CS559: Computer Graphics

Lecture 42: 3D Photography

Li Zhang

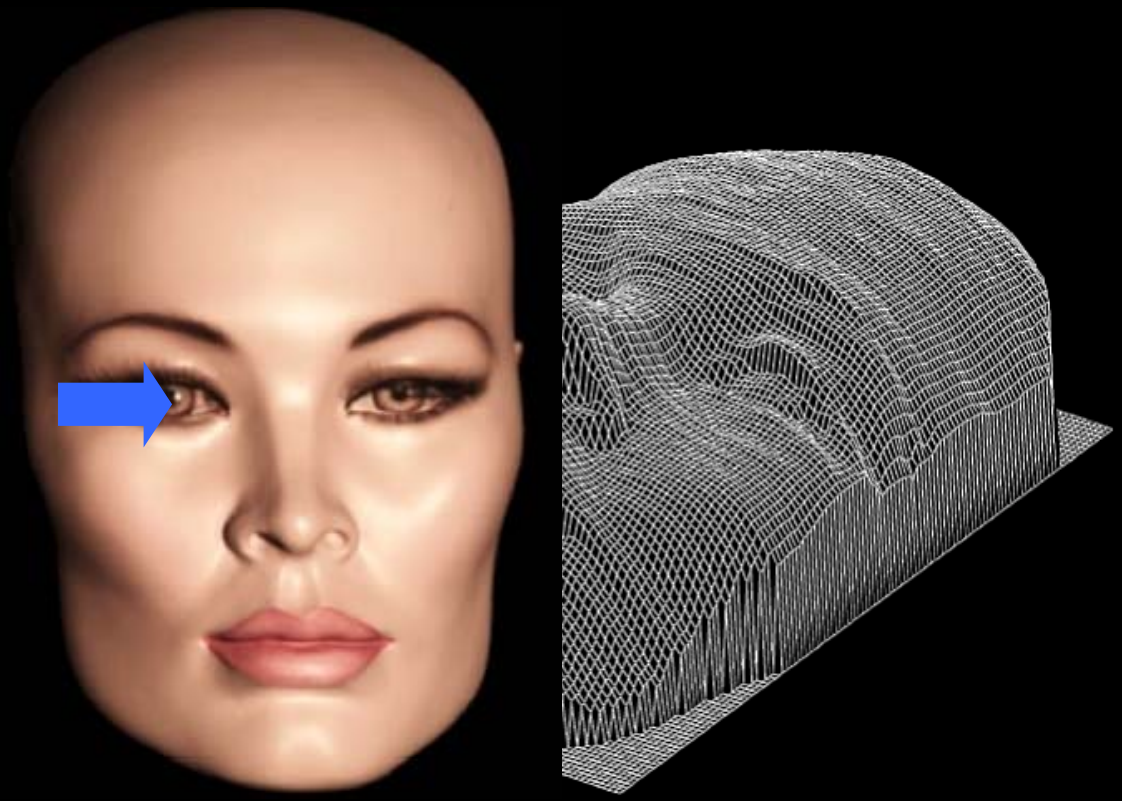
Spring 2008

Today

- 3D Photography

- Reading
  - NO

What is 3D Photography?

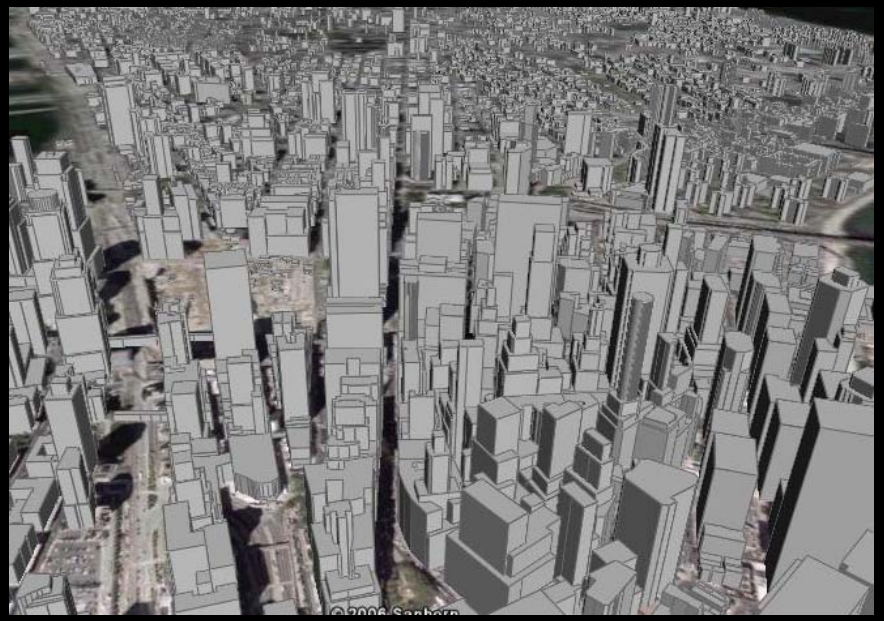


Computing the 3rd Dimension (depth) from 2D Photographs

Why 3D Photography?

Face Modeling

Google Earth



Virtual World

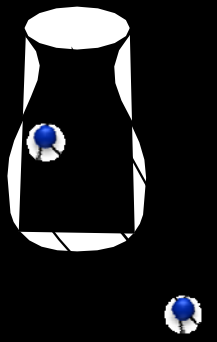
How to get a 3D model?

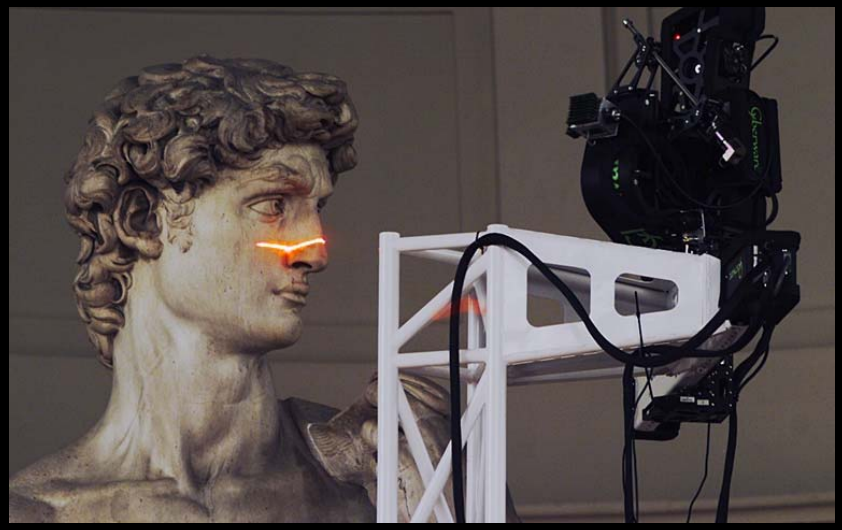
- Buy it (or find a free one)
  - Free meshes typically are not very good quality
- User defined: A user builds the mesh
  - Tools help with specifying many vertices and faces quickly
- More Automated techniques
  - Scan a real object
    - 3D probe-based systems
    - Range finders
  - Image based reconstruction
    - Take a bunch of pictures, and infer the object's shape (CS766)

Today

- Laser Scanner – Static Shapes
- Stereo – for Dynamic Surfaces
- Photometric Stereo – for Complex Reflectance

Laser Scanning



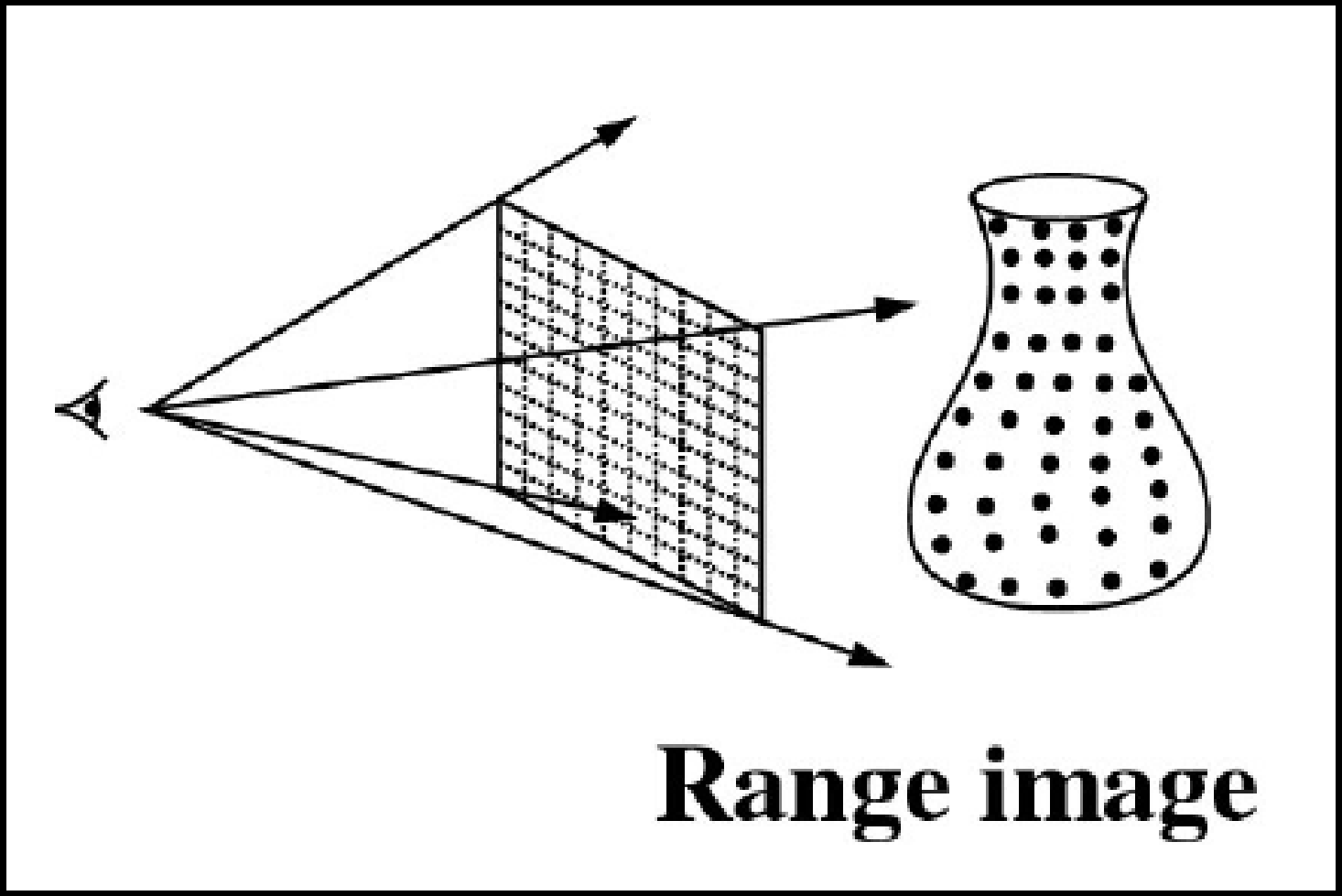


Digital Michelangelo Project
http://graphics.stanford.edu/projects/mich/

Optical triangulation

- Project a single stripe of laser light
- Scan it across the surface of the object

Laser Scanning



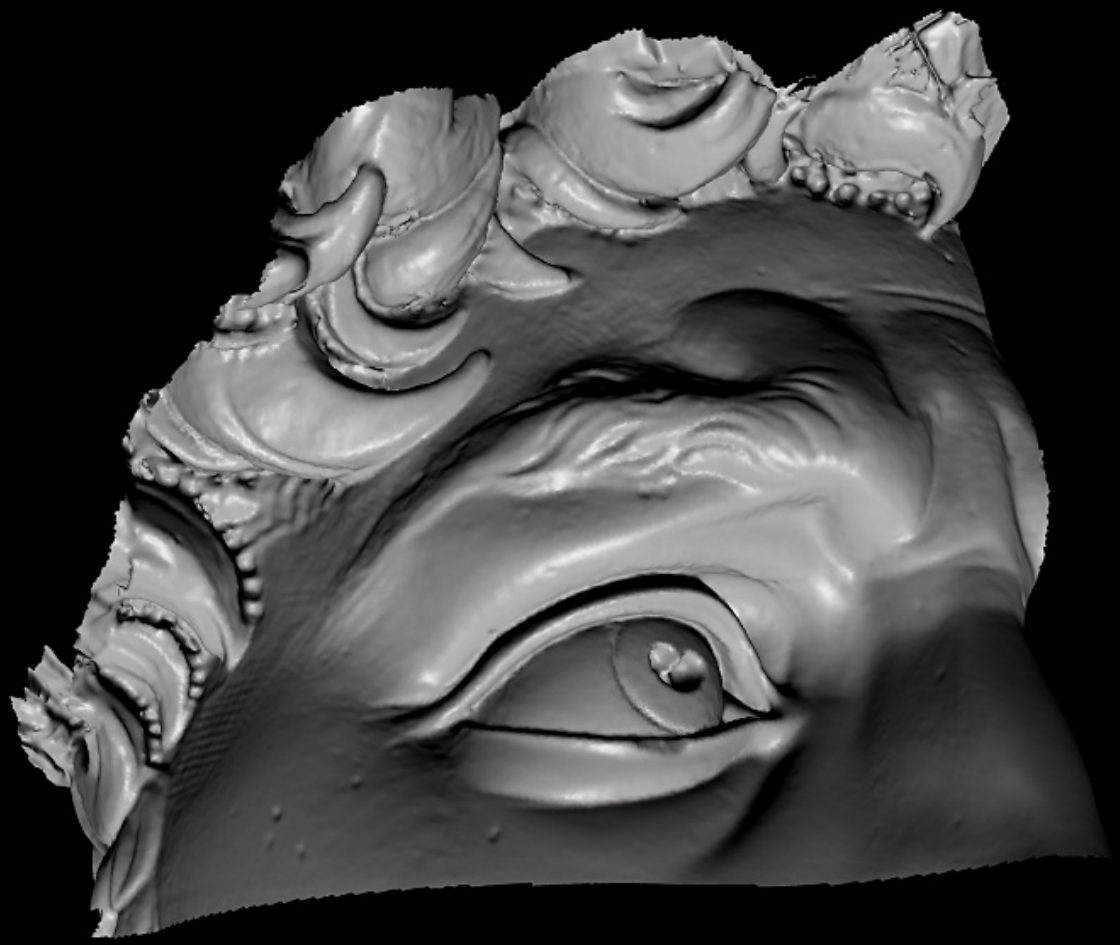
Laser scanned models

The Digital Michelangelo Project, Levoy et al.

Laser scanned models

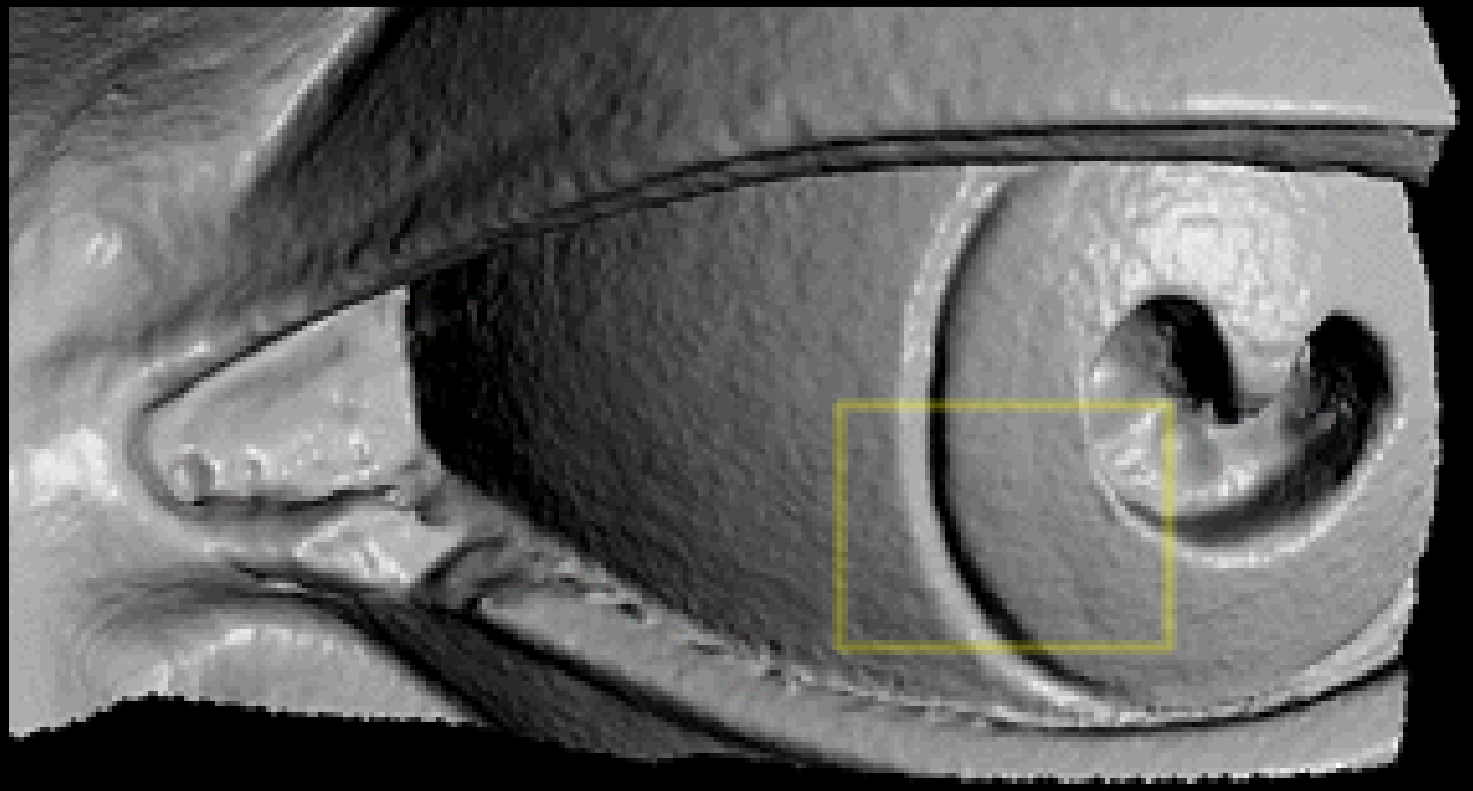
The Digital Michelangelo Project, Levoy et al.

