Introducción a la Fotografia 3D

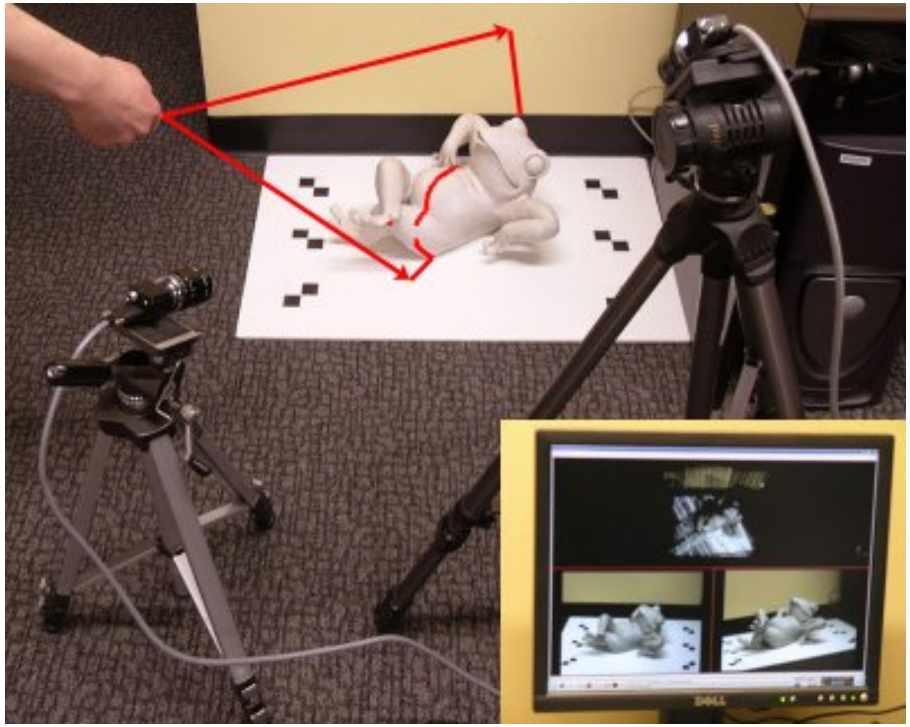
UBA/FCEN Marzo 27 – Abril 12 2013

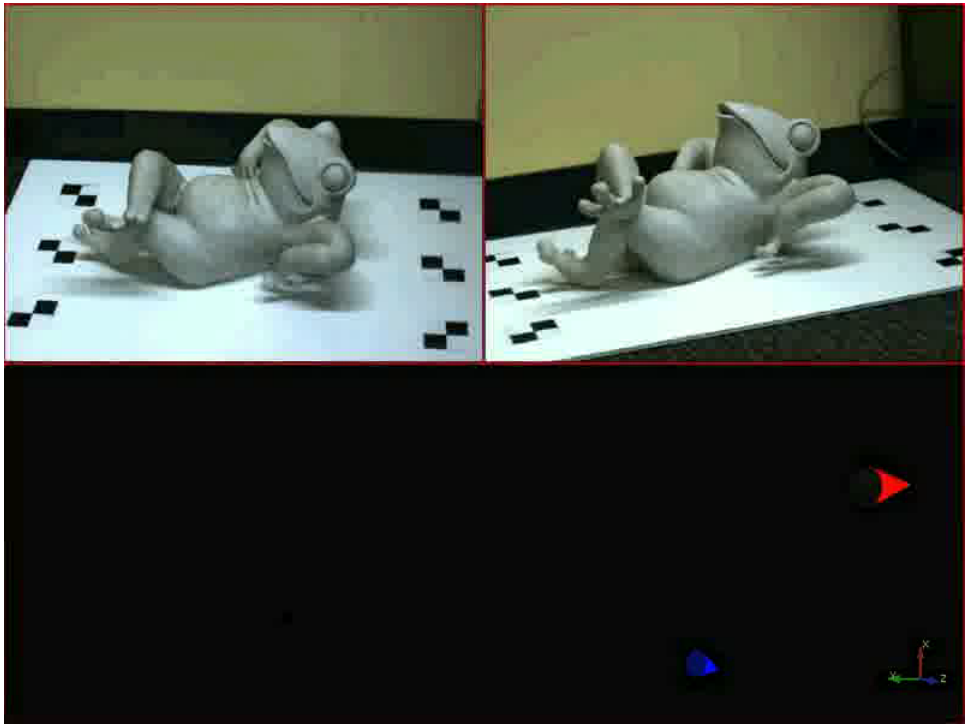
Clase 3 : Jueves Abril 4

Gabriel Taubin

Brown University

Triangulation by Laser Striping





- Manually or mechanically translated laser stripe
- Per-pixel depth by ray-plane triangulation
- Requires accurate camera and laser plane calibration
- Popular solution for commercial and DIY 3D scanners

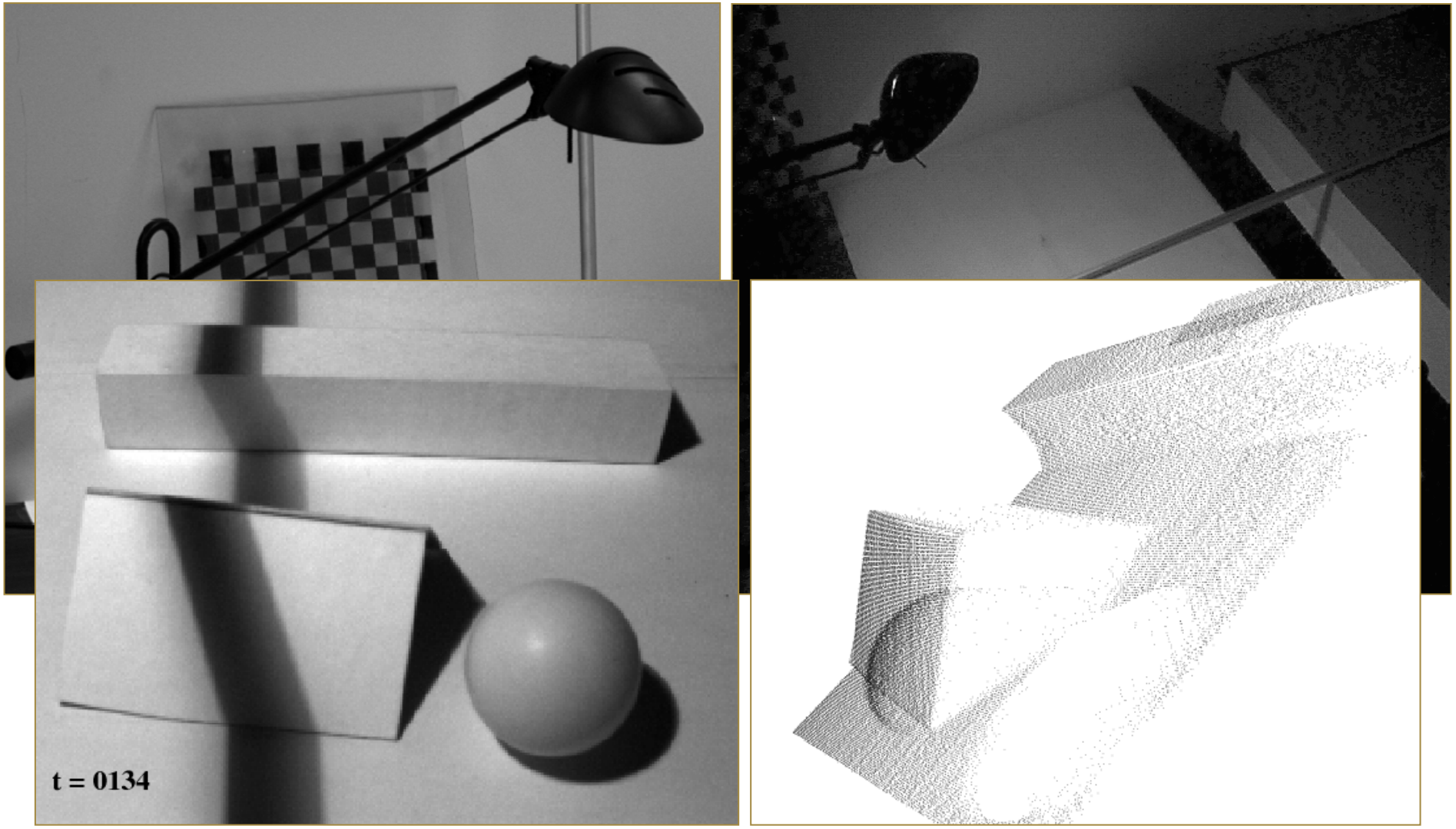
M. J. Leotta, A. Vandergon, and G. Taubin. 3D Slit Scanning With Planar Constraints. *Computer Graphics Forum*, 2008

