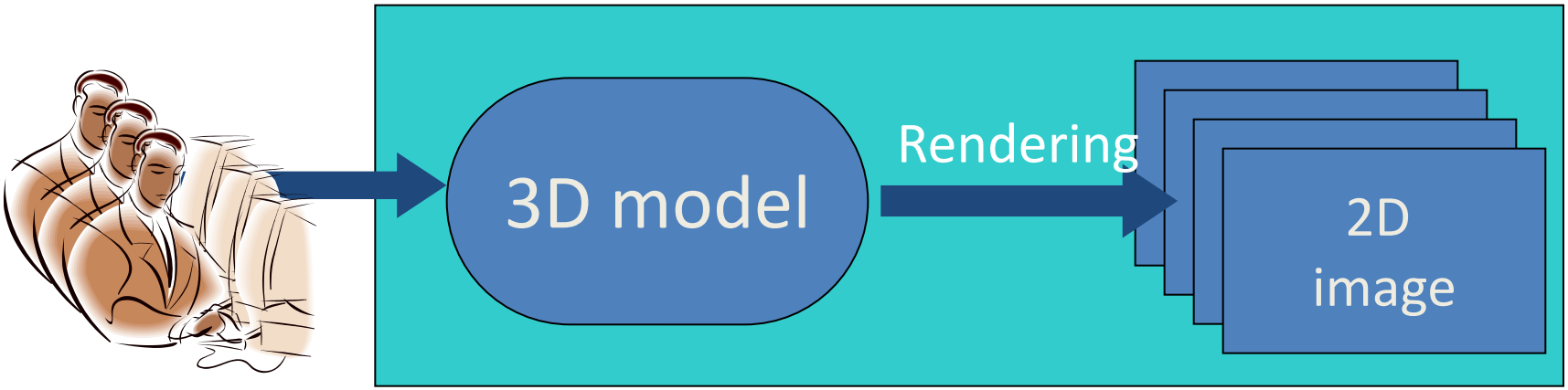
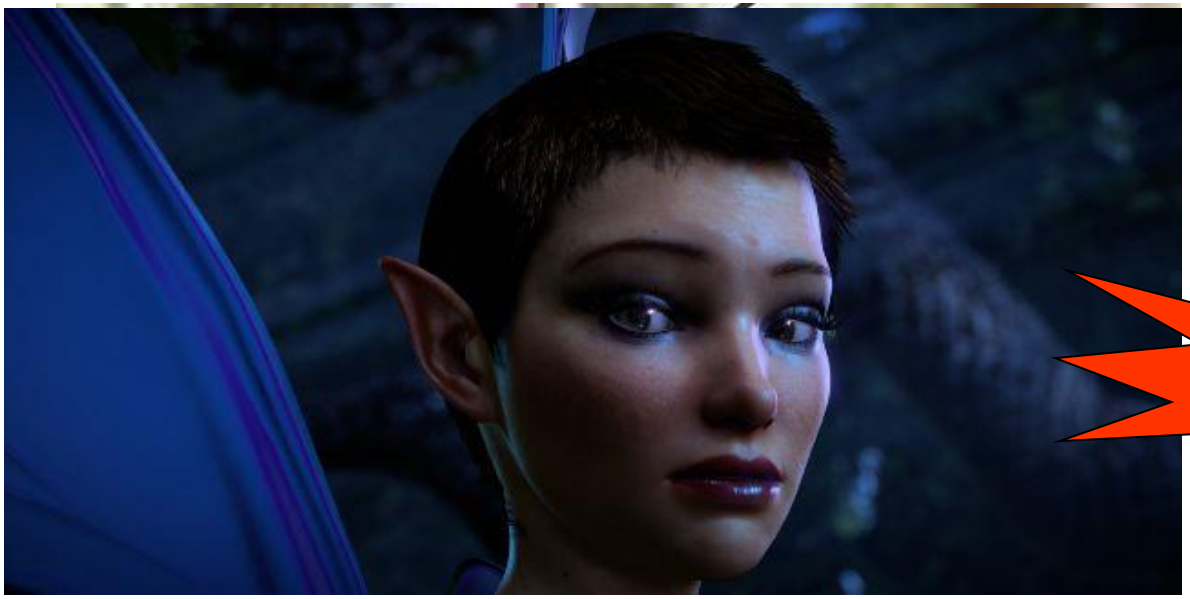
CoreDataTutorial

Traditional Rendering





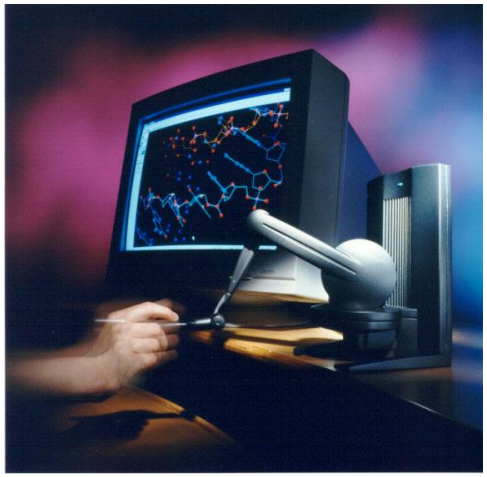
Real-time Rendering on
NVIDIA, 2012

Photo Realism

What Is Multimedia?