Laser scanned models



The Digital Michelangelo Project, Levoy et al.

Laser scanned models



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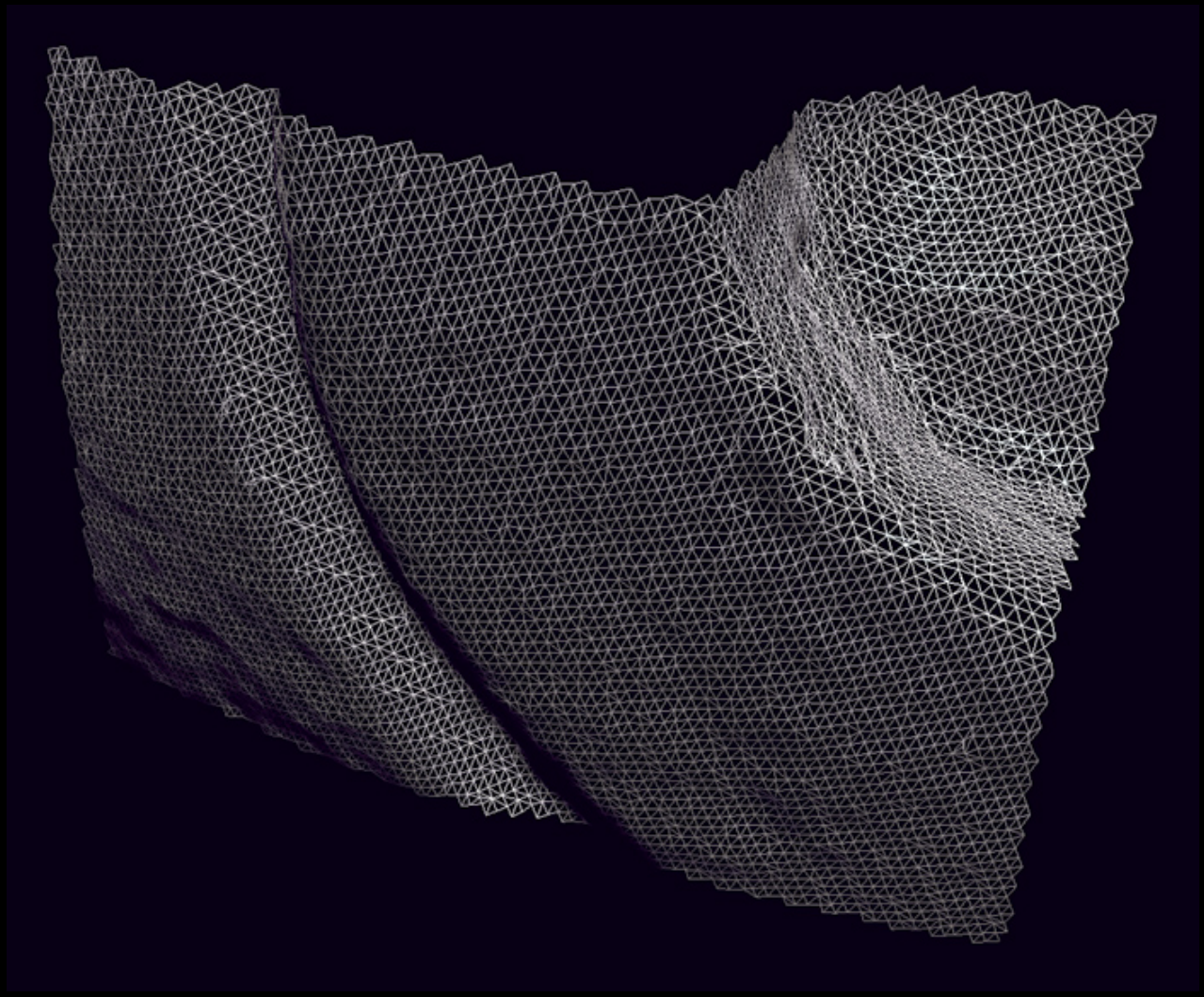


The Digital Michelangelo Project, Levoy et al.

Laser scanned models

How many triangles?

~56M

St Matthew

372 million triangles

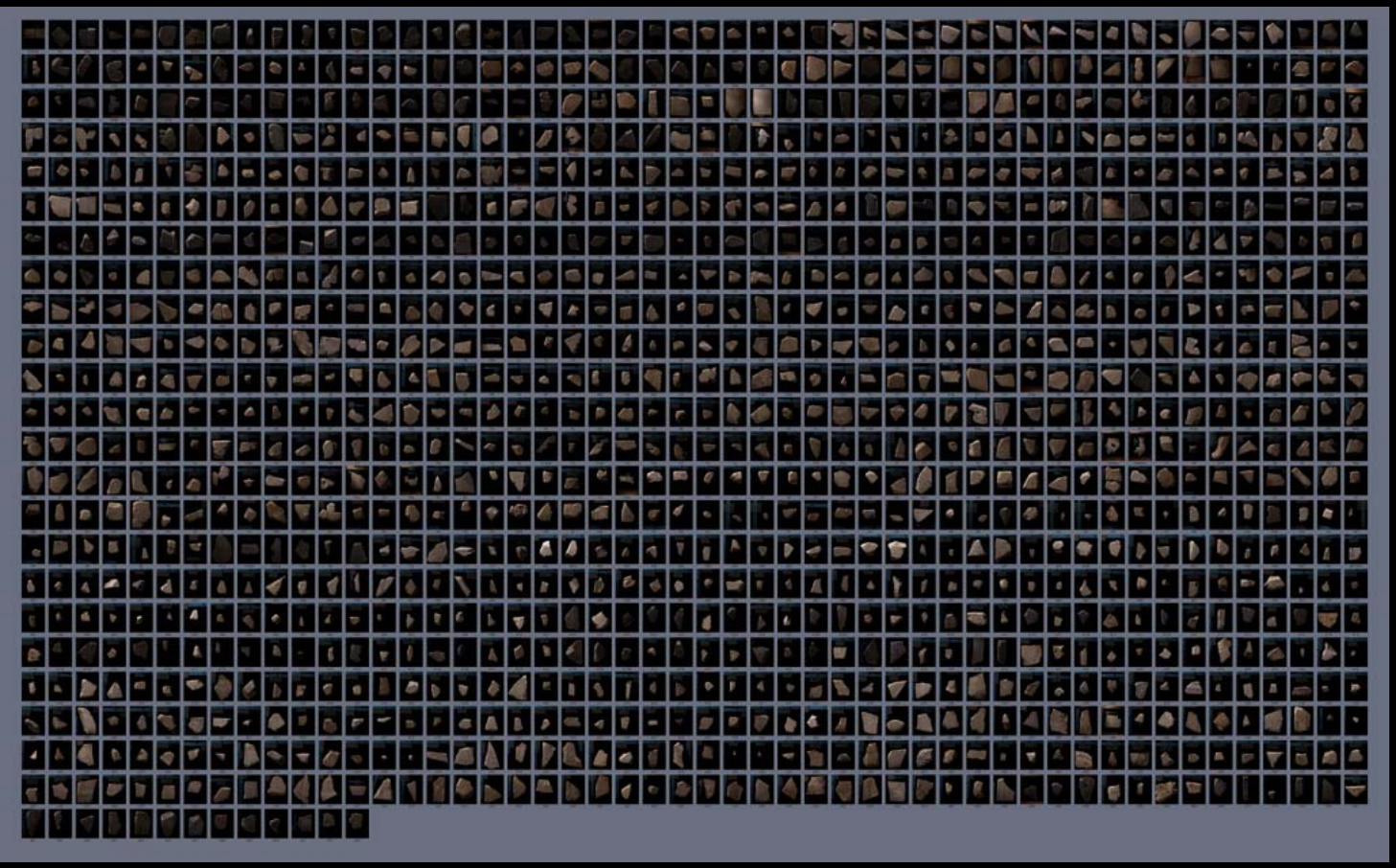
Forma Urbis Romae

- A giant marble map of ancient Rome.
  - 60 feet X 45 feet
  - in fragments:1,186 of them

3 feet long, 150 pounds

Forma Urbis Romae

- A giant marble map of ancient Rome.
  - 60 feet X 45 feet
  - in fragments:1,186 of them



8 billion polygons

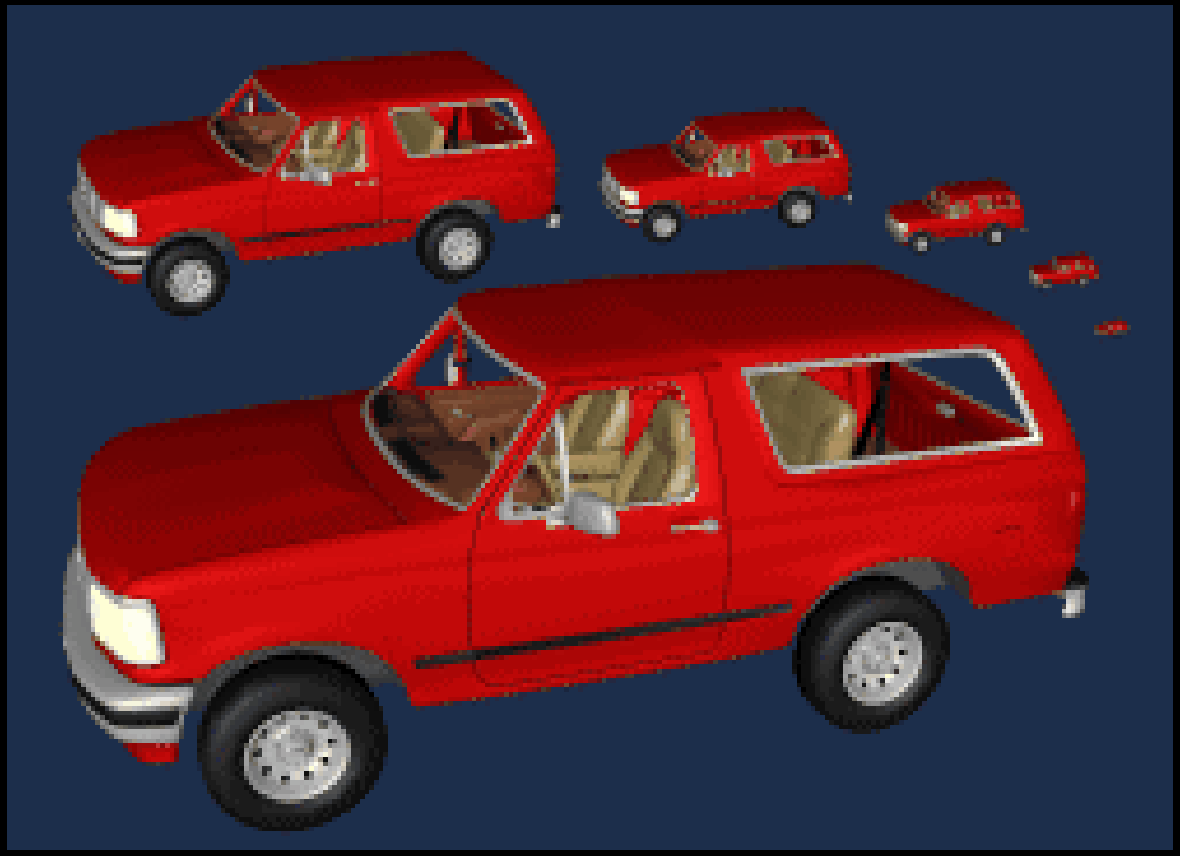
We have a problem here

- Too many triangles

Level Of Detail

- There is no point in having more than 1 polygon per pixel
- Level of detail strategies
  - balance the resolution of the mesh against the viewing conditions
    - Must have a way to reduce the complexity of meshes
    - Must have a way to switch from one mesh to another
    - An ongoing research topic, made even more important as laser scanning becomes popular
    - Also called mesh decimation, multi-resolution modeling and other things