3D Photography on Your Desk:
Bouguet and Perona [ICCV 1998]

- DIY scanner using only a camera, a halogen lamp, and a stick
- Per-pixel depth by ray-plane triangulation
- Requires accurate camera and shadow plane calibration

J.-Y. Bouguet and P. Perona. 3D photography on your desk.
Intl. Conf. Comp. Vision, 1998

3D Photography on Your Desk:
Bouguet and Perona [ICCV 1998]



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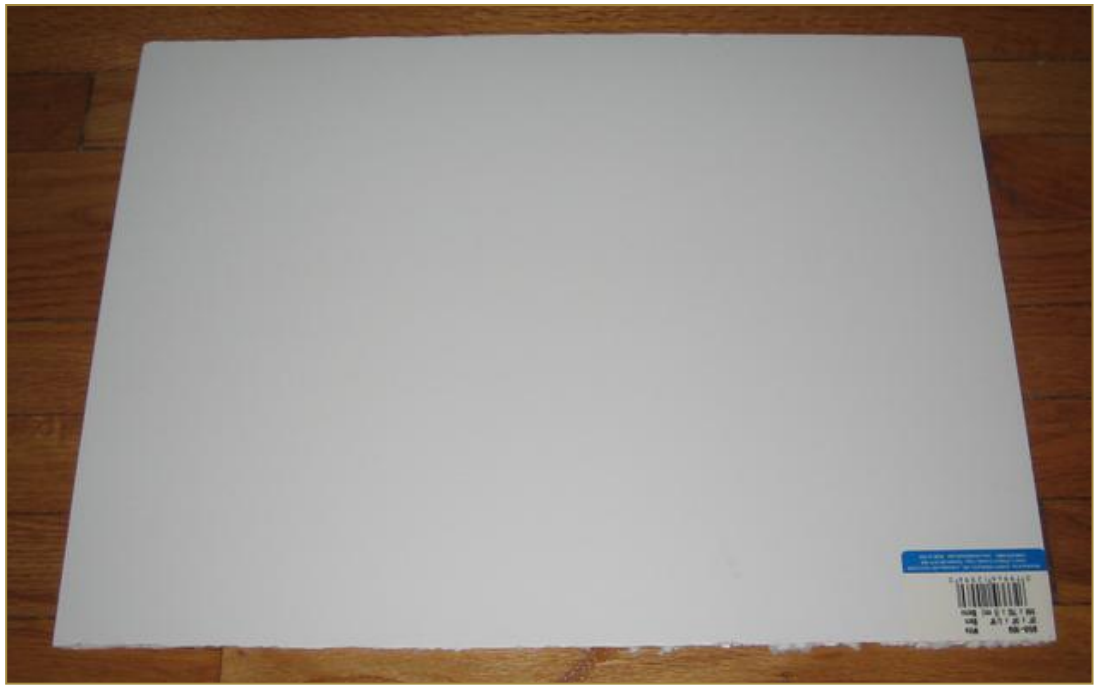
Assembling Your Own Scanner



- Parts: camera (QuickCam 9000), lamp, stick, two planar objects [~$100]
- Step 1: Build the calibration boards (include fiducials and chessboard)
- Step 2: Build the point light source (remove reflector and place in scene)
- Step 3: Arrange the camera, light source, and calibration boards

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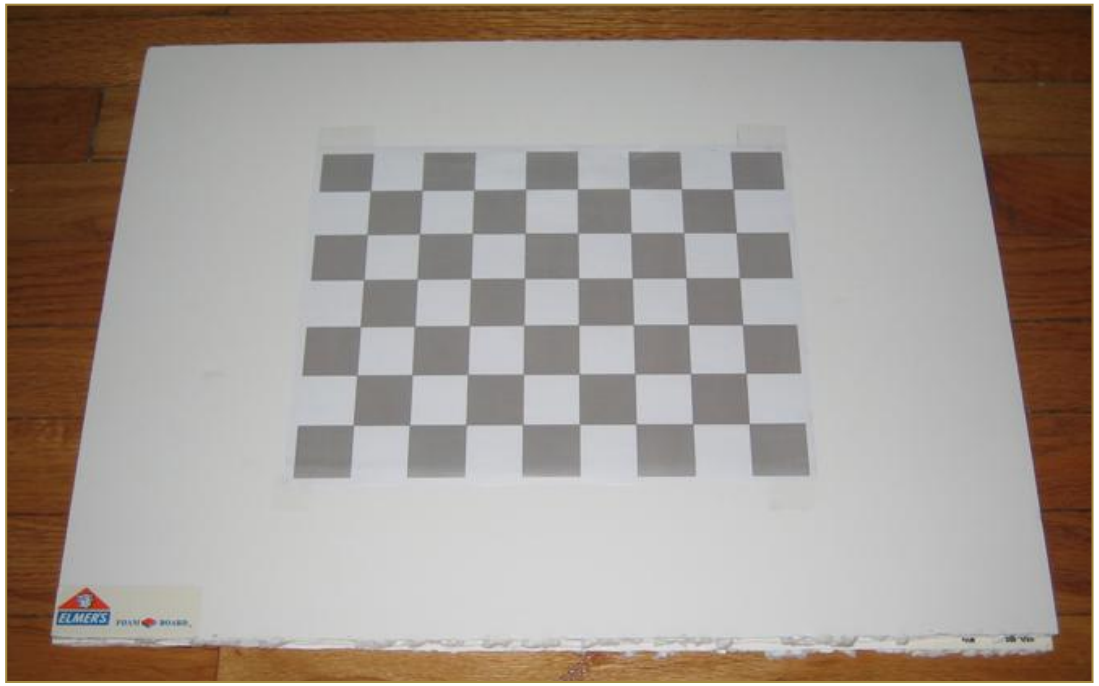