- **Multimedia** is media and content that uses a combination of different content forms
- It includes a combination of text, audio, still images, animation, video, or interactivity content forms.

Haptic interface

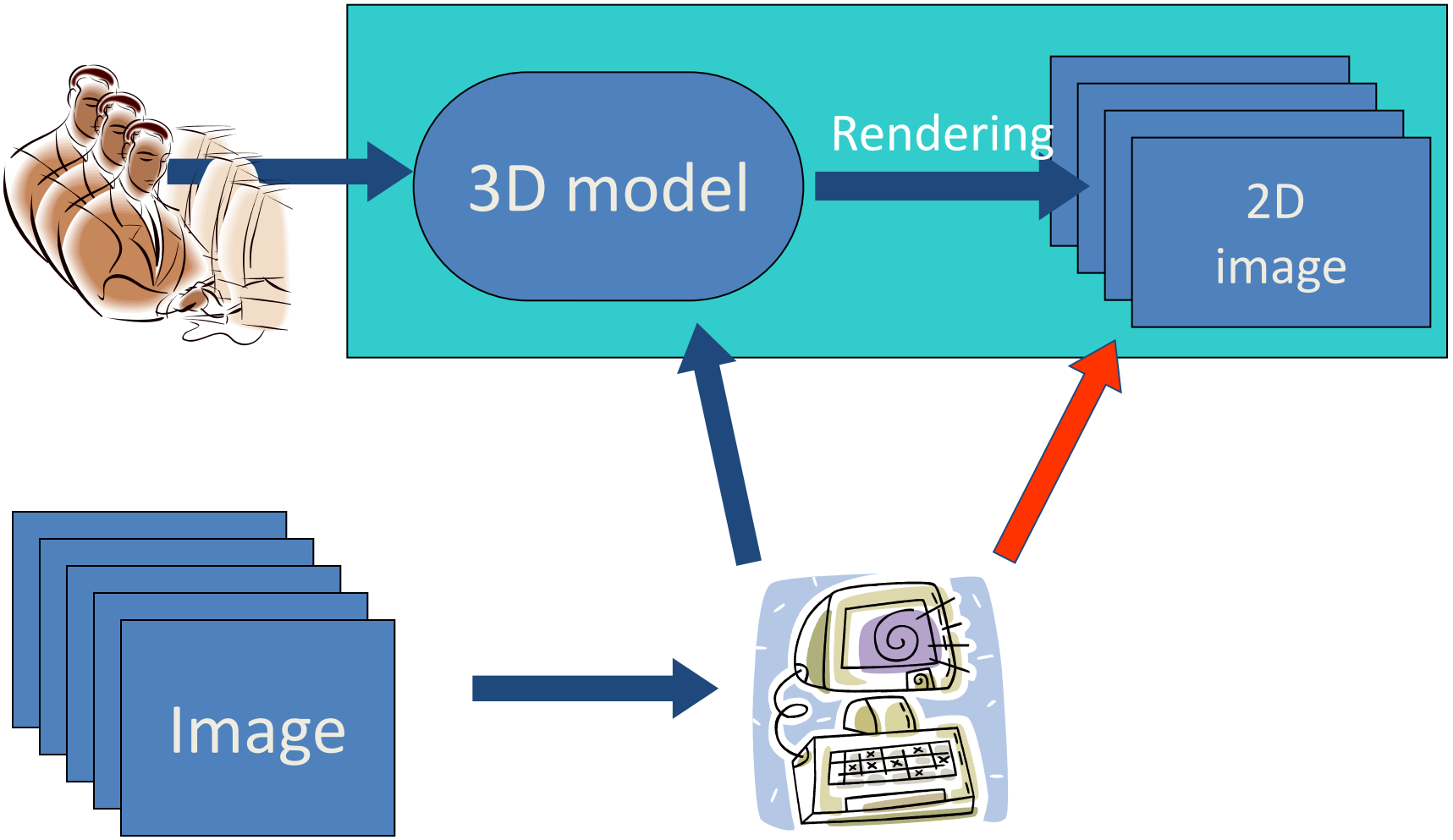


Sensable Technologies Inc.
PHANTOM Desktop

Immersion co.
Impulse stick

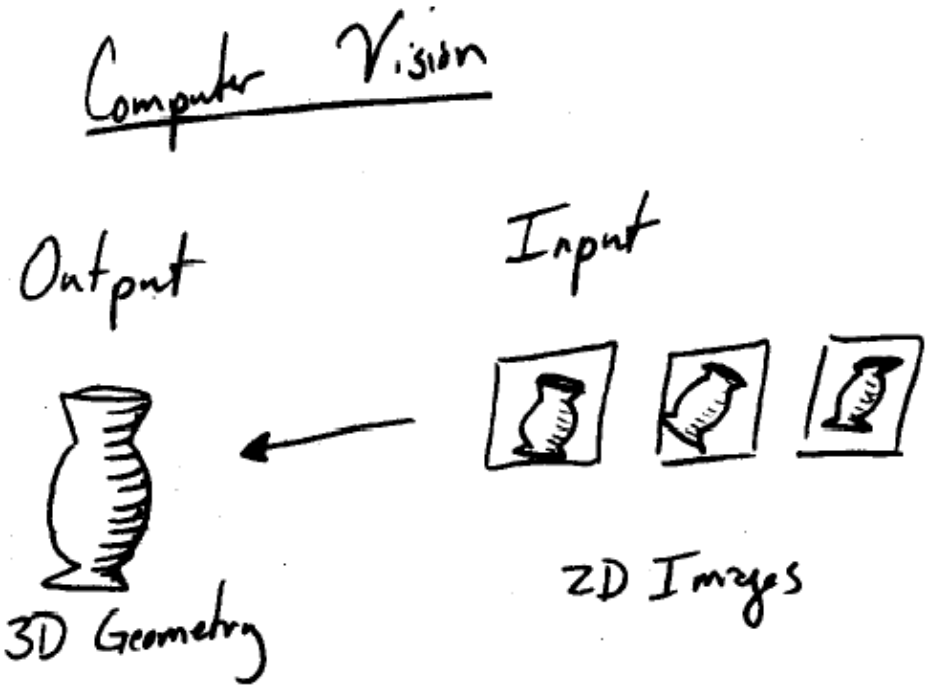
Virtual Technologies Inc.
Cyber Force

Image-Based Modeling and Rendering



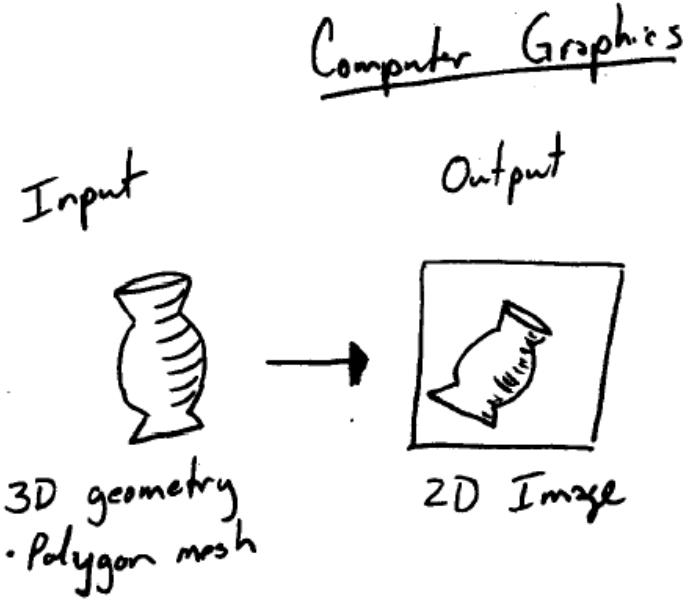
Computer Vision

- A discipline related to Artificial Intelligence
  - "Let computer see"
- Obtaining 3D models – A Branch of CV that focuses on reconstruction of 3D model from 2D images