Level of Detail

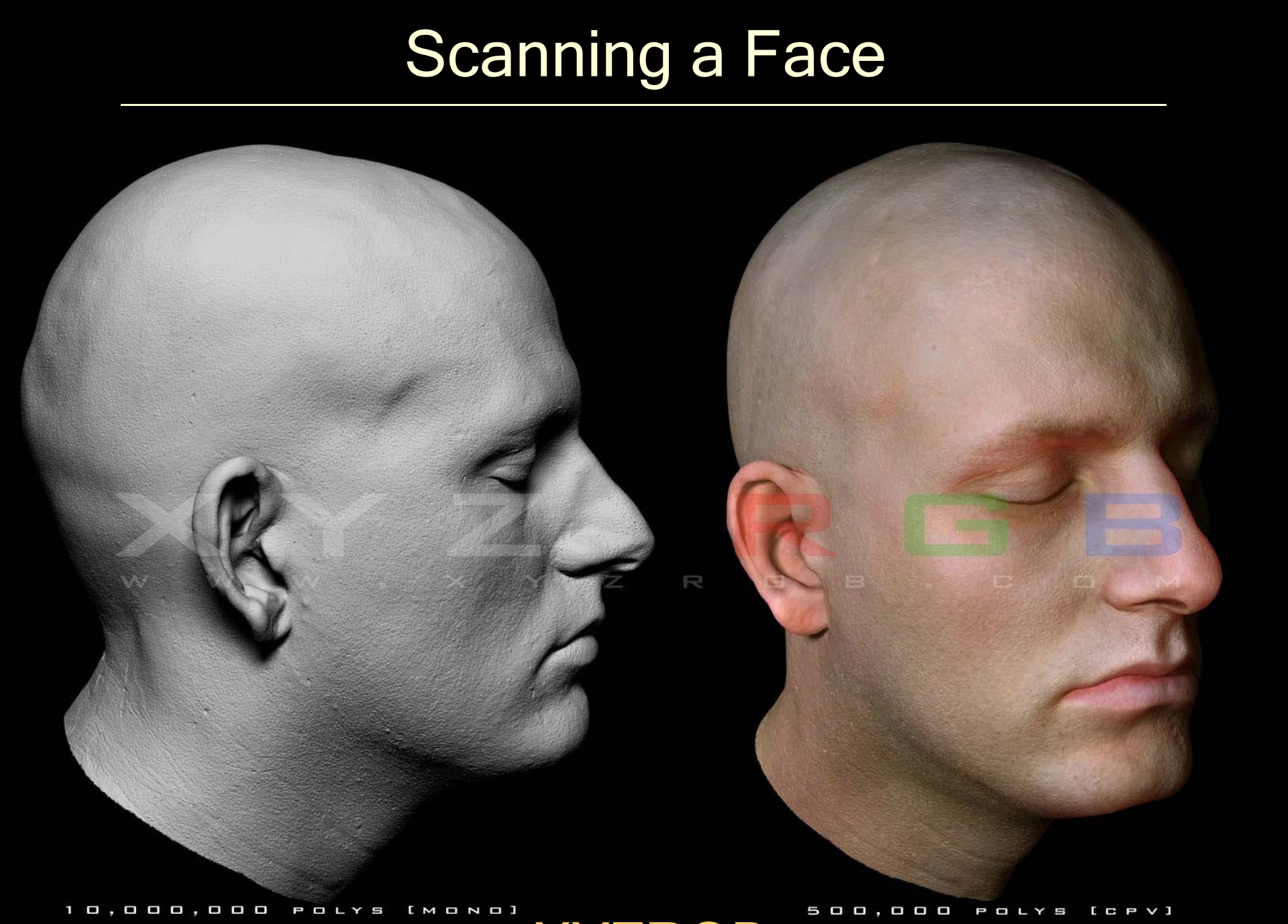


http://www.cs.unc.edu/~geom/SUCC_MAP/

Level of Detail

- Basic Idea: reducing # vertices
  - Vertex decimation
  - Edge collapsing

Scanning a Face



Scanning a Face

- Create a Plaster Mold

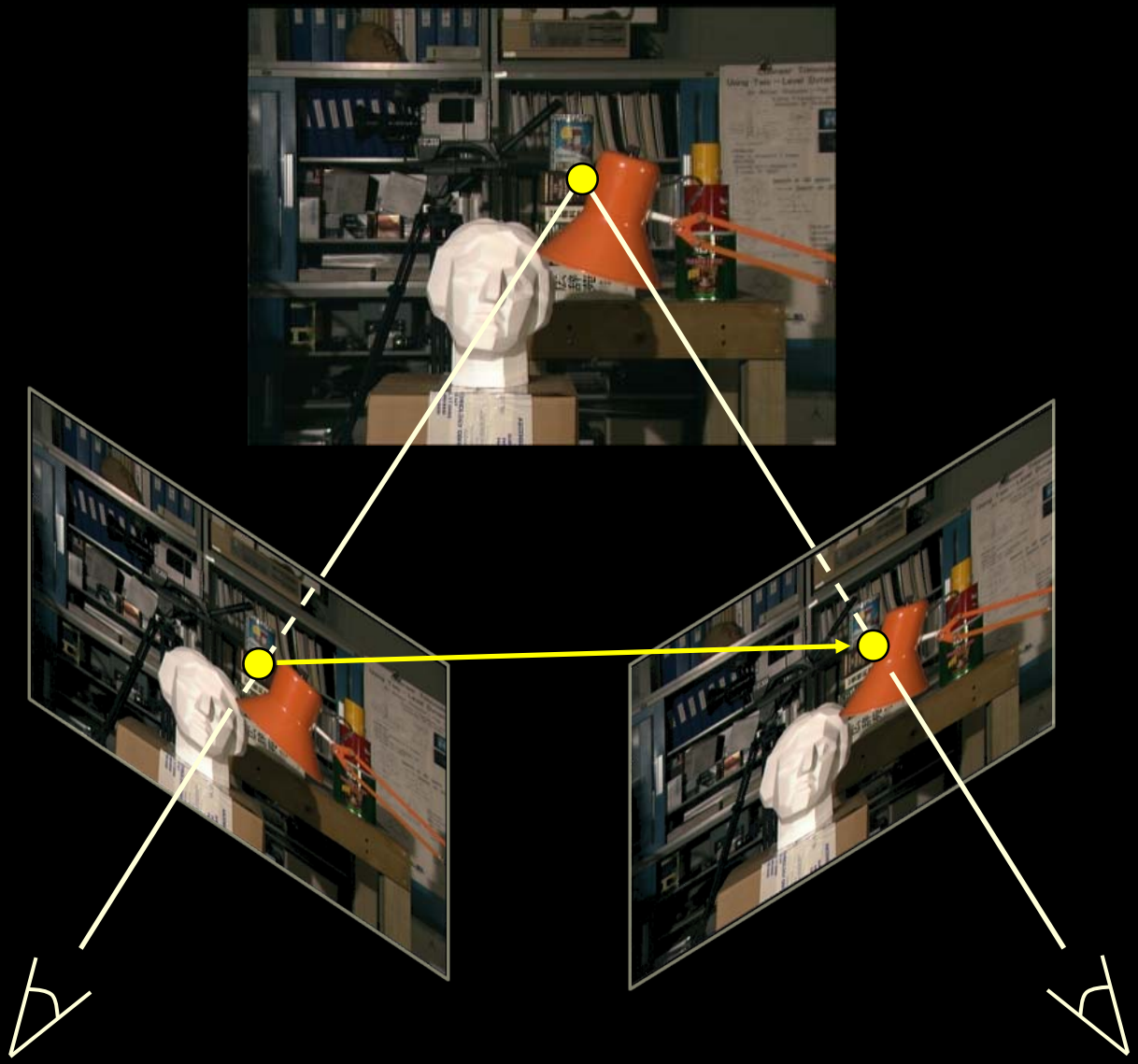
- Scan the mold
- Why?
  - Keep the Subject Static
  - Skin Reflectance

Meshes from Scanning

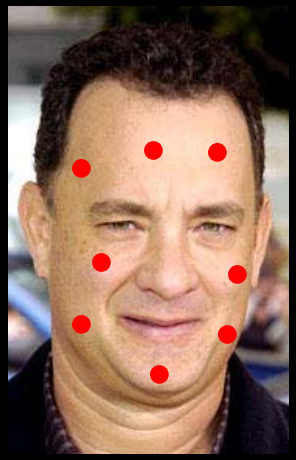
- Laser scanners sample 3D positions
  - One method uses triangulation
  - Another method uses time of flight
  - Some take images also for use as textures

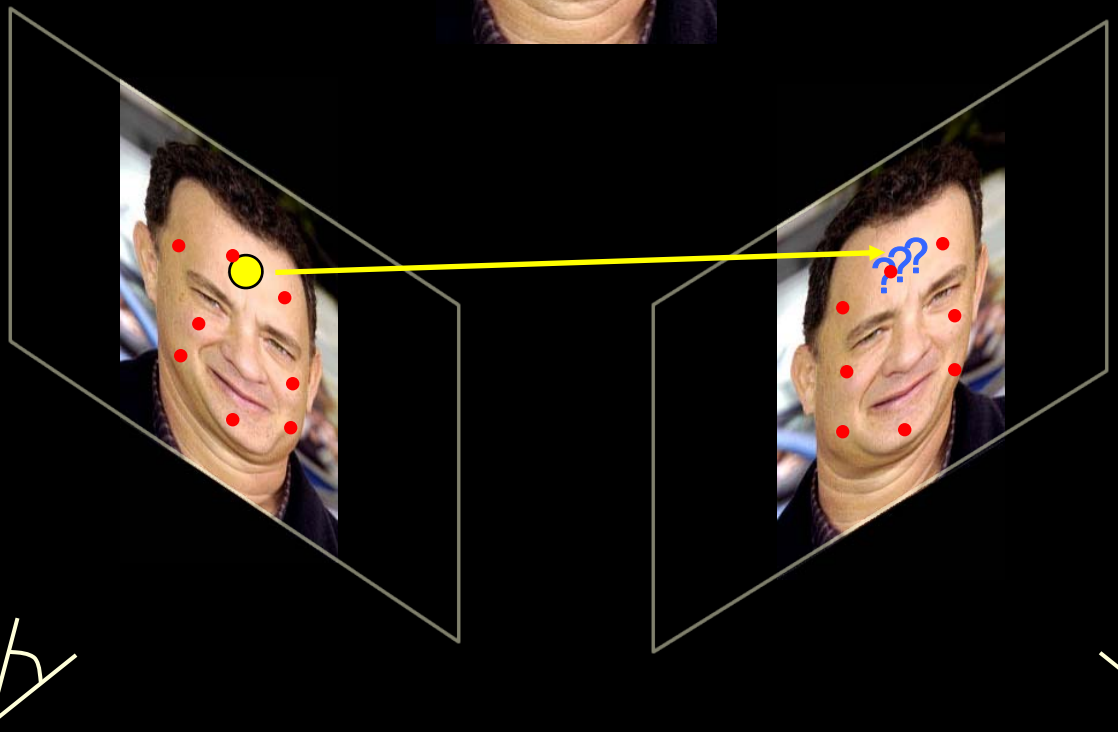
http://www.mandli.com/systems/srh.php

Stereo



Stereo





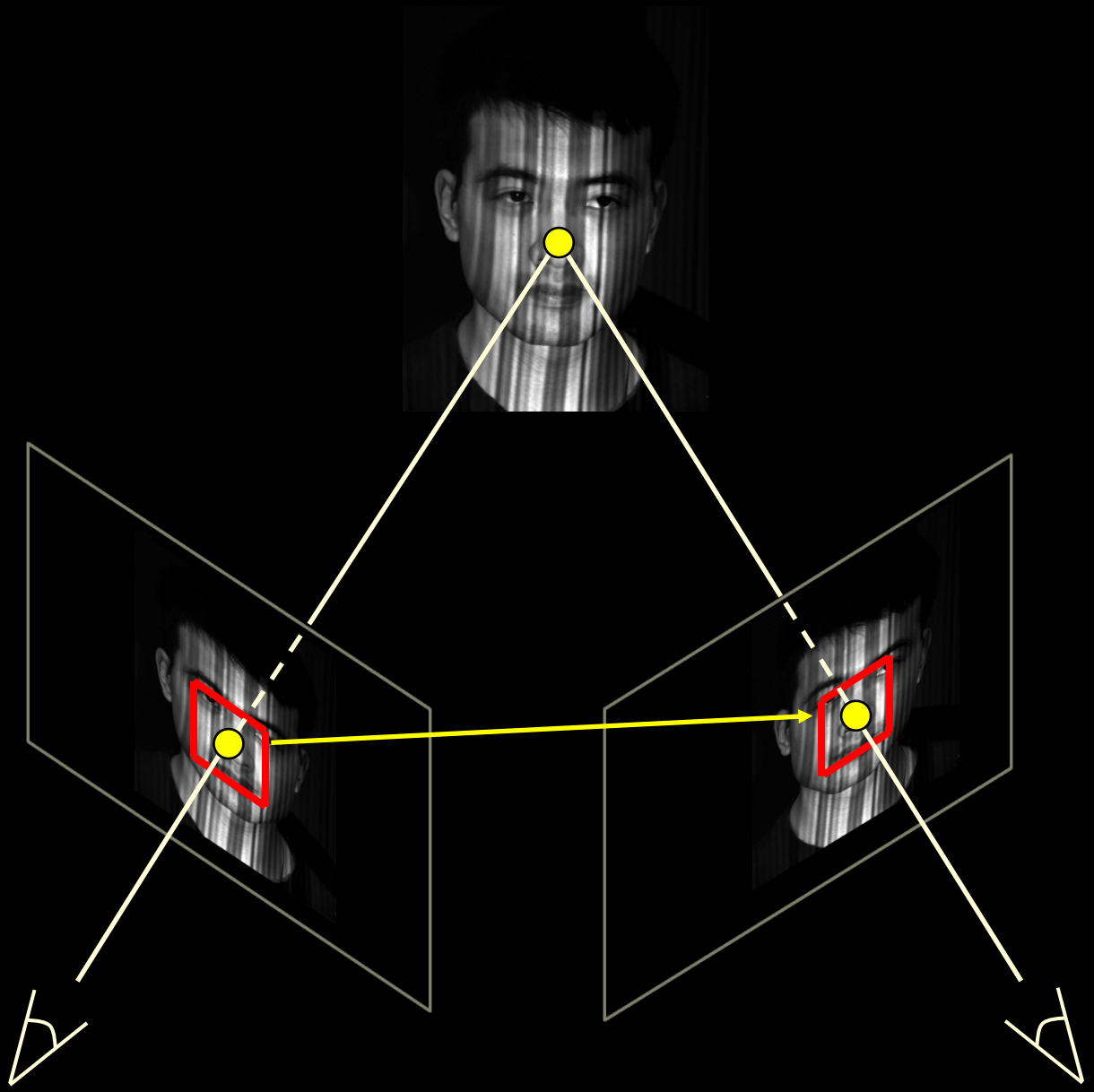
Marker-based Face Capture

The Polar Express, 2004

"The largest intractable problem with 'The Polar Express' is that the motion-capture technology used to create the human figures has resulted in a film filled with creepily unlifelike beings."