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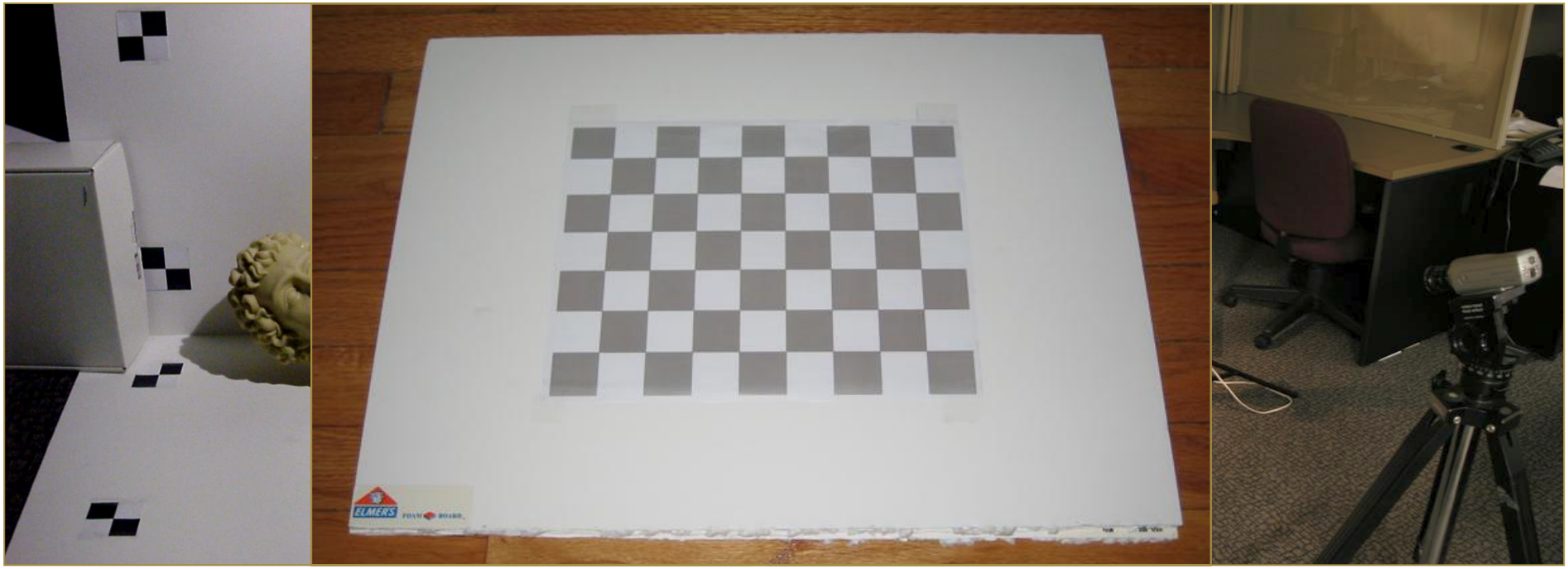

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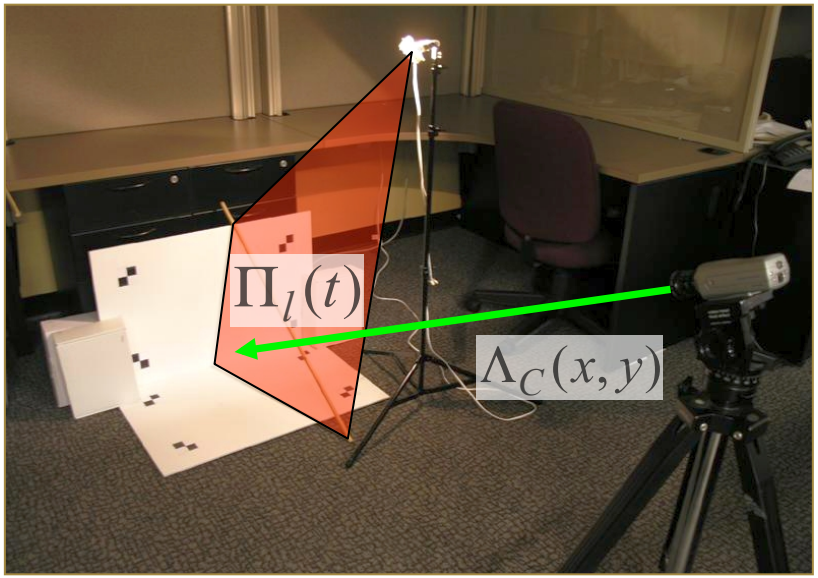
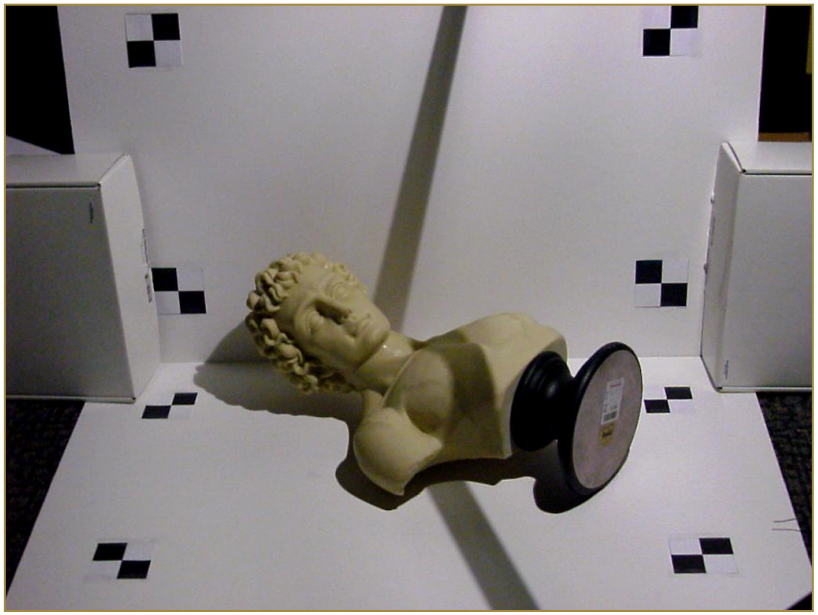
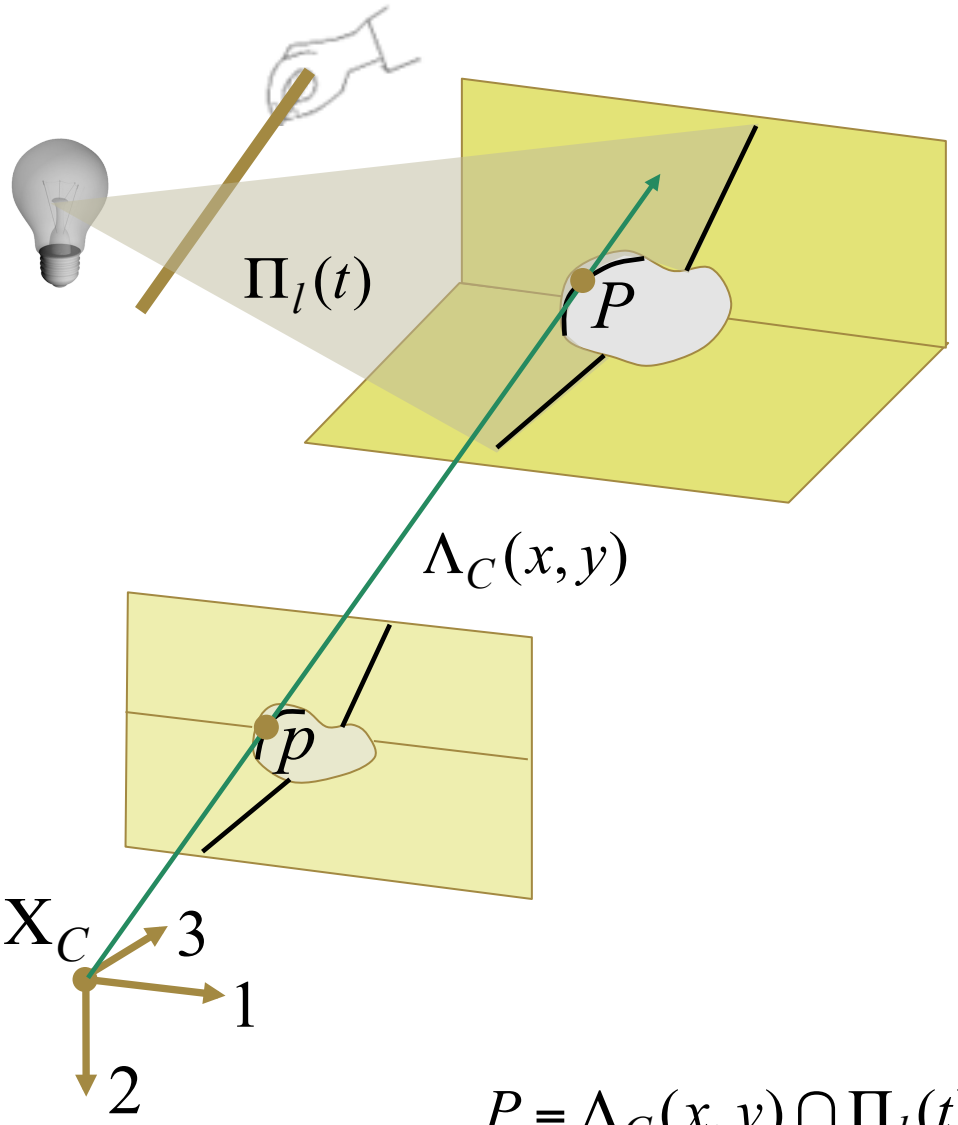
Swept-Plane Reconstruction Geometry