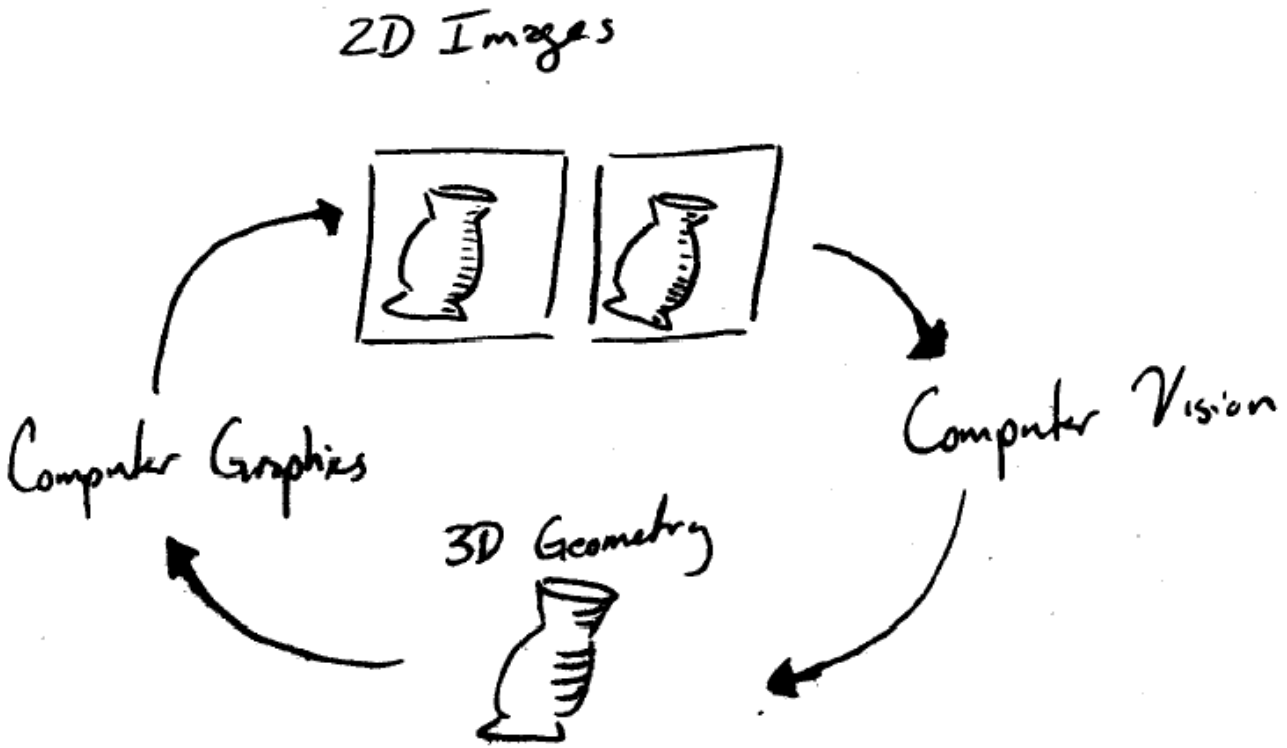


Computer Graphics

- What is the goal of computer graphics again
- Given a 3D model, we'll make a 2D image