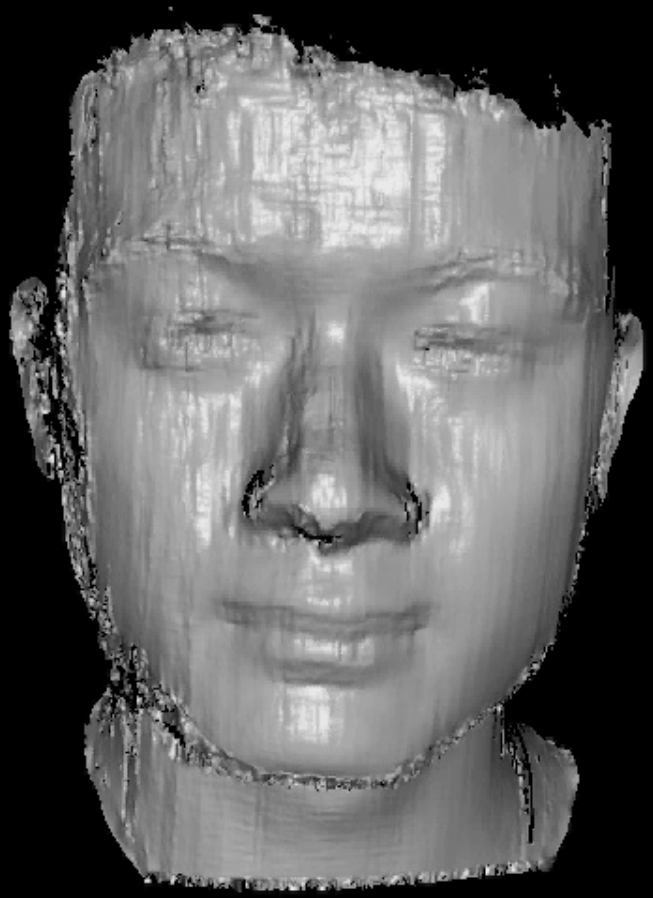
New York Times Review, Nov 2004

Stereo



Stereo

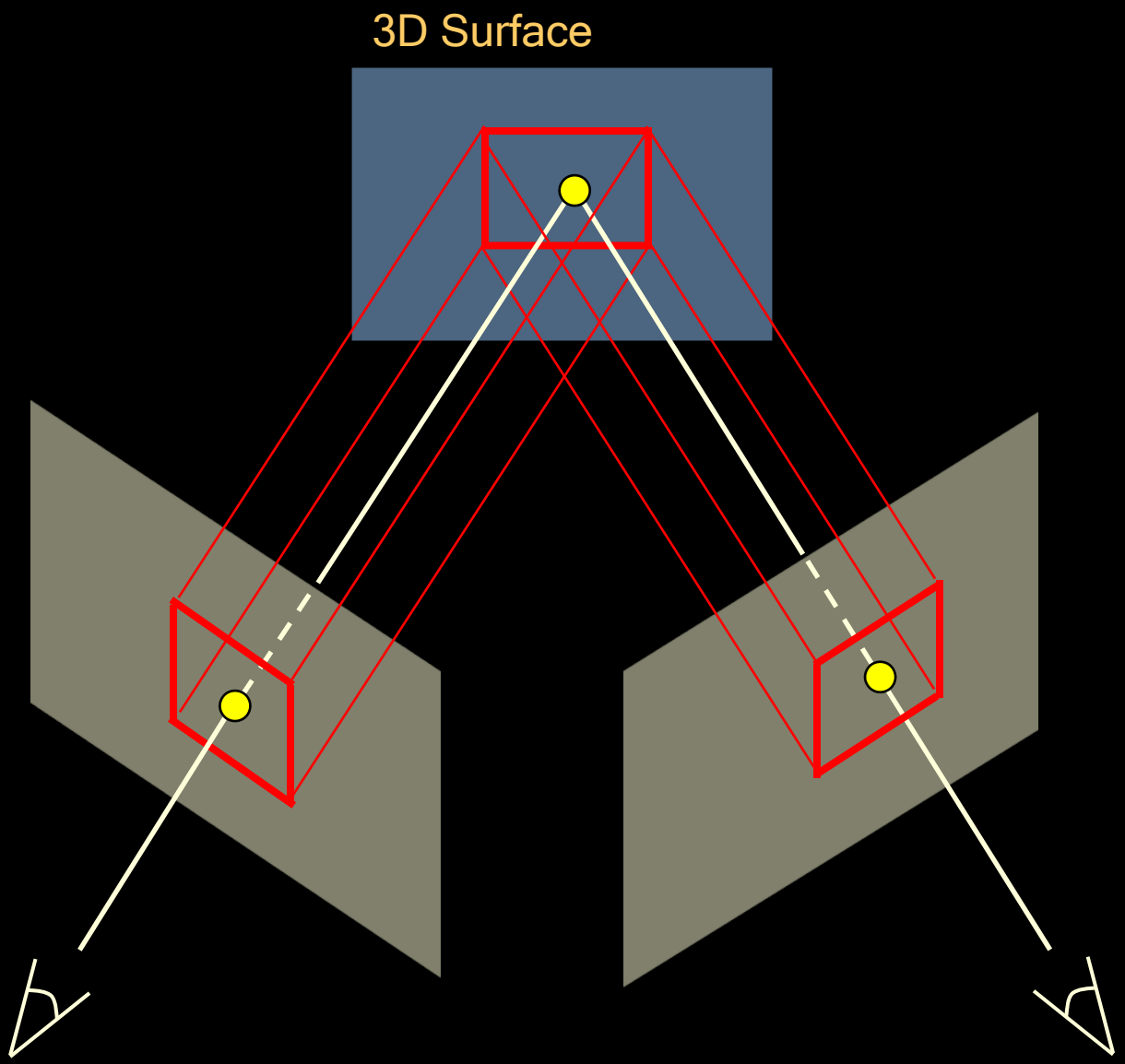
A Pair of Videos
640×480@60fps Each



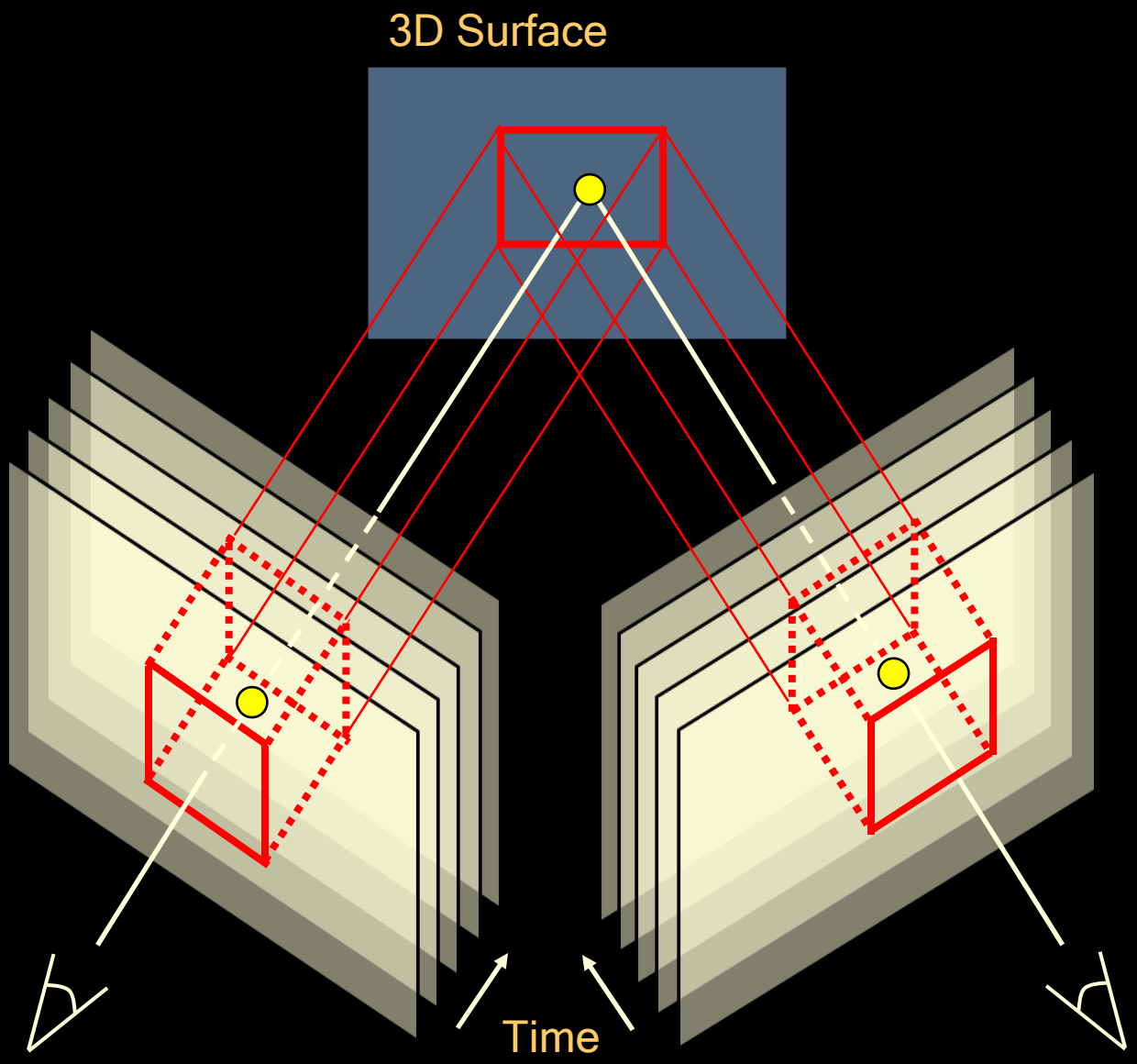
Frame-by-Frame Stereo
W×H = 15×15 Window