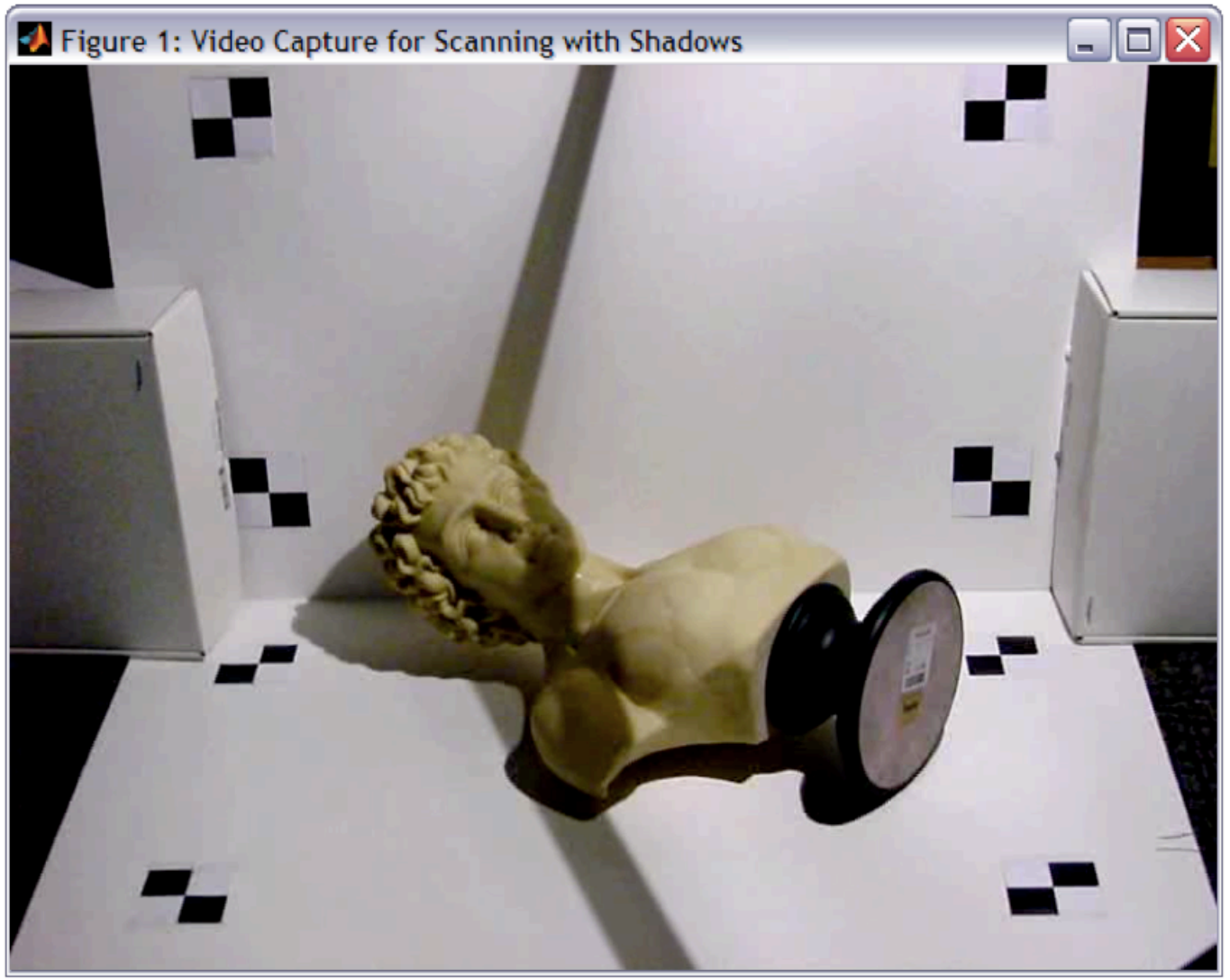




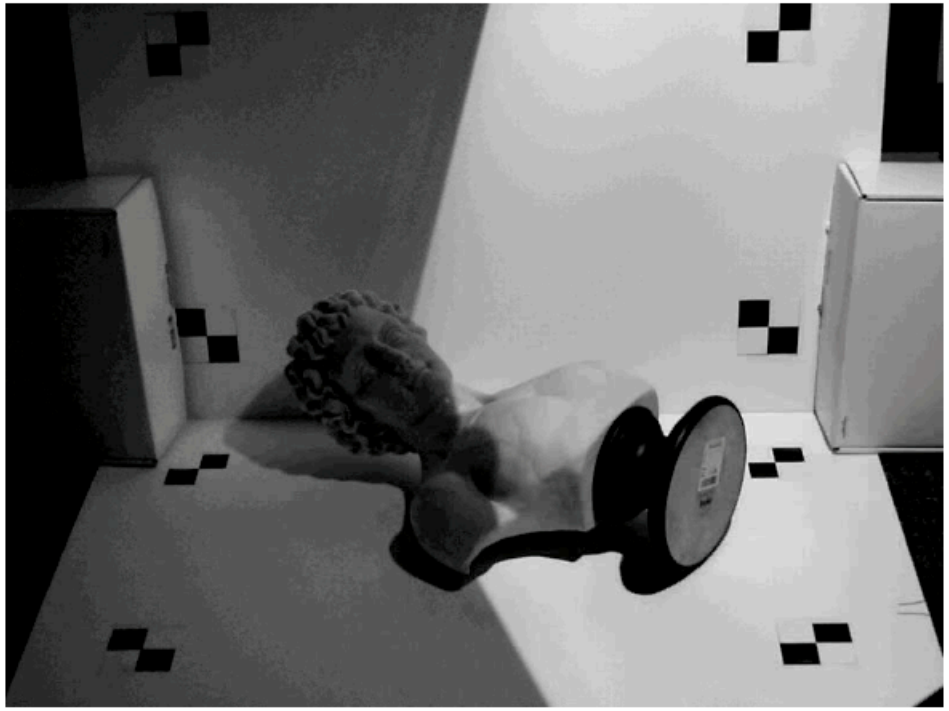


$$P = \Lambda_C(x,y) \cap \Pi_l(t)$$

Demo: Data Capture



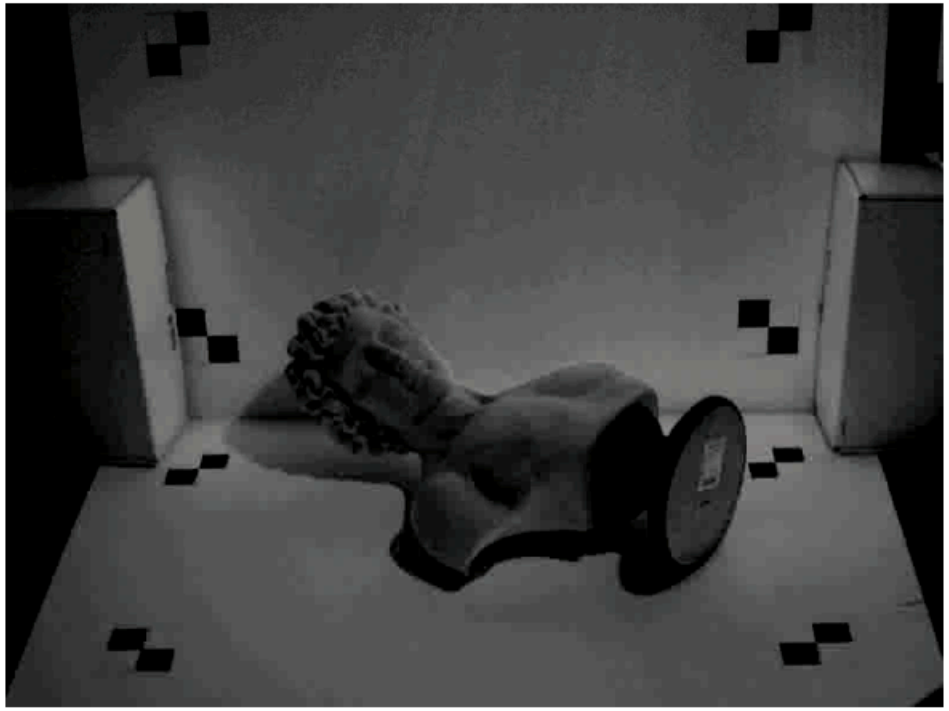
Video Processing:
Assigning Per-Pixel Shadow Thresholds