Bridge the Gap between Computer Graphics & Computer Vision

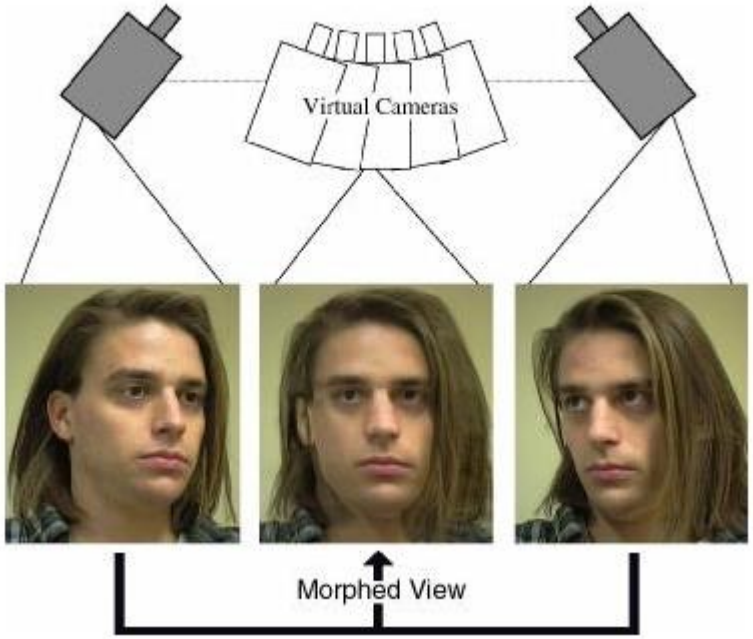


State of the Art

Image Inpainting

http://www.iua.upf.es/~mbertalmio//restoration.html

View Morphing



http://www.cs.washington.edu/homes/seitz/vmorph/vmorph.htm

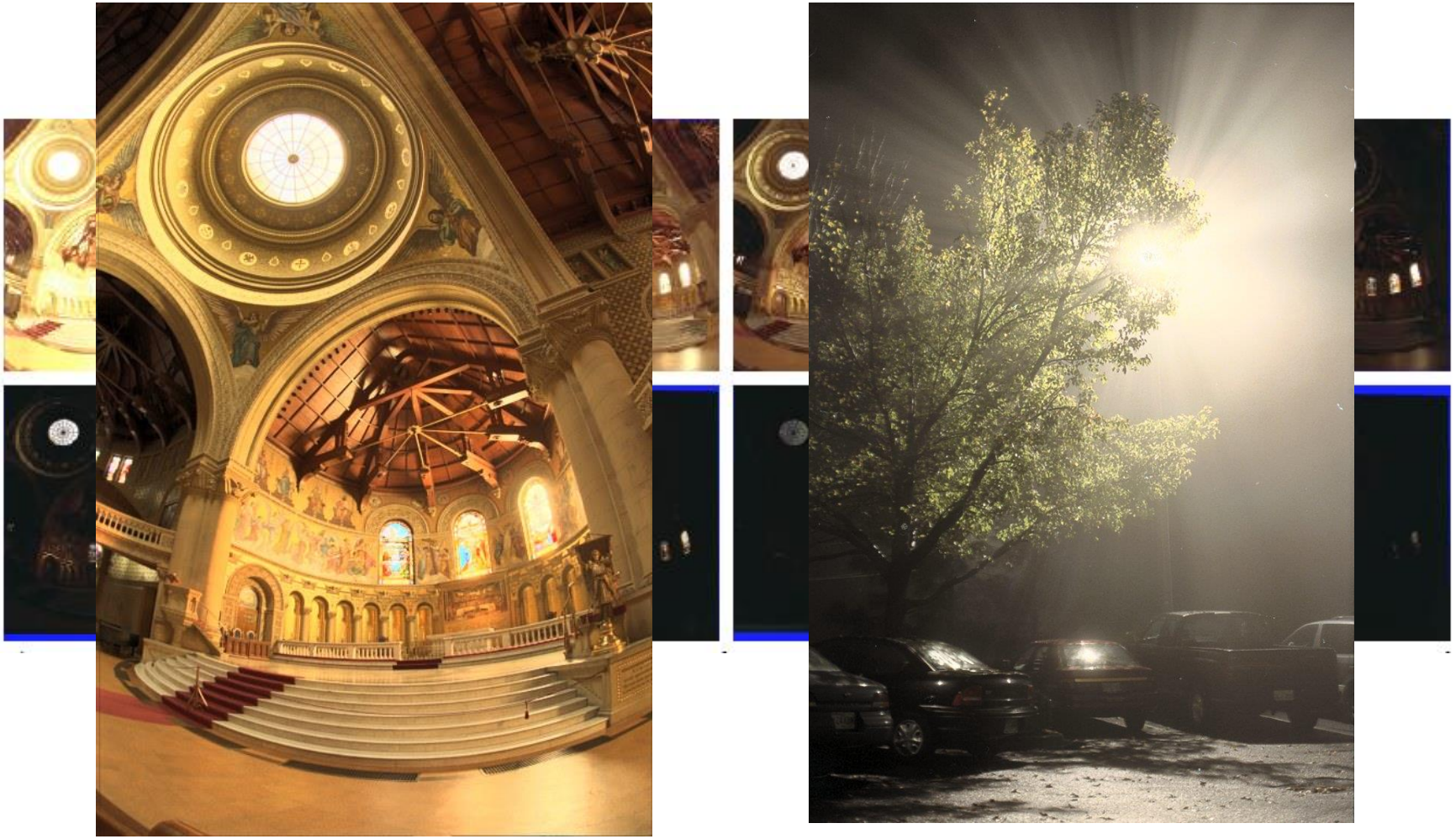
Matting

http://www.cs.ust.hk/~leojia/all_final_papers/matting_siggraph04.pdf

Interactive Digital Photomontage

http://grail.cs.washington.edu/projects/photomontage/photomontage.pdf

High-Dynamic Imaging



Colorization Using Optimization

http://www.cs.huji.ac.il/~yweiss/Colorization/index.html

Giga Images

http://research.microsoft.com/ivm/HDView.htm

SIGGRAPH 2007 Capturing and Viewing Gigapixel Images
Johannes Kopf, Matt Uyttendaele, Oliver Deussen, Michael Cohen