Inaccurate & Jittering

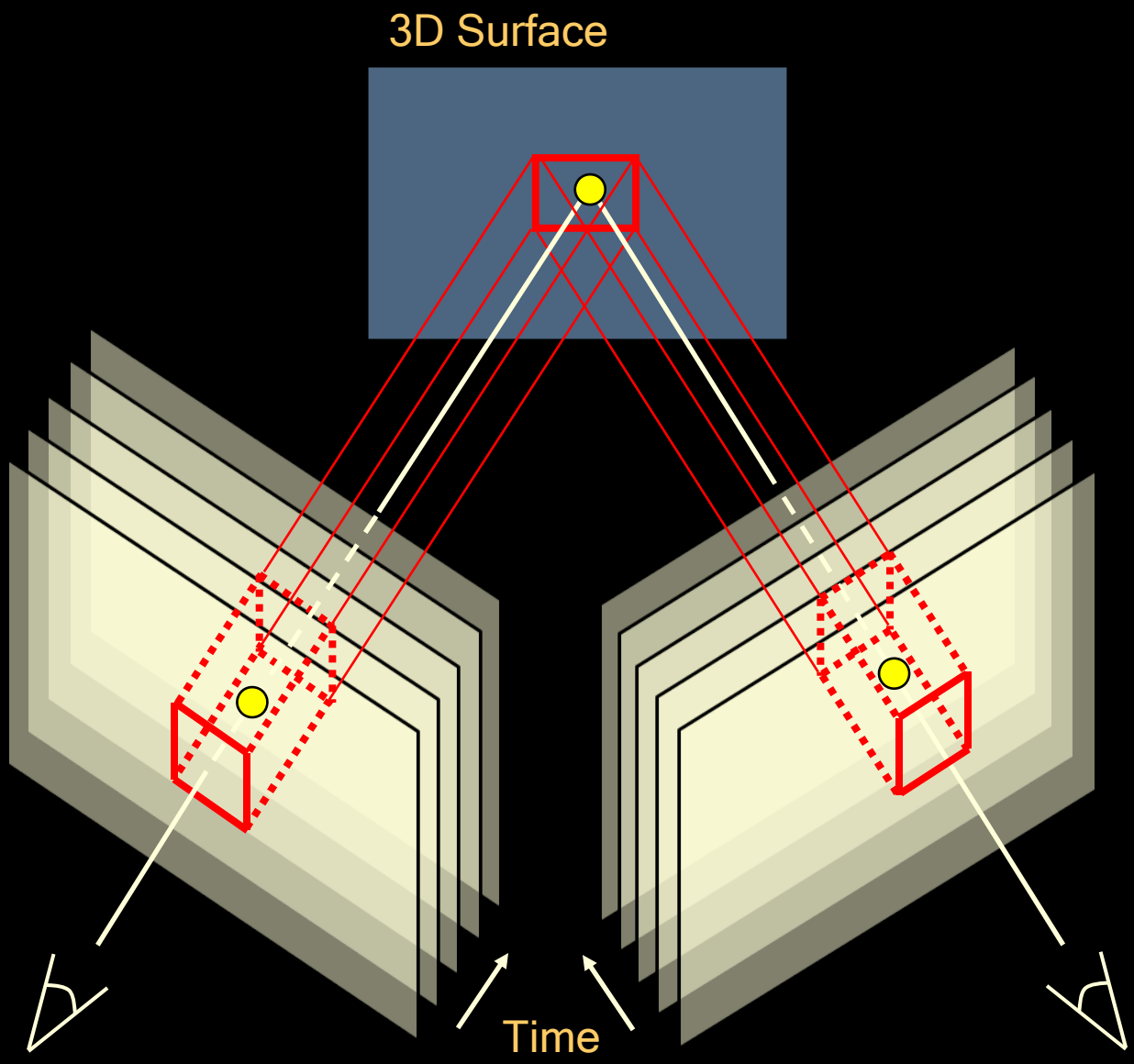
Spacetime Stereo



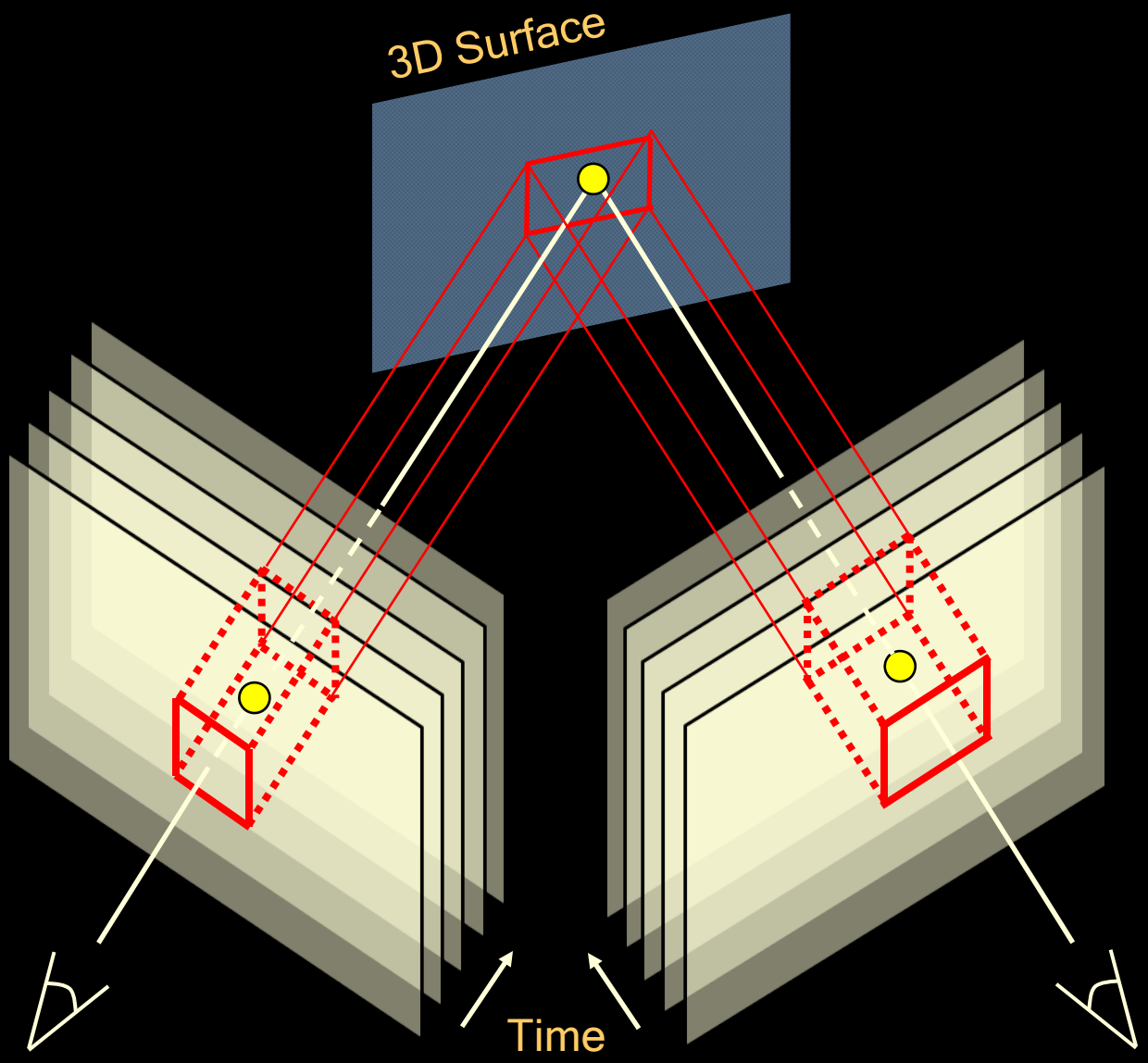
Spacetime Stereo



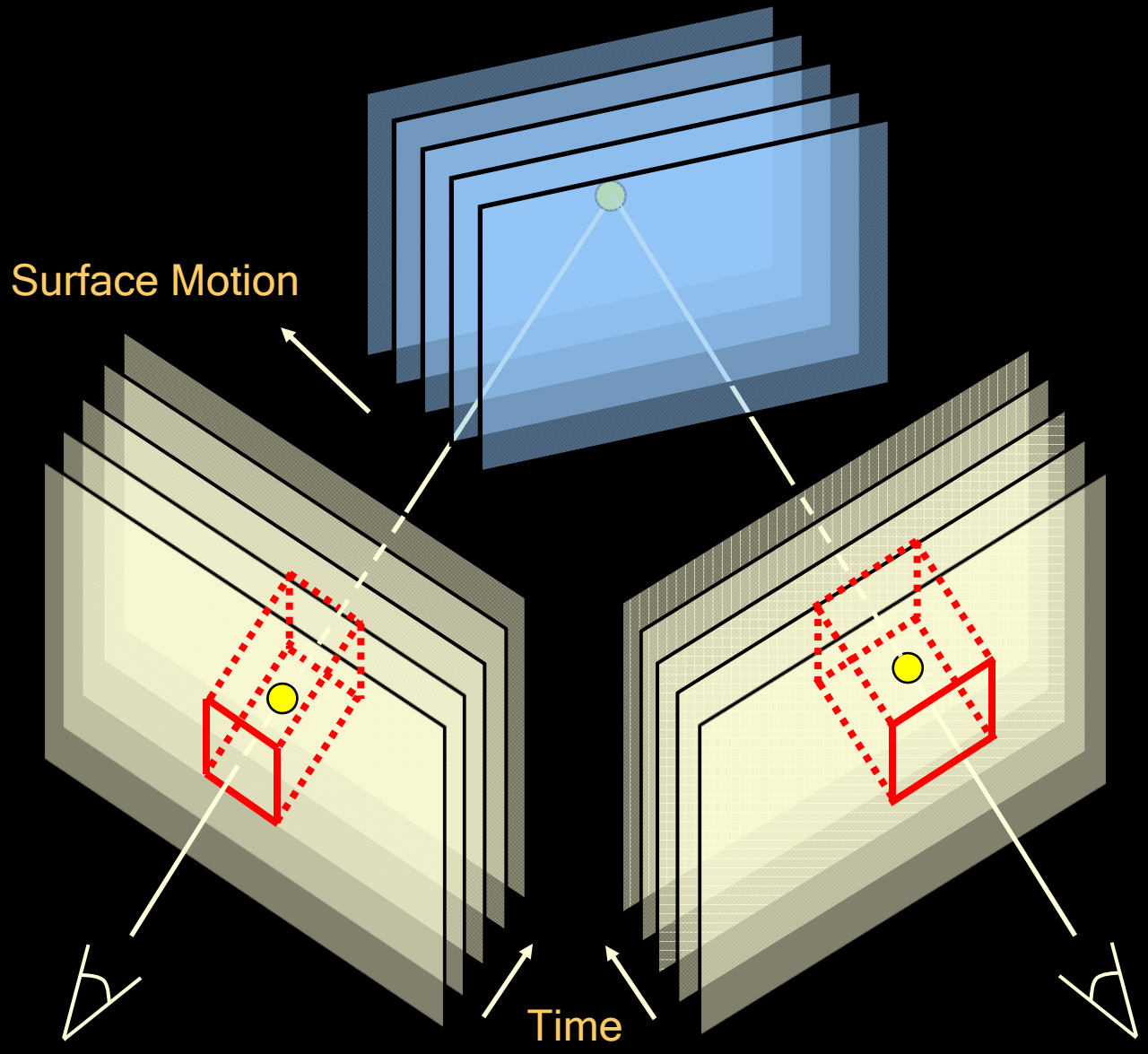
Spacetime Stereo



Spacetime Stereo



Spacetime Stereo



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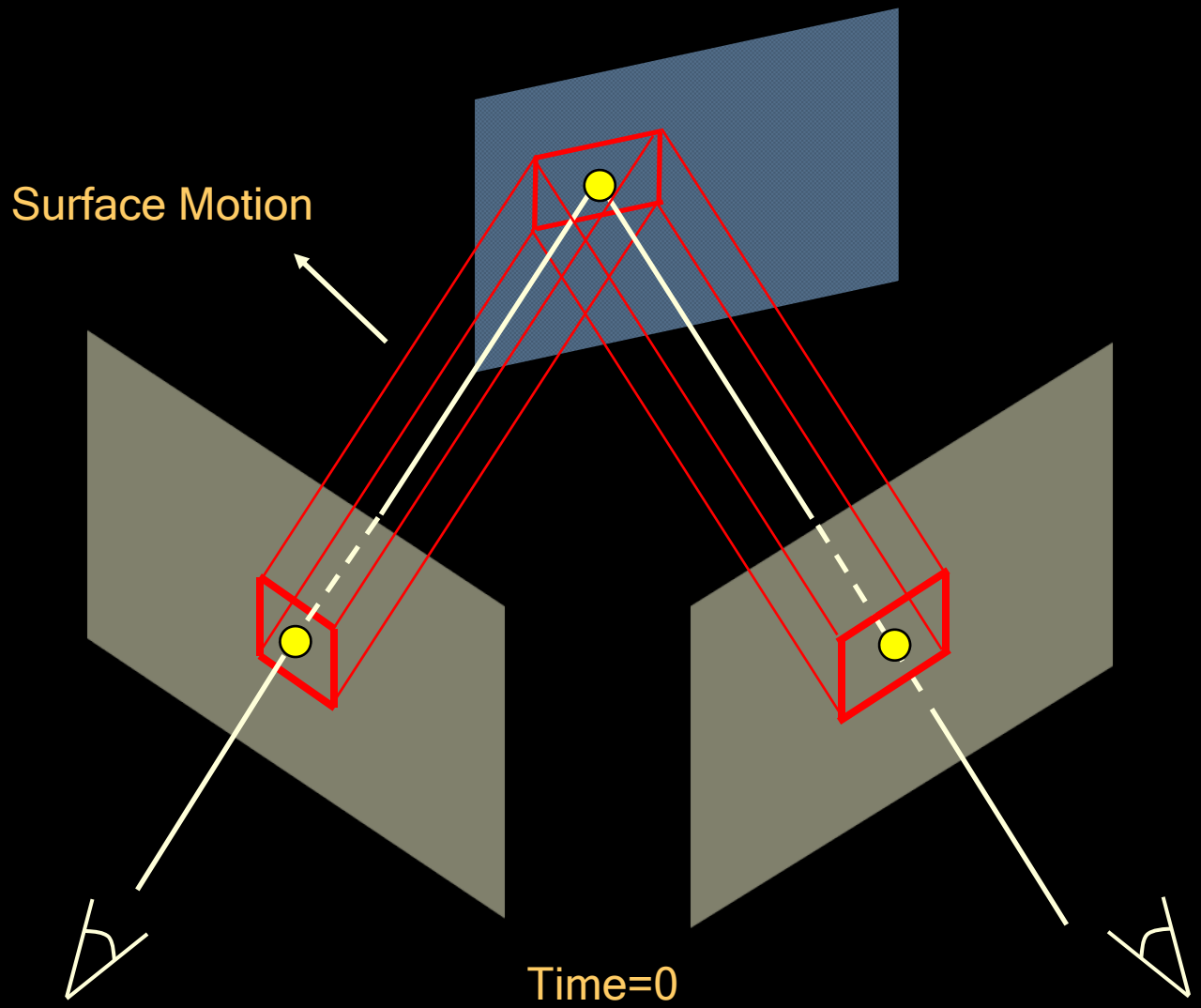

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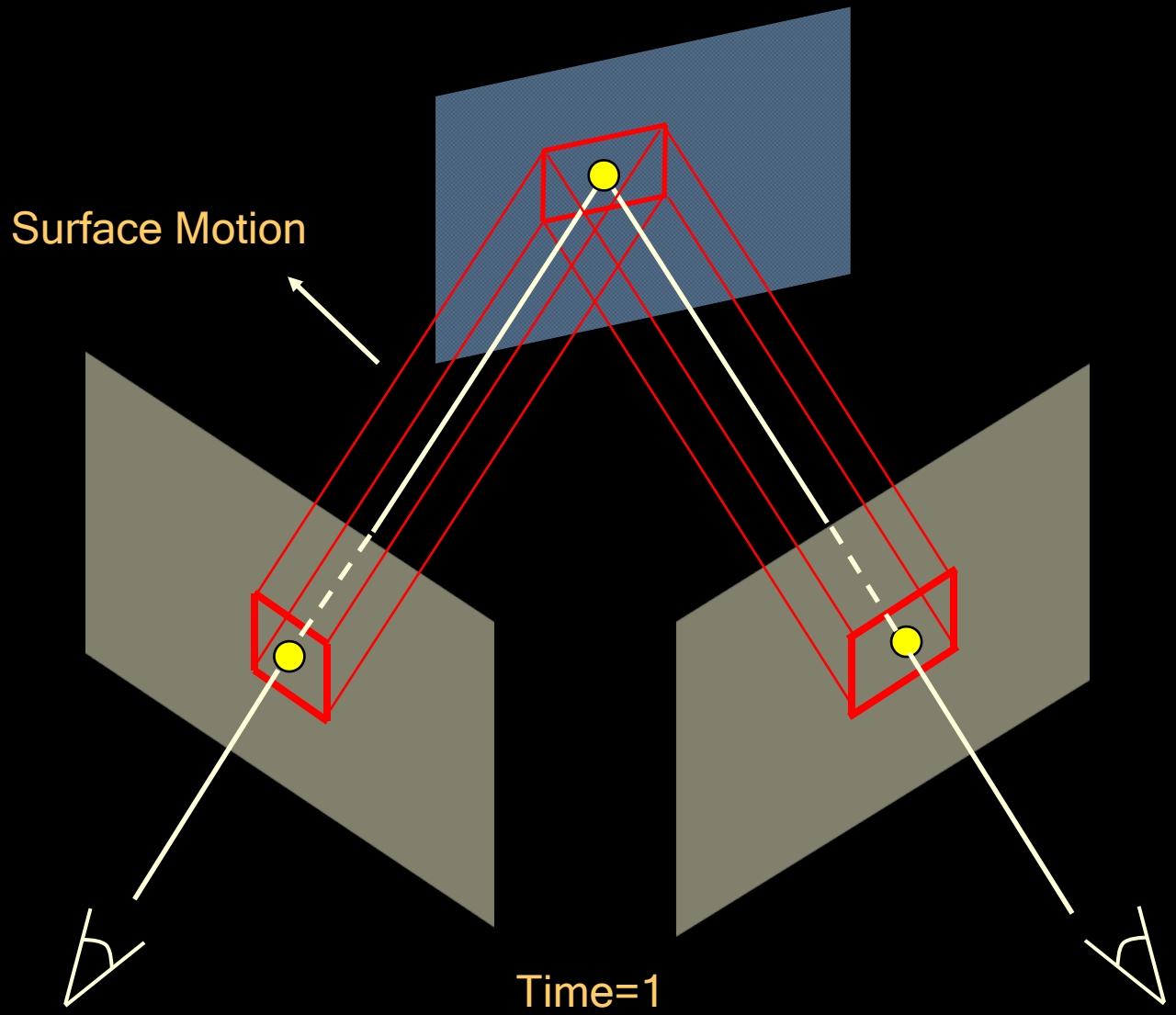

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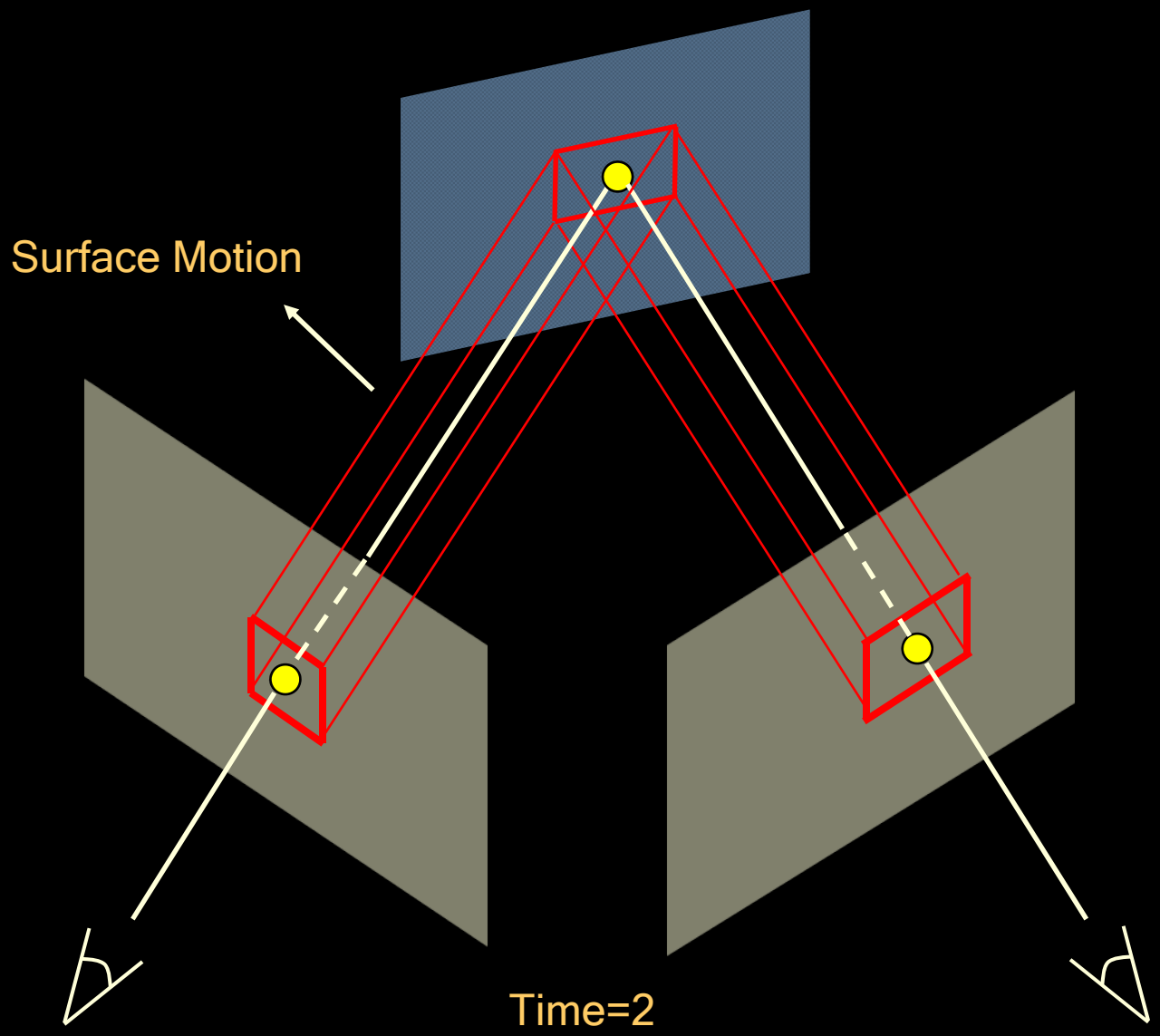
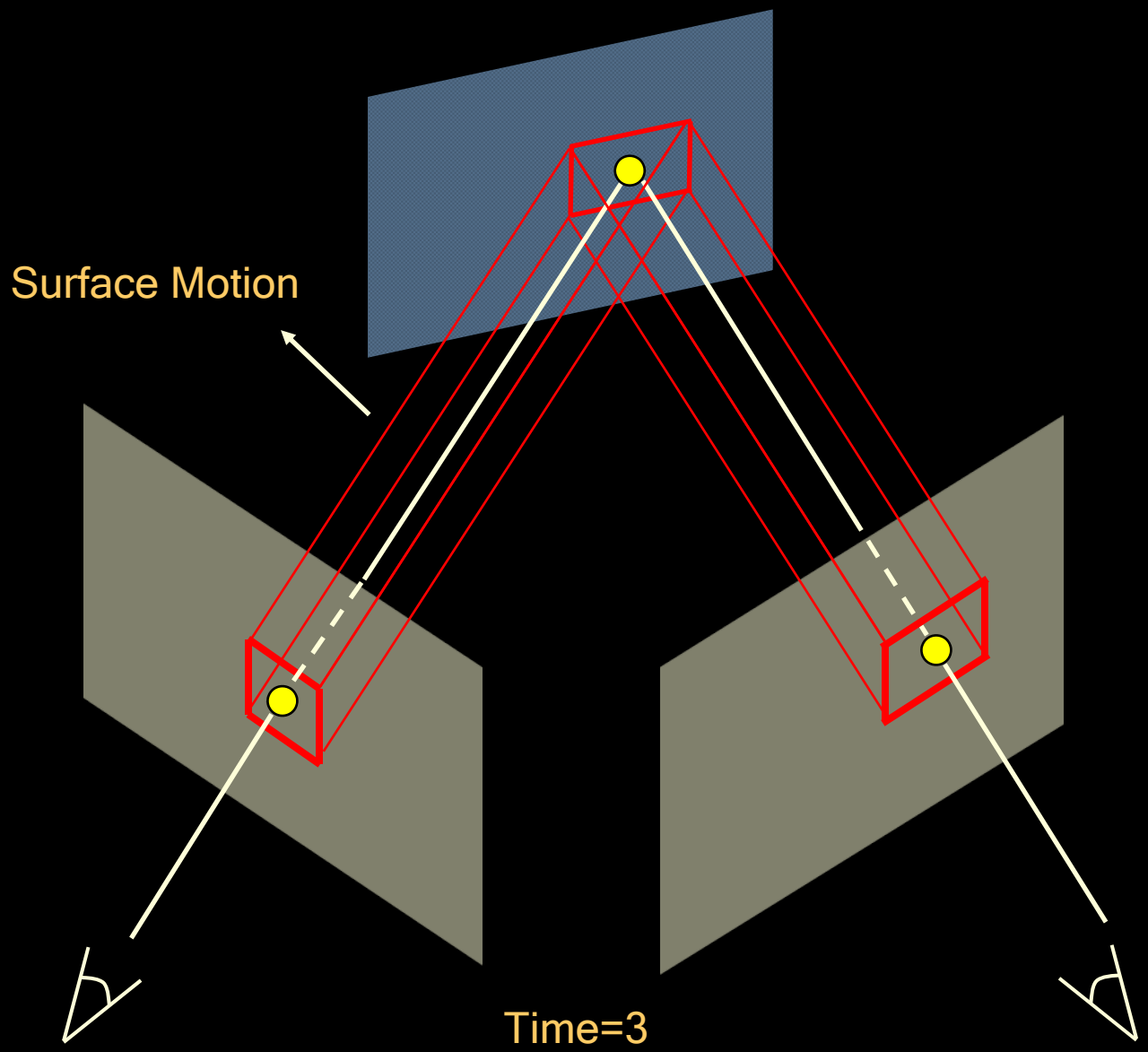