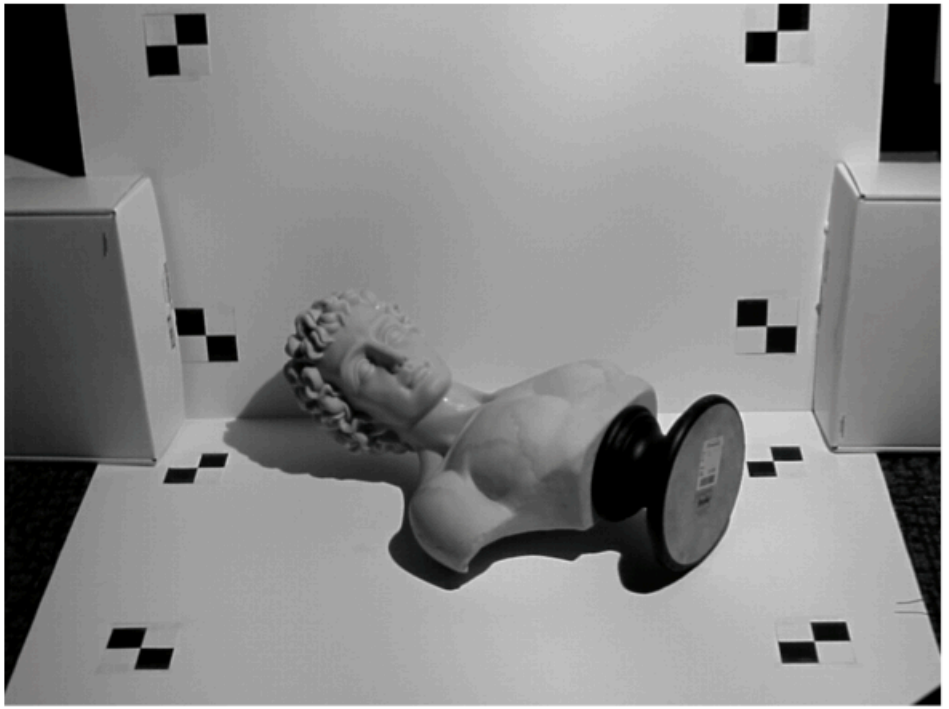


$$I_{min}(x;y) = \min_{t} I(x;y;t)$$

- Convert from RGB to grayscale (for luminance-domain processing)
- Determine per-pixel minimum and maximum value over sequence