Photo Tourism

Exploring photo collections in 3D

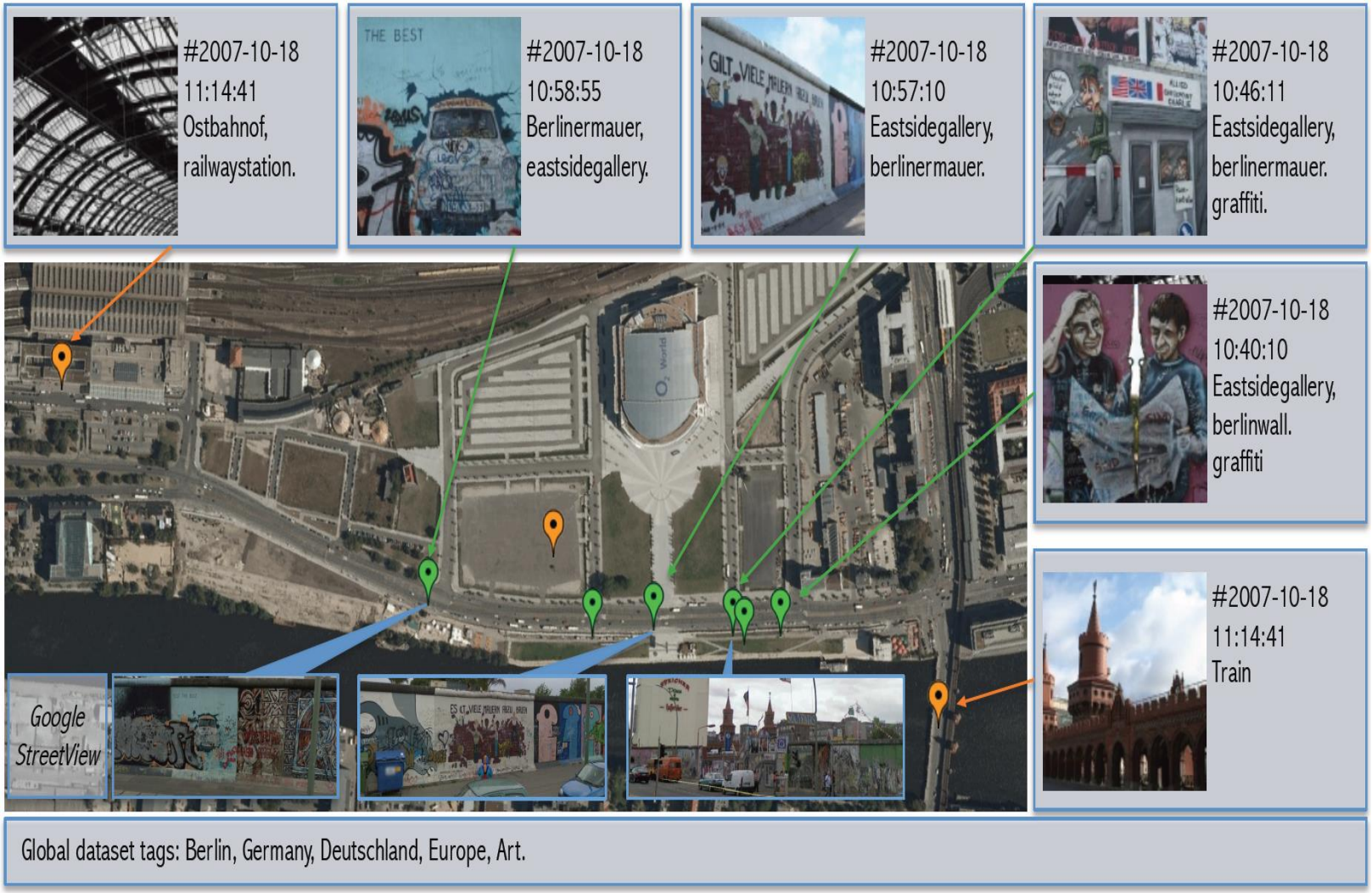
Microsoft

(a)

(b)

(c)

GEO-Tagging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railwaystation.
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10:58:55
Berlinermauer,
eastsidegallery.
#2007-10-18
10:57:10
Eastsidegallery,
berlinermauer.