Spacetime Stereo



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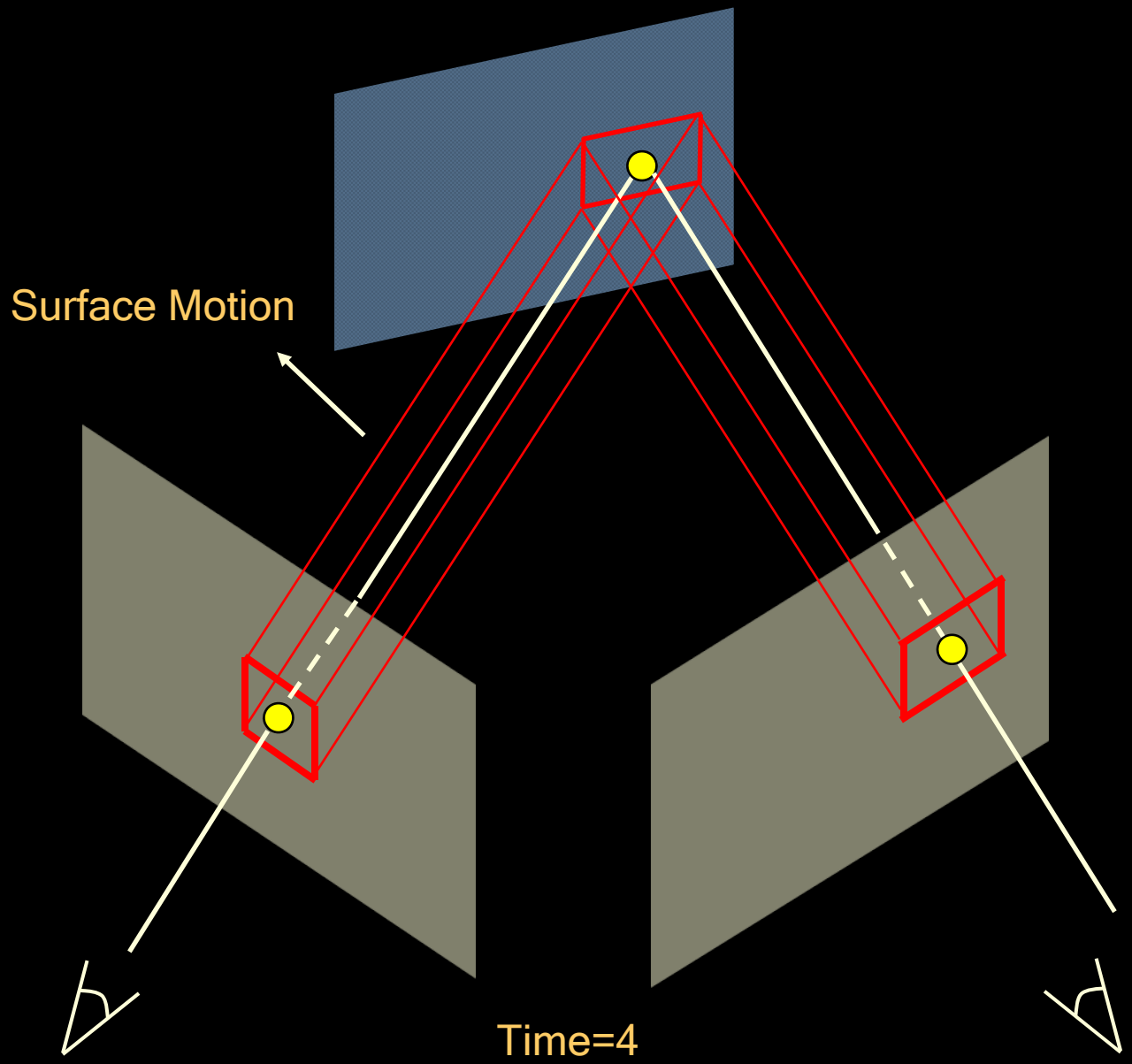

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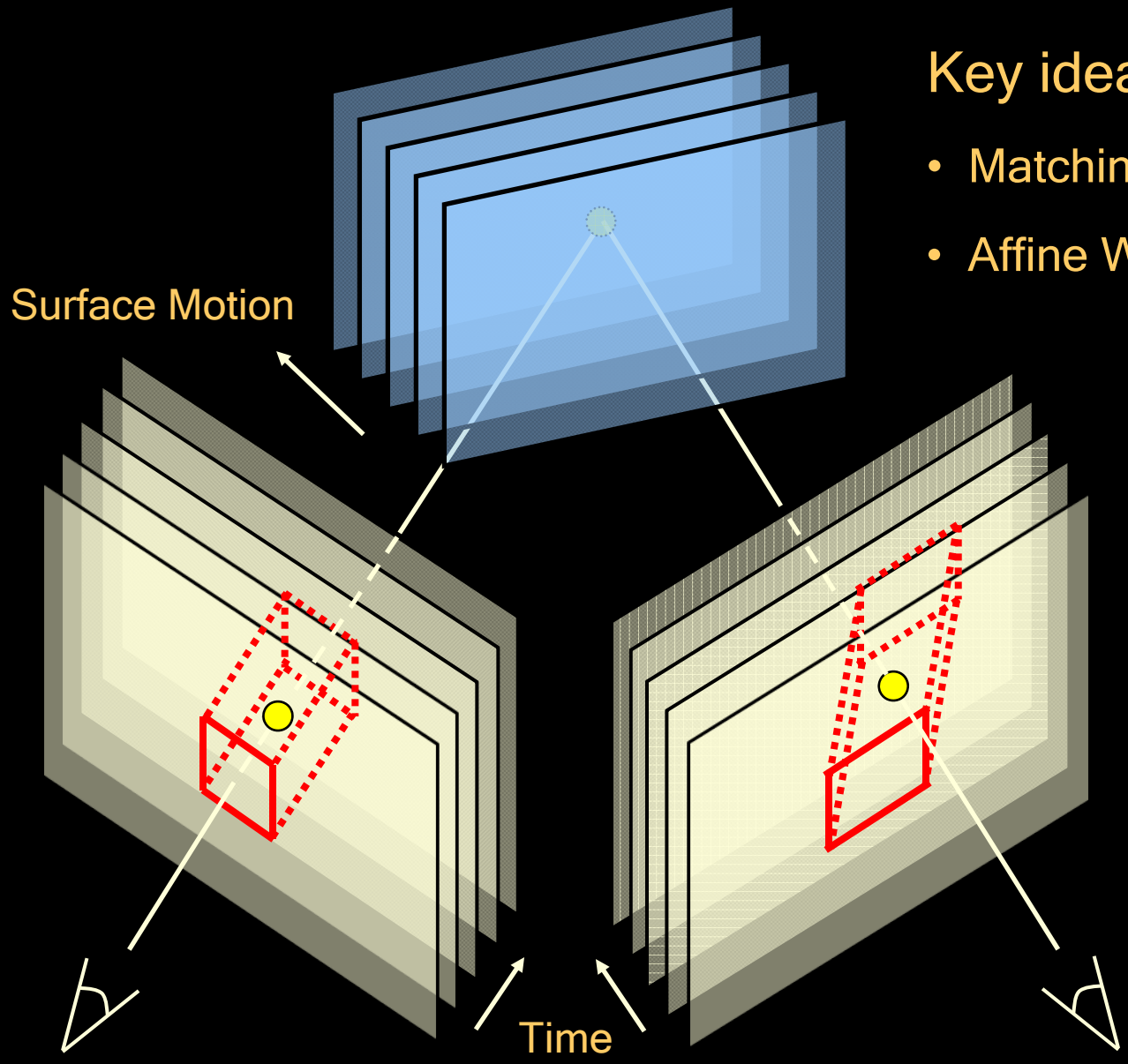
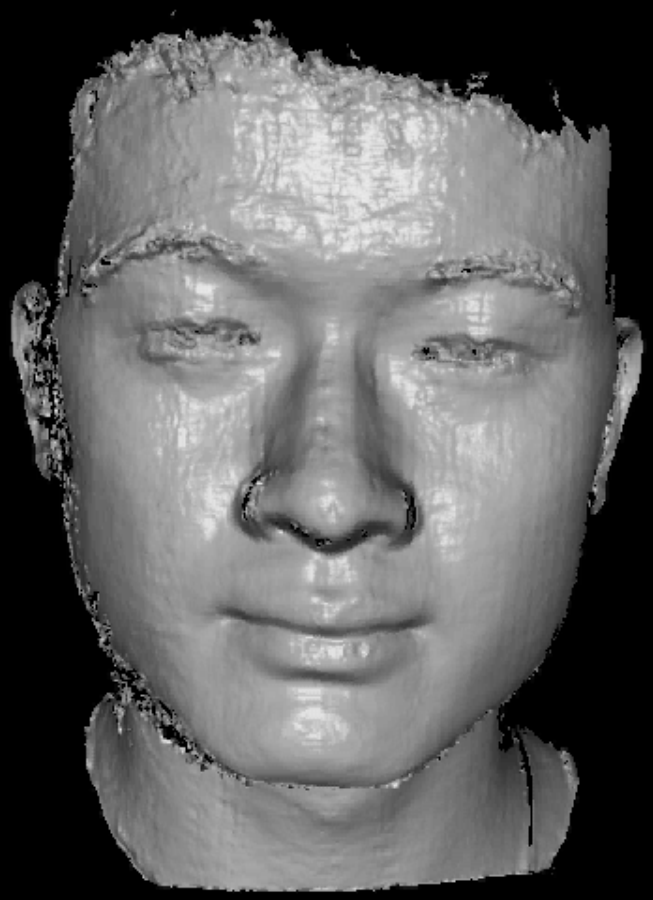


Key ideas:

- Matching Volumetric Window
- Affine Window Deformation

Spacetime Stereo

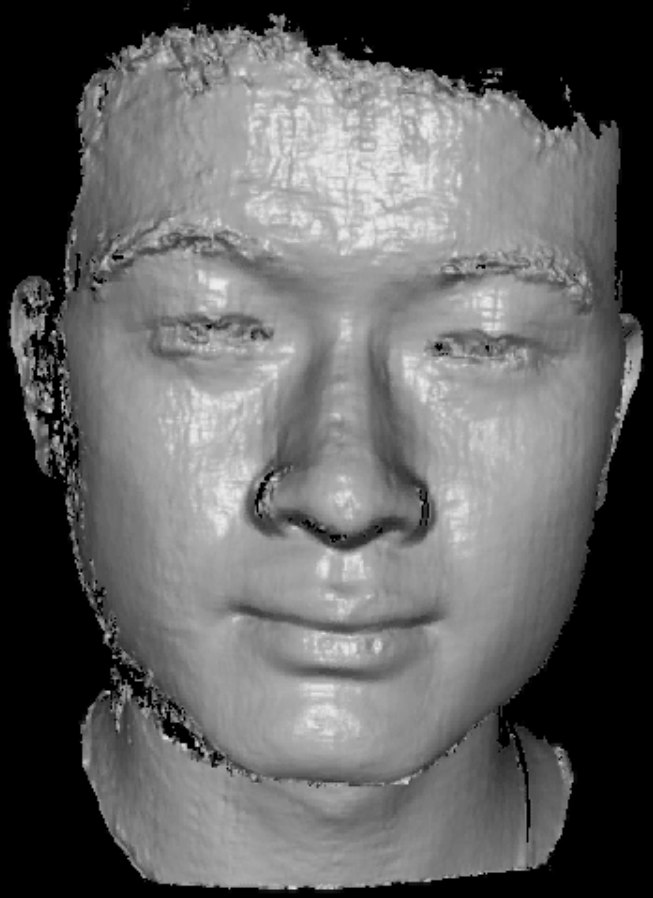
A Pair of Videos
640×480@60fps Each



Spacetime Stereo
W×H×T = 9×5×5 Window

Frame-by-Frame vs. Spacetime Stereo

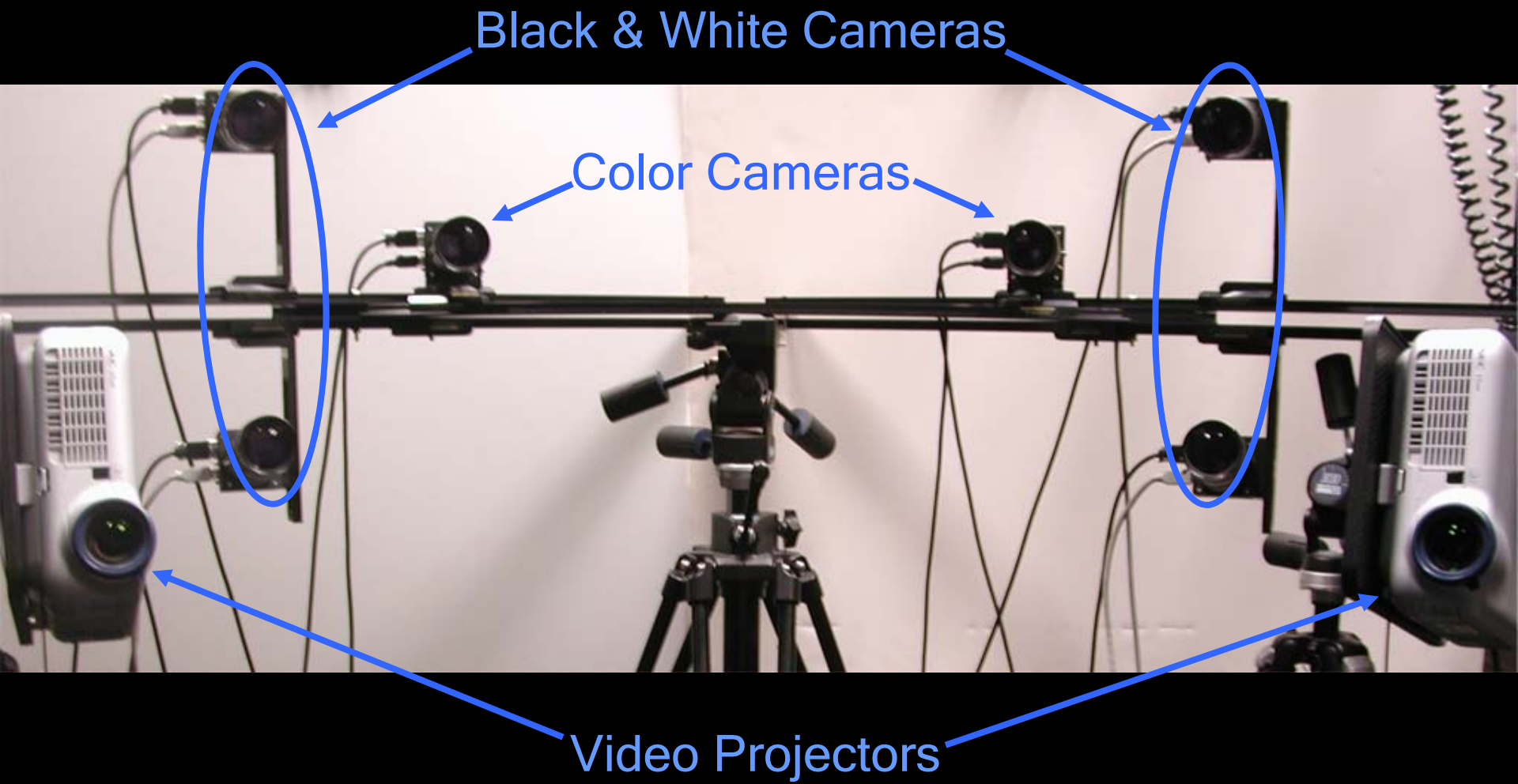
Frame-by-Frame
W×H = 15×15 Window



Spacetime Stereo
W×H×T = 9×5×5 Window

Spatially More Accurate
Temporally More Stable

Spacetime Face Capture System



System in Action

Input Videos (640×480, 60fps)