Video Processing:
Assigning Per-Pixel Shadow Thresholds

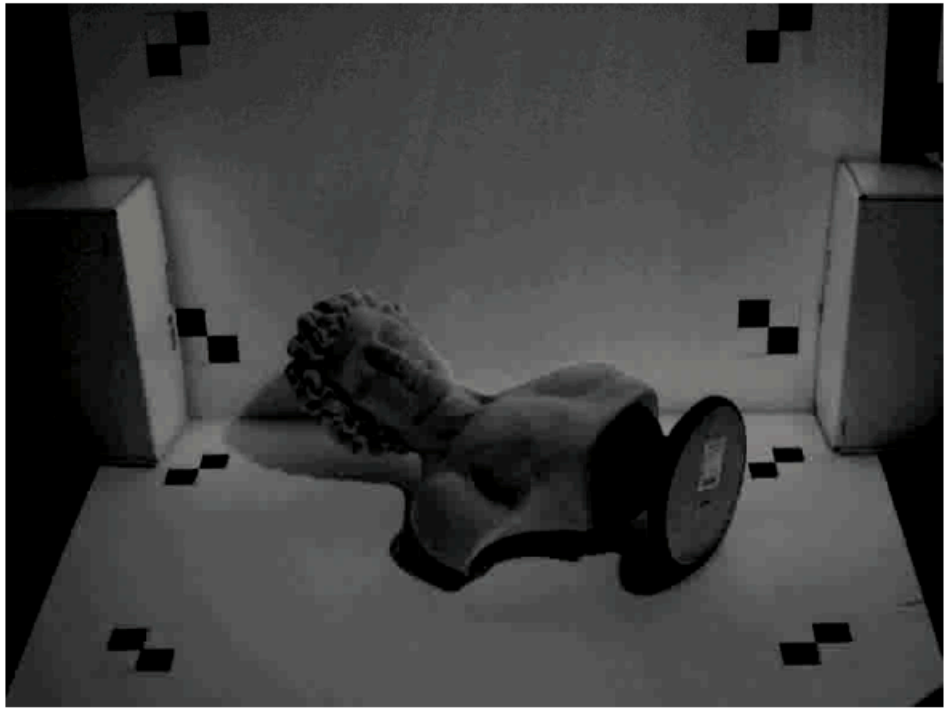


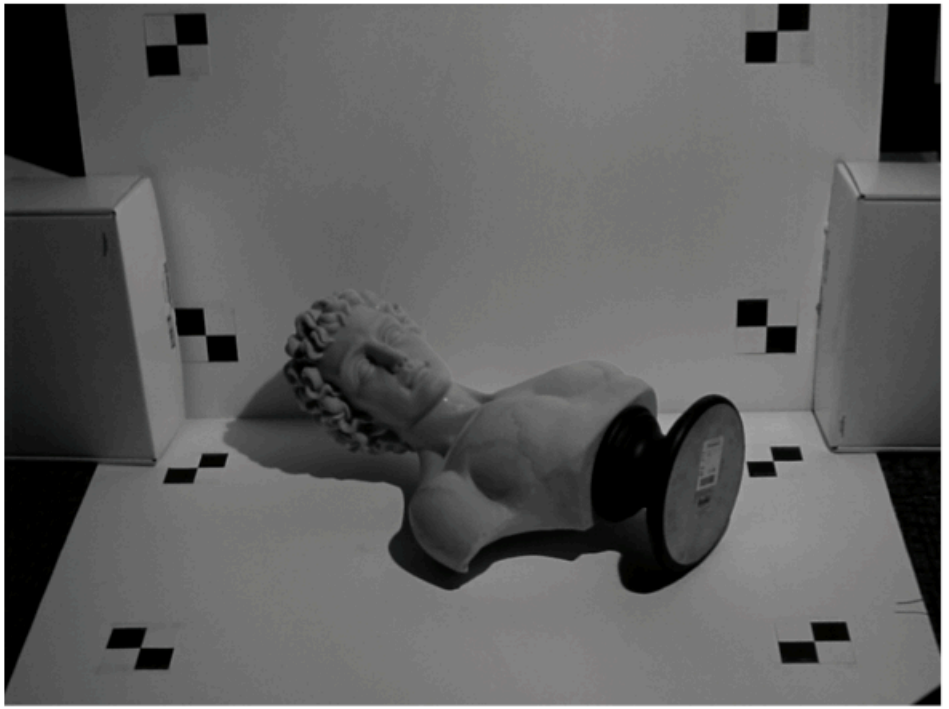


$$I_{min}(x;y) = \min_t I(x;y;t) \qquad I_{max}(x;y) = \max_t I(x;y;t)$$

- Convert from RGB to grayscale (for luminance-domain processing)
- Determine per-pixel minimum and maximum value over sequence

Video Processing:
Assigning Per-Pixel Shadow Thresholds



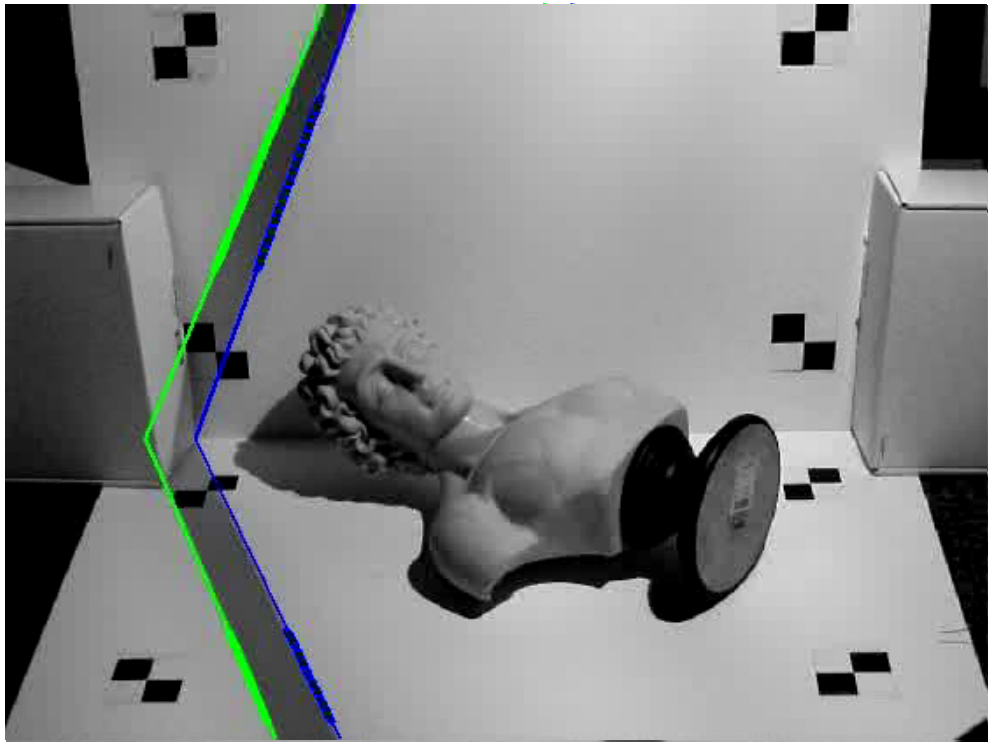


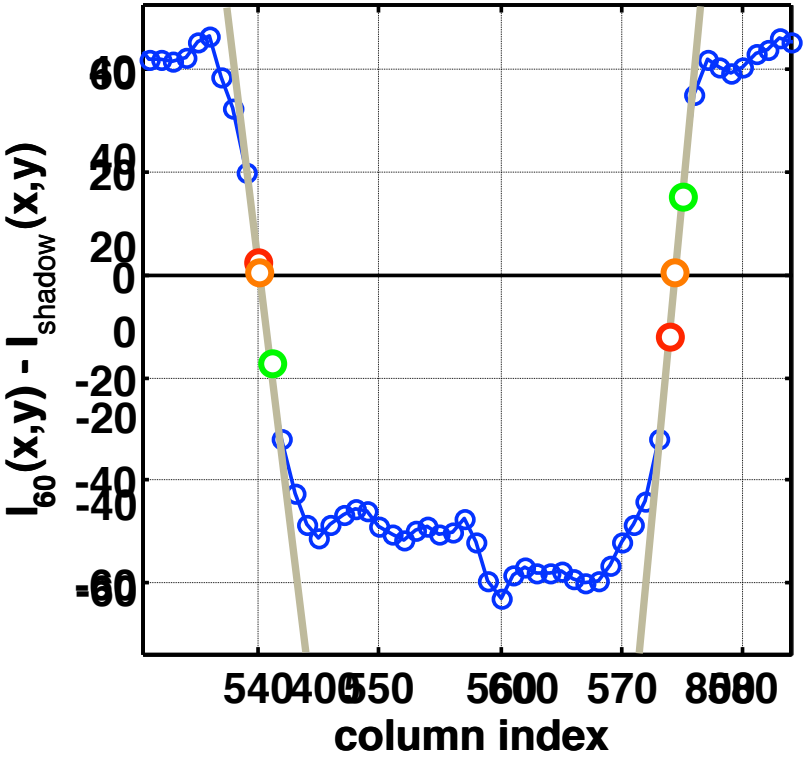
$$I_{min}(x;y) = \min_{t} I(x;y;t)$$

$$I_{shadow}(x;y) = \frac{I_{max}(x;y) + I_{min}(x;y)}{2}$$

- Convert from RGB to grayscale (for luminance-domain processing)
- Determine per-pixel minimum and maximum value over sequence
- Evaluate per-pixel “shadow threshold” as average of min. and max.