#2007-10-18
10:46:11
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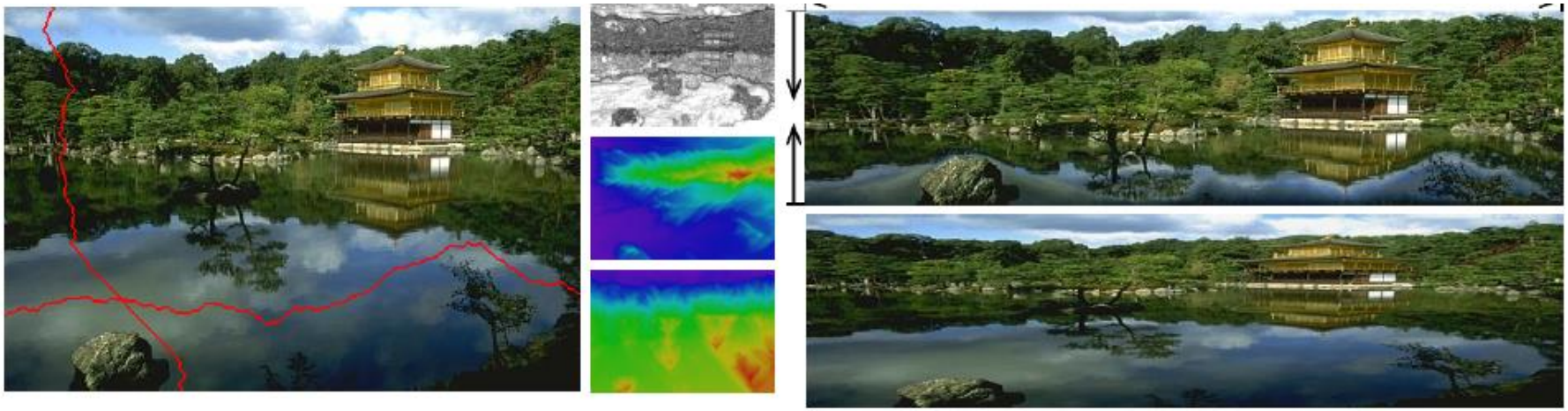
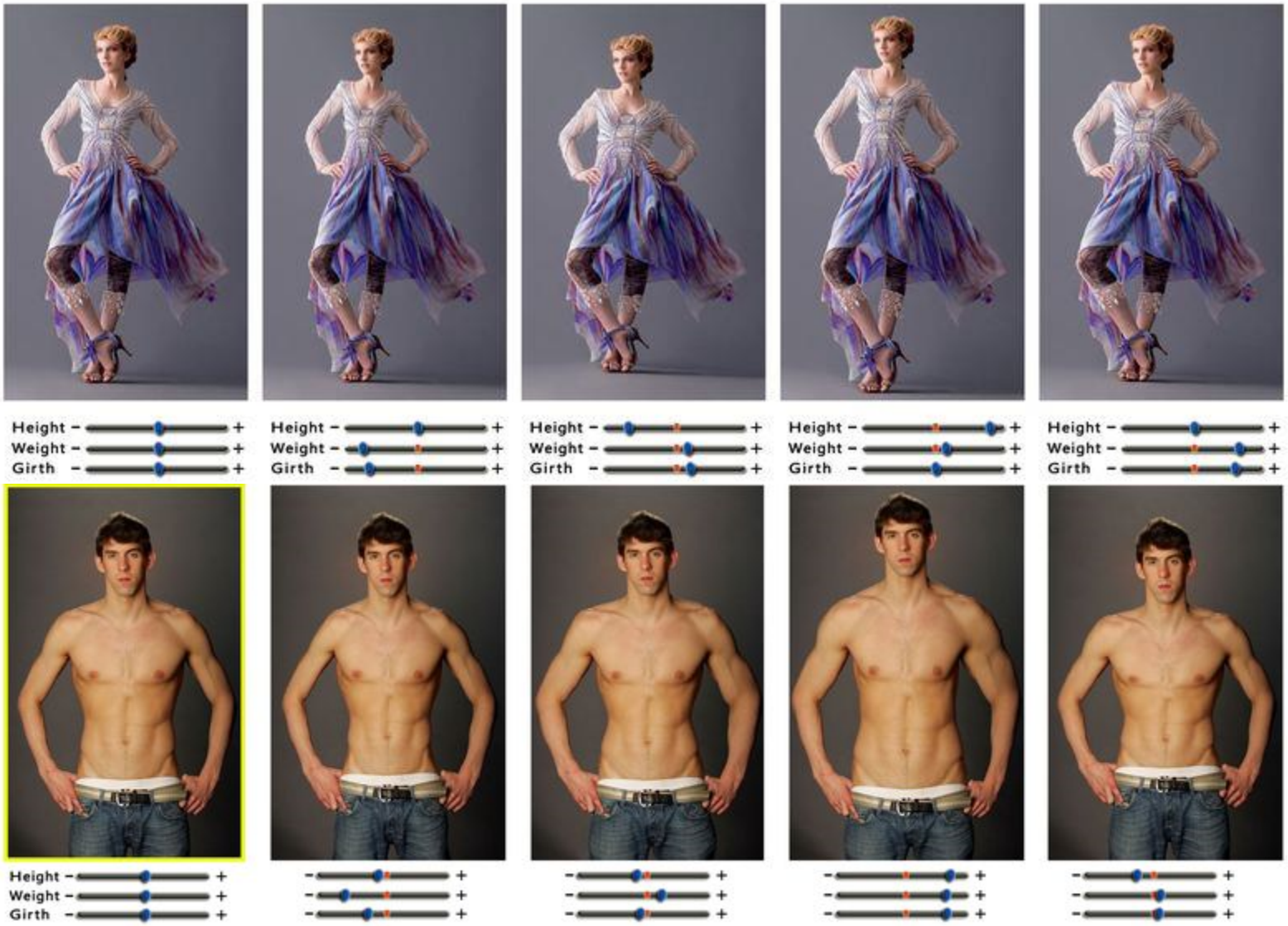
berlinermauer.
graffiti.
#2007-10-18
10:40:10
Eastsidegallery,
berlinwall.
graffiti
#2007-10-18
11:14:41
Train
Google
StreetView
Global dataset tags: Berlin, Germany, Deutschland, Europe, Art.