Black & White
Top Left

Color Left

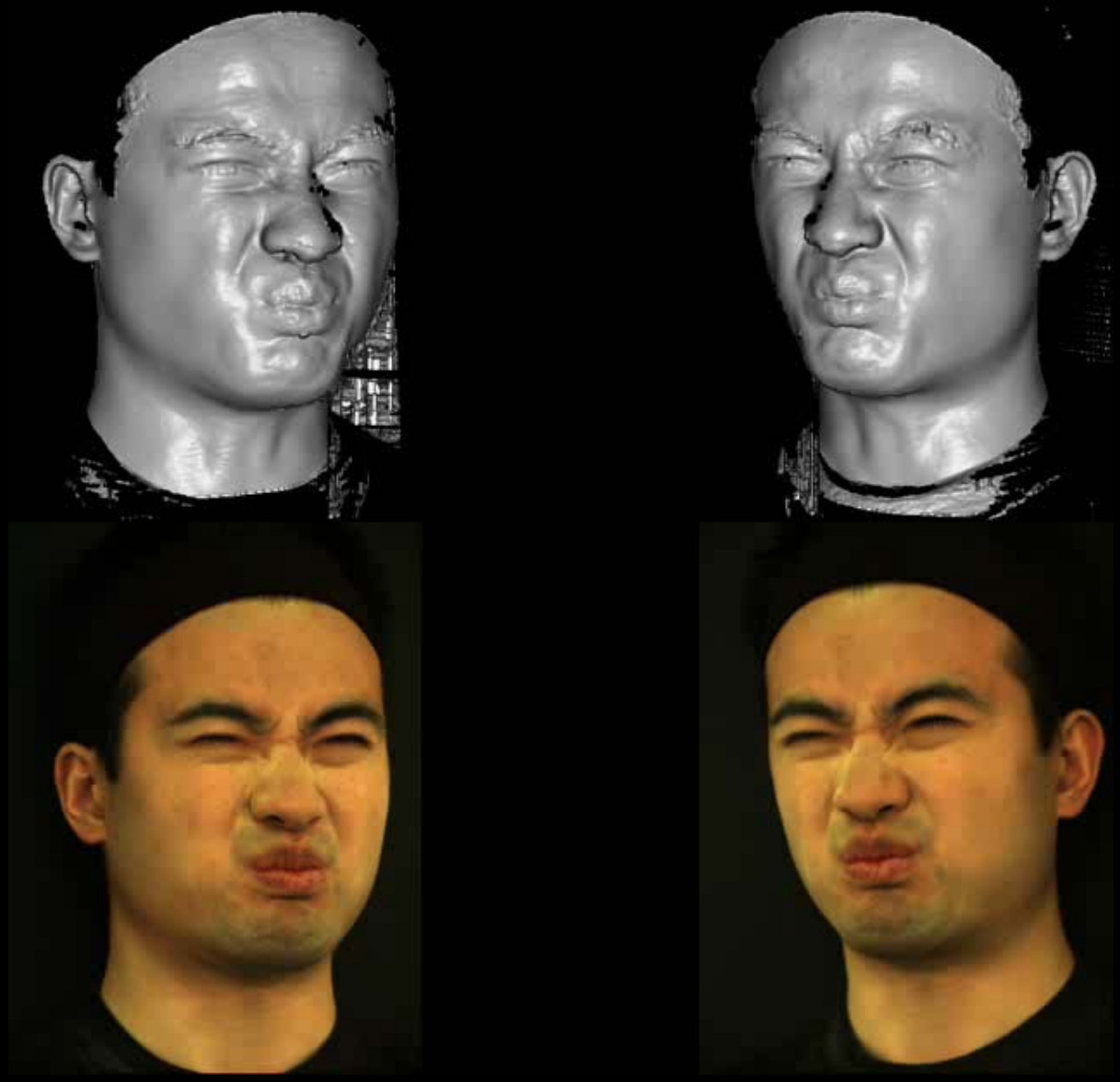
Color Right

Black & White
Top Right

Black & White
Bottom Left

Black & White
Bottom Right

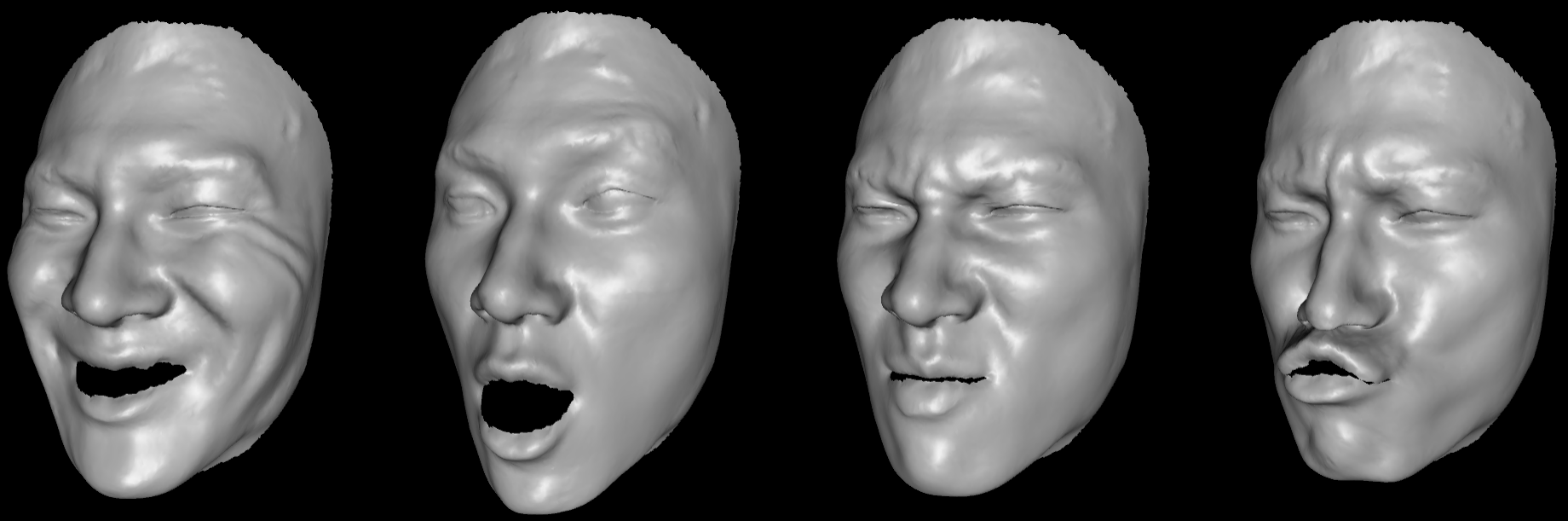
Spacetime Stereo Reconstruction



Spacetime Stereo Reconstruction

Brett Allen

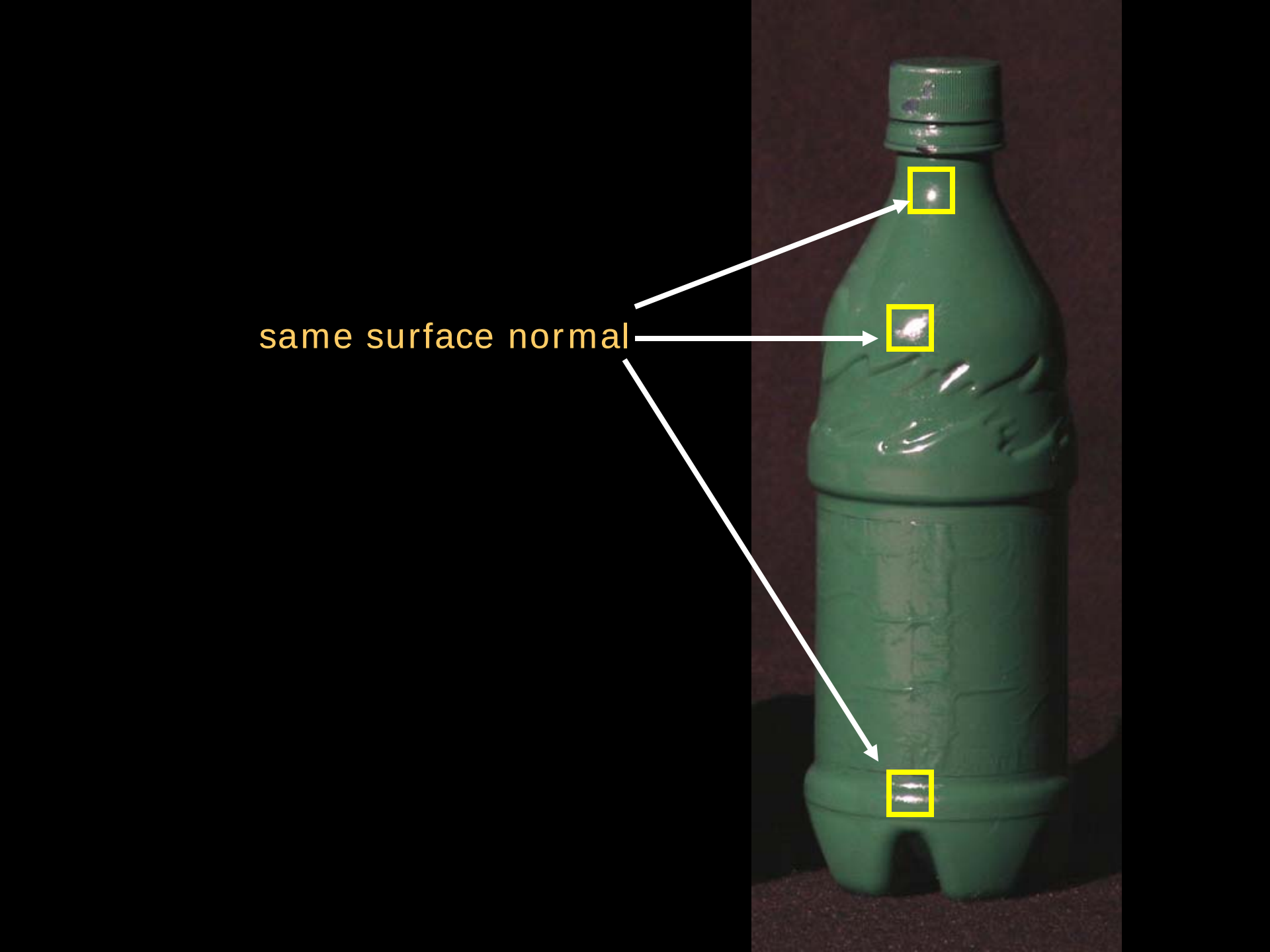
Spacetime Stereo Reconstruction

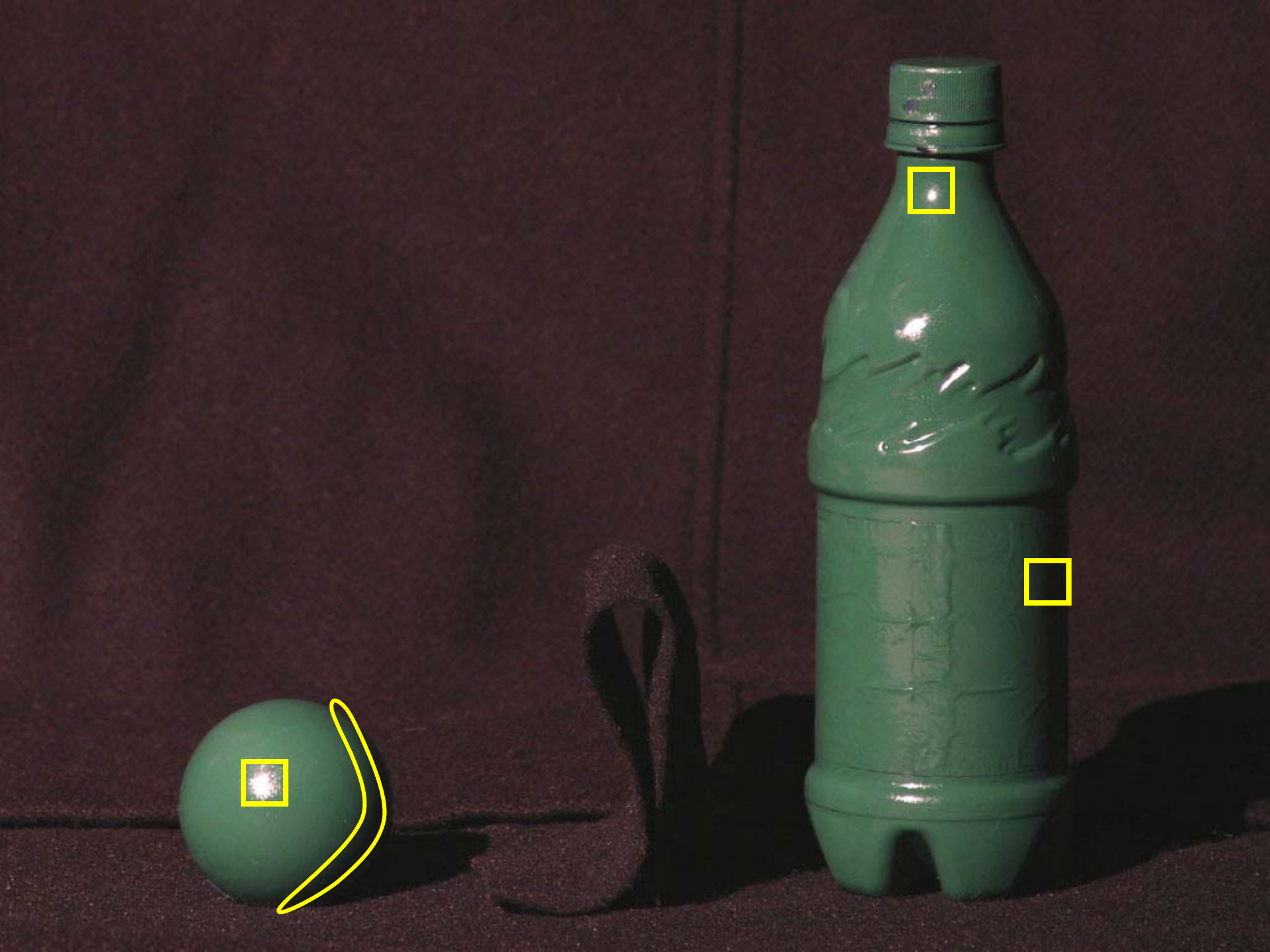


Daichi Sasaki

Shading Cue

Merle Norman Cosmetics, Los Angeles

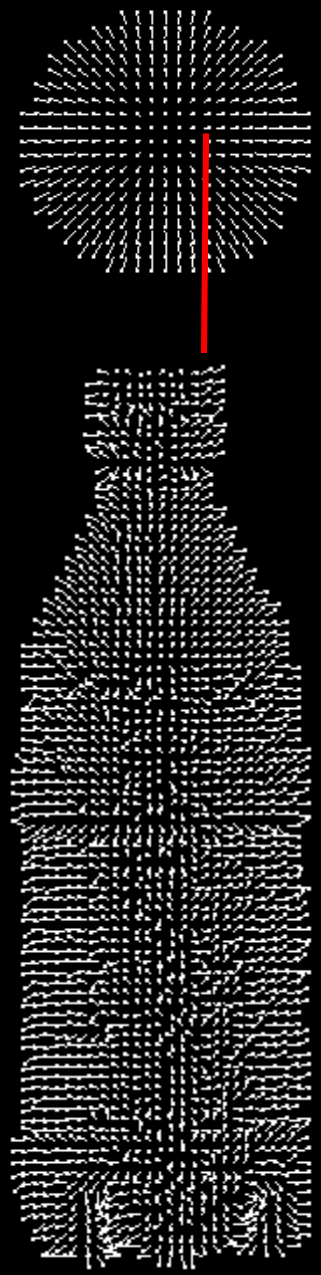

same surface normal



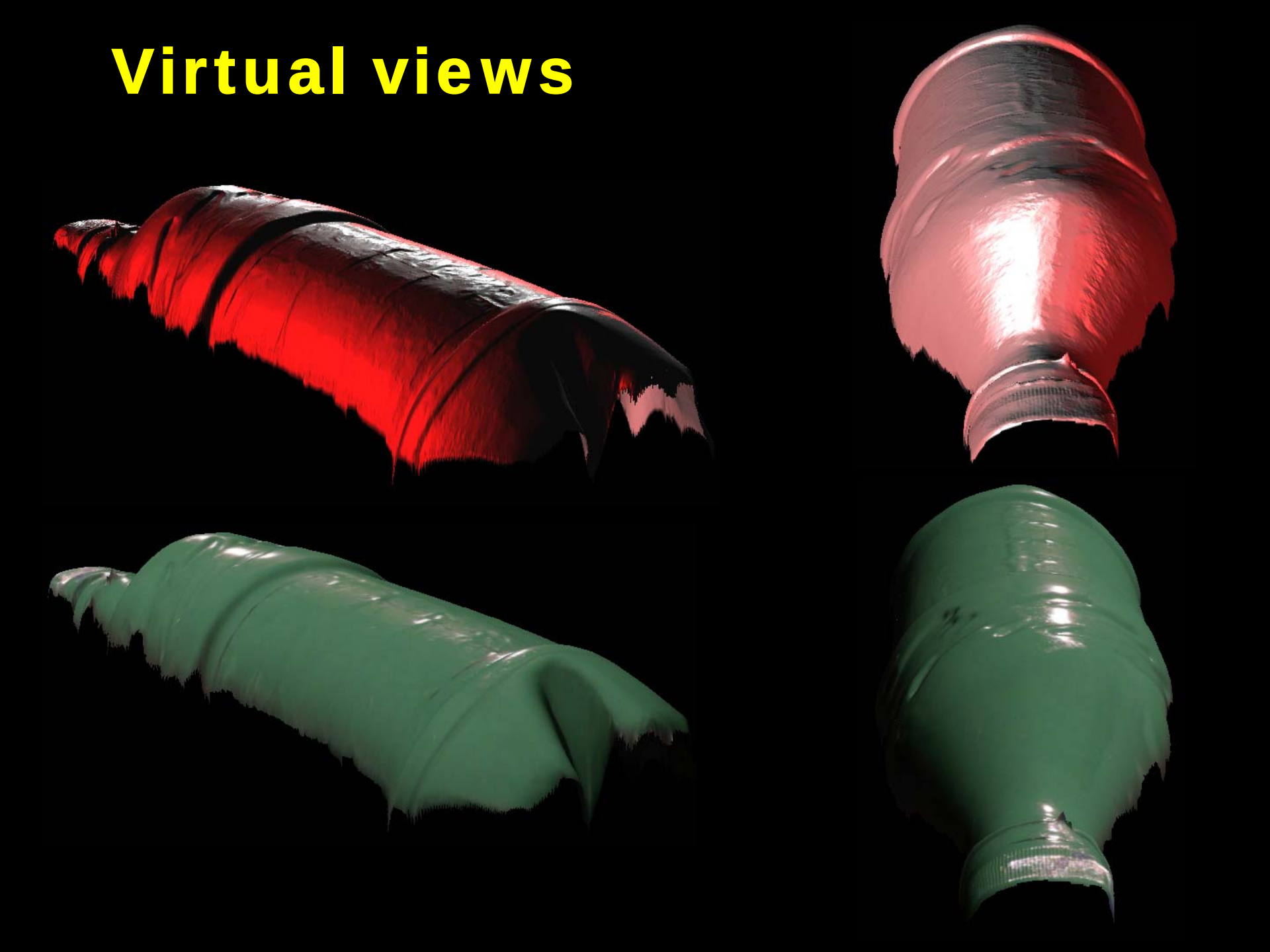








Virtual views

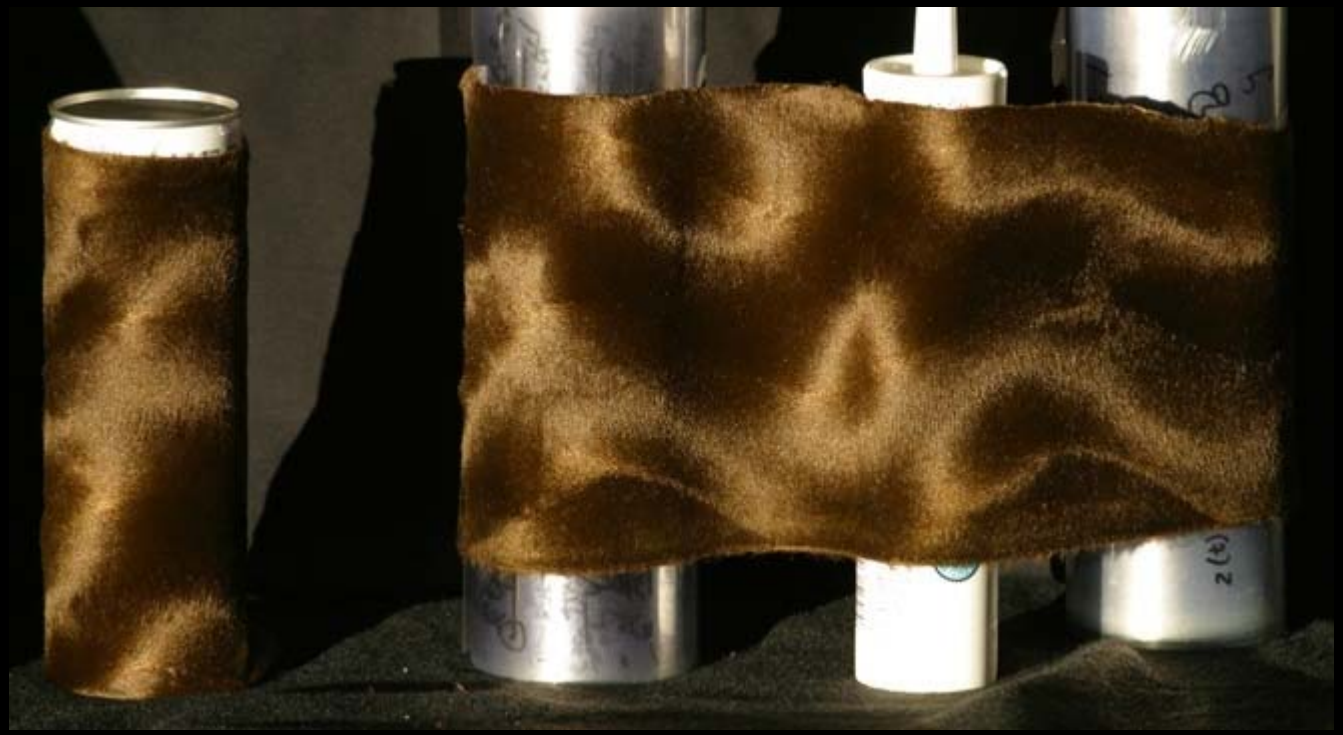


Velvet

Virtual Views

Brushed Fur

Brushed Fur



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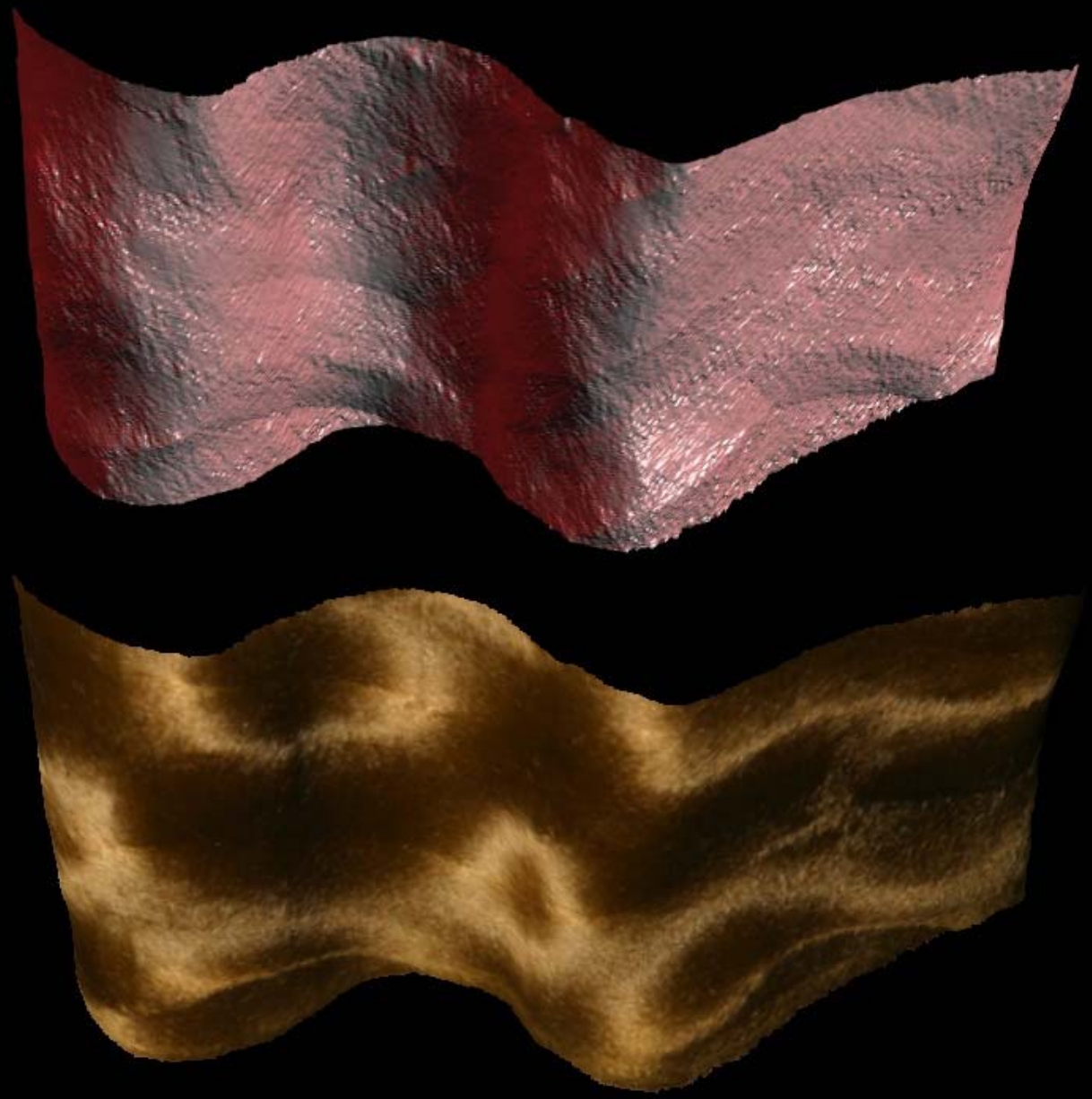
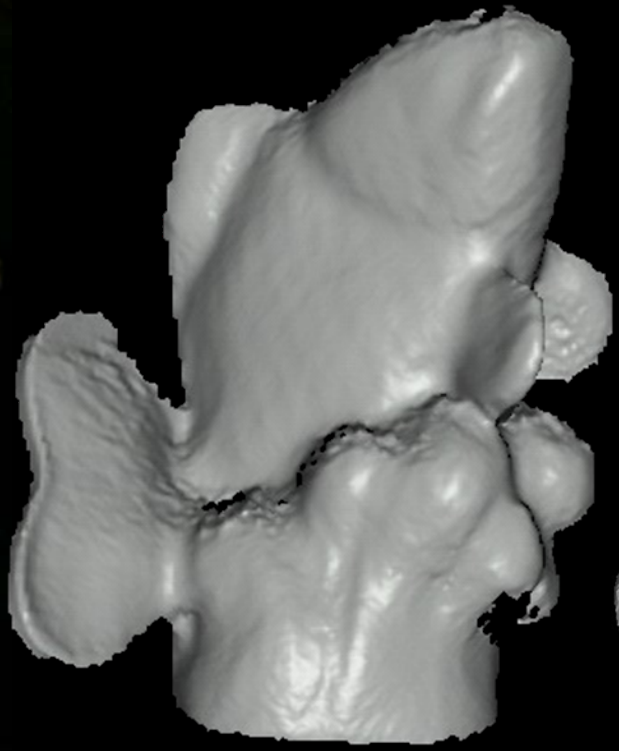


Salem Specialty Ball Company

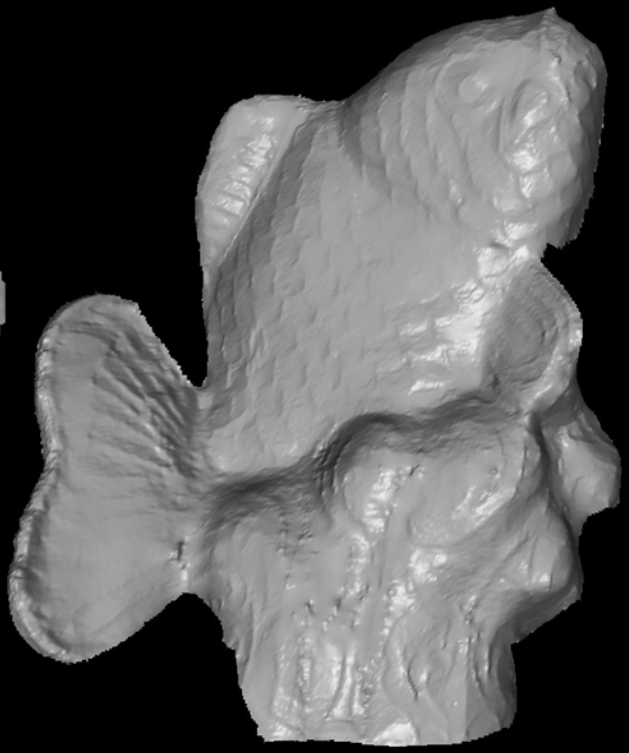
Salem Specialty Ball supplies industrial grade balls that are used in bearings, pumps, valves and other commercial applications. We can supply balls in just about any size that is machineable. We have produced precision balls