Video Processing:
Spatial Shadow Edge Localization

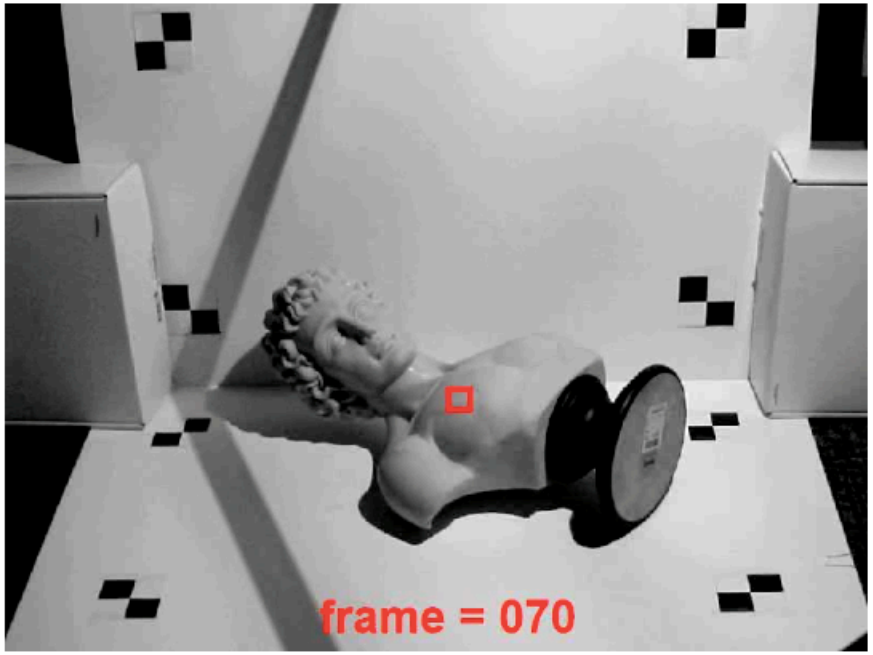


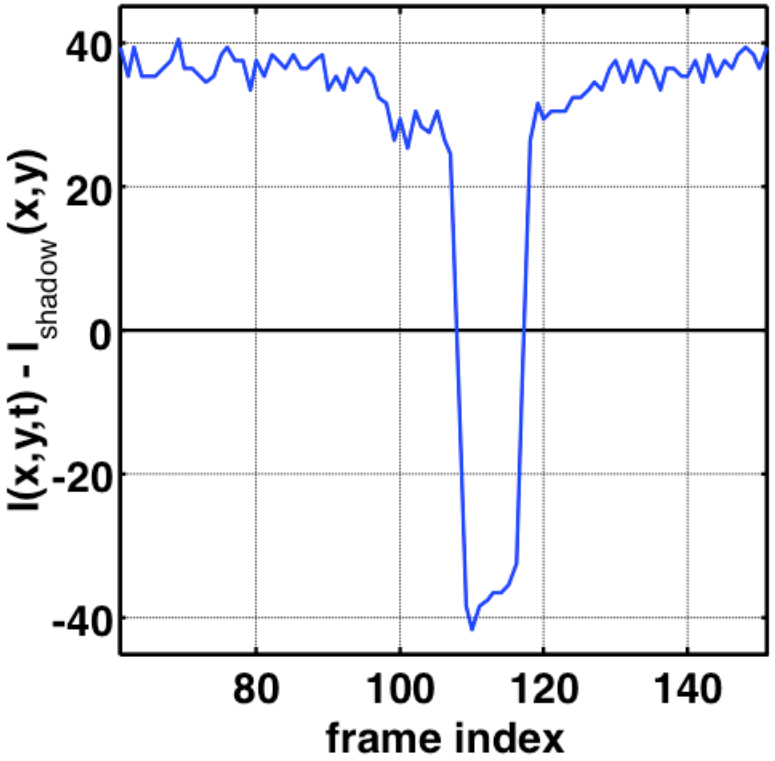


- Select region of interest on each calibration plane (occlusion-free)
- Estimate zero-crossings to find leading and trailing shadow boundaries
- Fit a line to the set of points along each shadow boundary

➔ **Result: Best-fit 2D lines for each shadow edge (in image coordinates)**

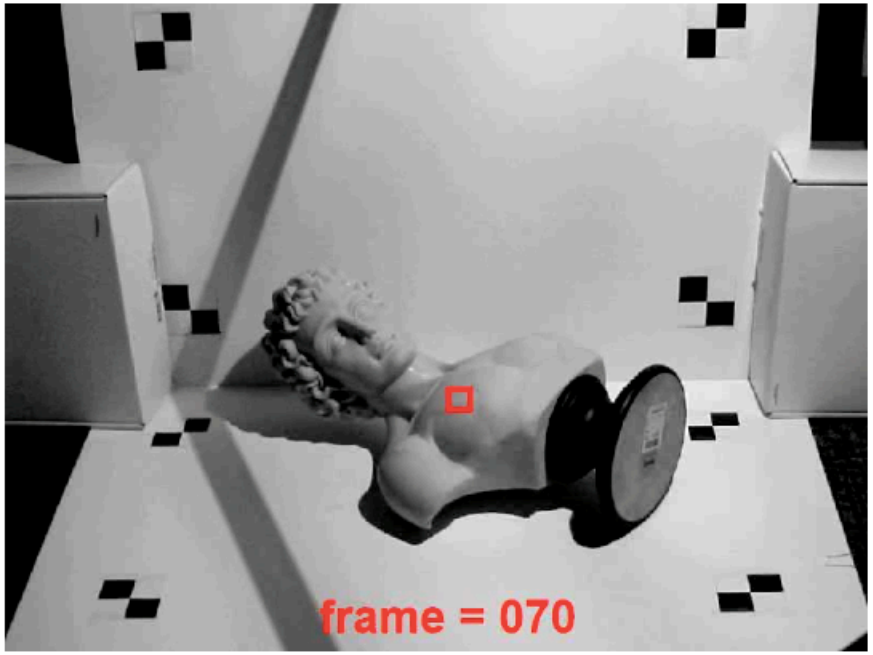
Video Processing:
Temporal Shadow Edge Localization

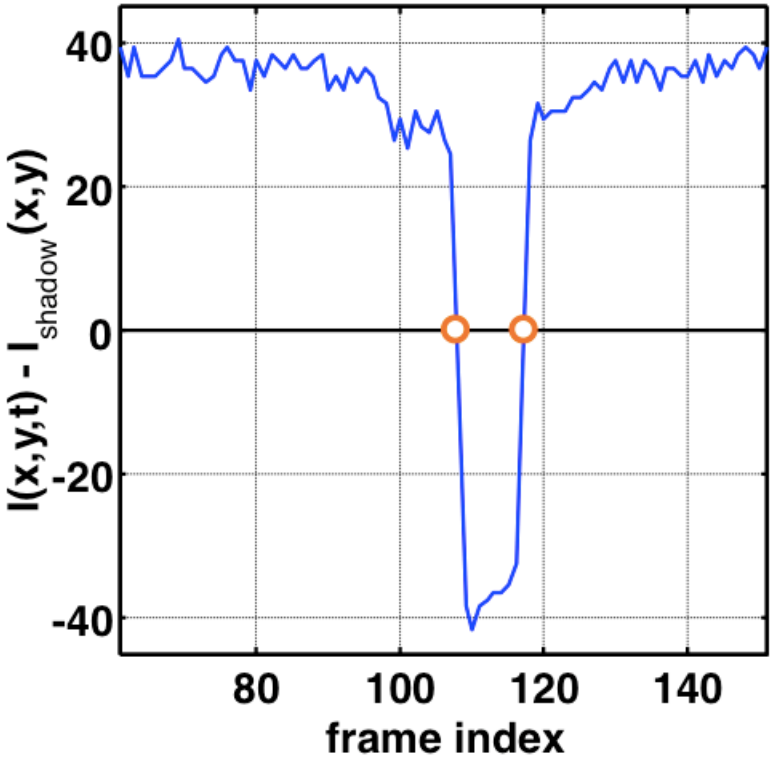




- Tabulate per-pixel temporal sequence (minus shadow threshold)