Seam Carving for Content-Aware Image Resizing



http://www.youtube.com/watch?v=vIFCV2spKtg

Parametric Reshaping of Human Bodies in Images



Depixelizing Pixel Art

http://research.microsoft.com/en-us/um/people/kopf/pixelart/supplementary/index.html

INTRODUCTION

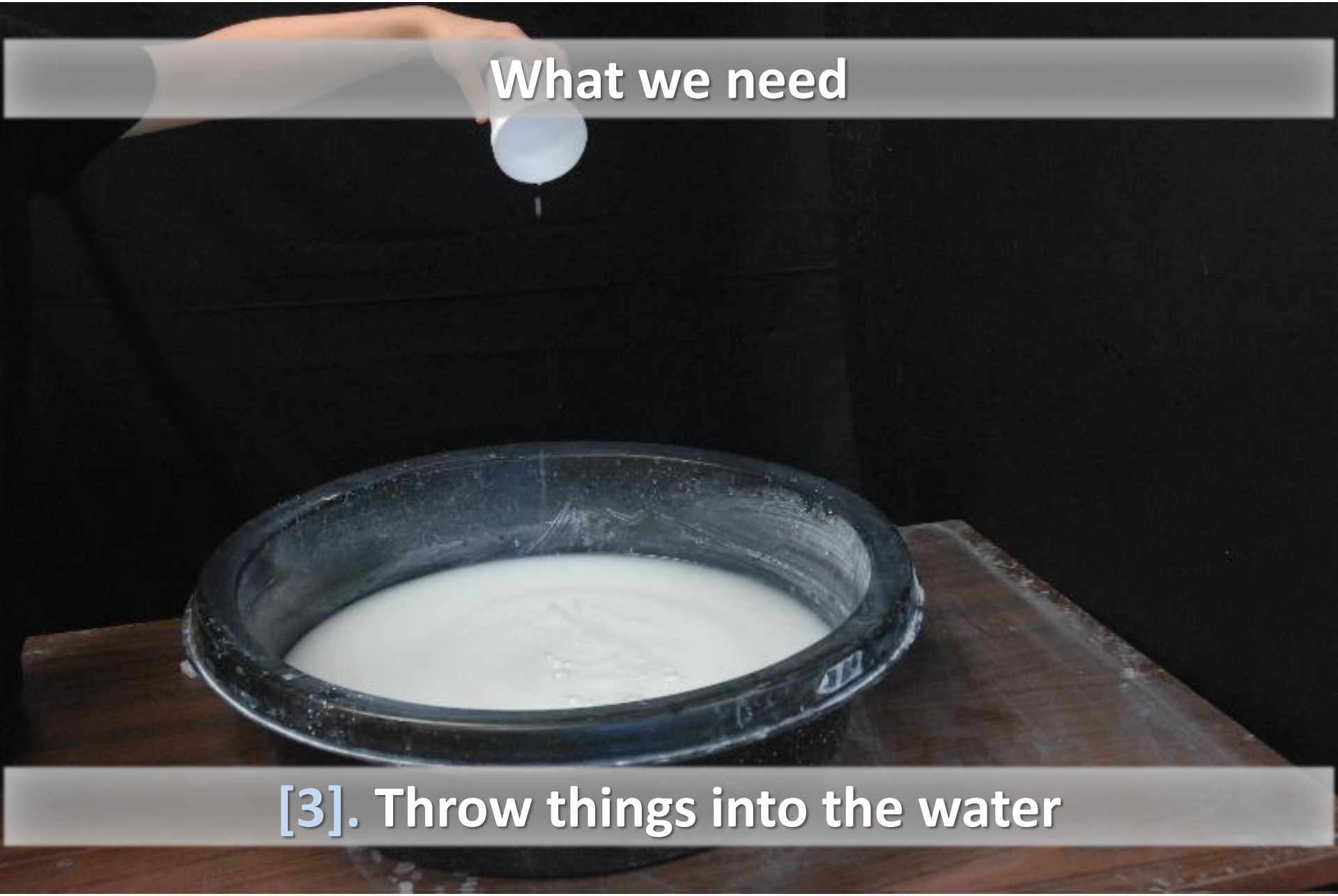
Problem: How to model the water?