from .002" all the way up to 12.0" and beyond. We can also produce these balls in any material. Almost without exception, if the material exists, we can make it into a ball. Not only do we specialize in hard to find materials, we also carry standard materials such as chrome steel and the stainless steels. We stock an extensive inventory of ready to ship balls. Most orders are shipped the same day. And if is isn't in stock, we can make it for you in matter of days. In addition, you will find that our prices are very competitive.

Located in the beautiful northwest corner of Connecticut, Canton has been our company's home for the last three years and we have been in complete operation for over ten years. Proud of our reputation, Salem Specialty Ball Company has over fifty years of combined experience allowing us to provide top-notch quality technical support and expert engineering consultation

Photo

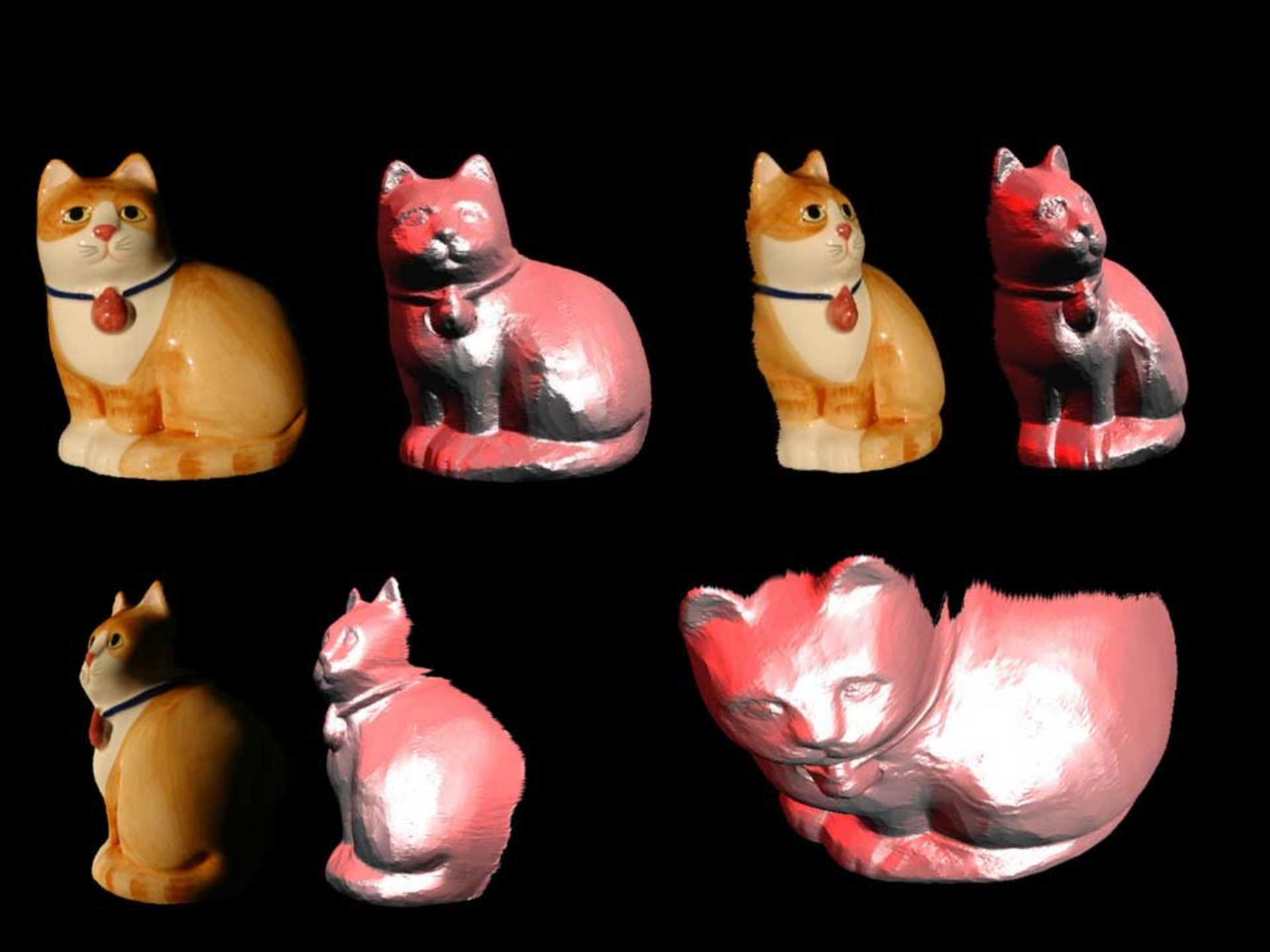


laser scan



photometric stereo

Virtual views



Summary

- Laser Scanner – Static Shapes
- Stereo – for Dynamic Surfaces
- Photometric Stereo – for Complex Reflectance