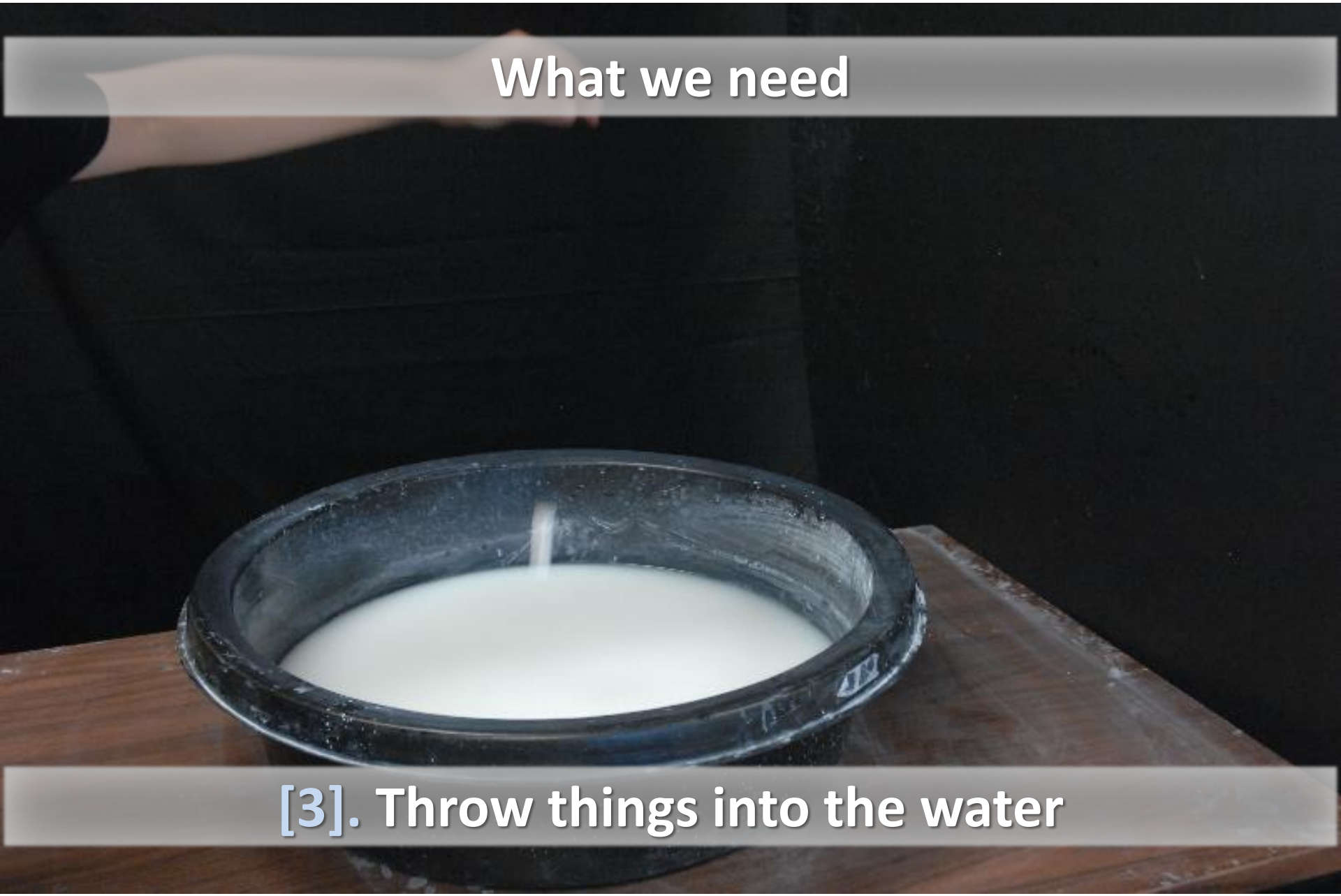
What we need

[1]. High speed cameras

What we need

[2]. Dye the water


What we need
[3]. Throw things into the water


What we need
[3]. Throw things into the water

What we need

[4]. Apply physical model and then …

Why Engineering

Thank you

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