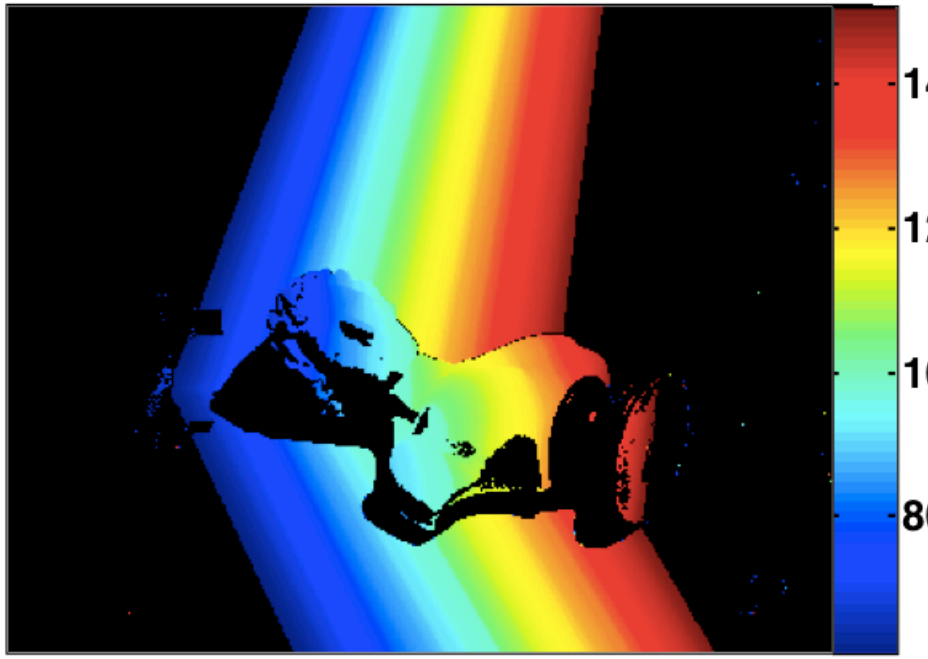
Video Processing:
Temporal Shadow Edge Localization



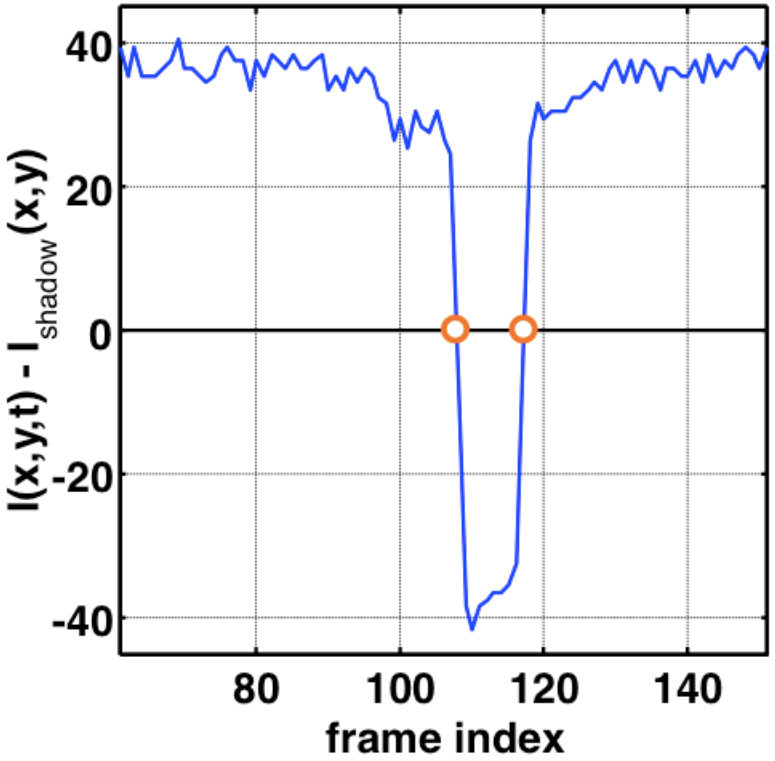


- Tabulate per-pixel temporal sequence (minus shadow threshold)
- Estimate zero-crossings to find shadow-crossing times

Video Processing:
Temporal Shadow Edge Localization



crossing frame index for leading shadow



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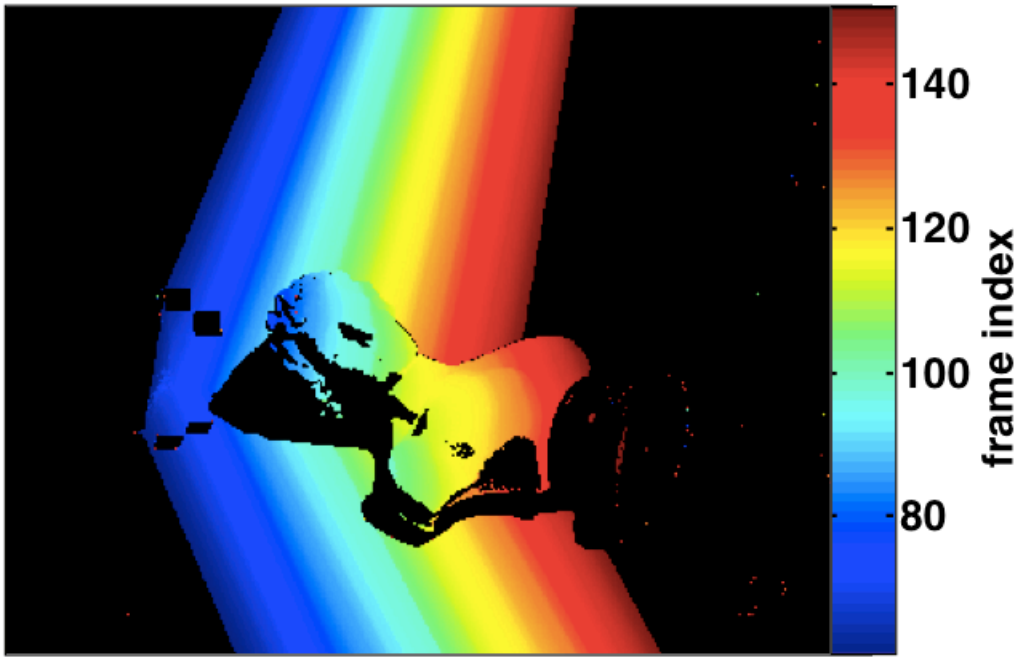
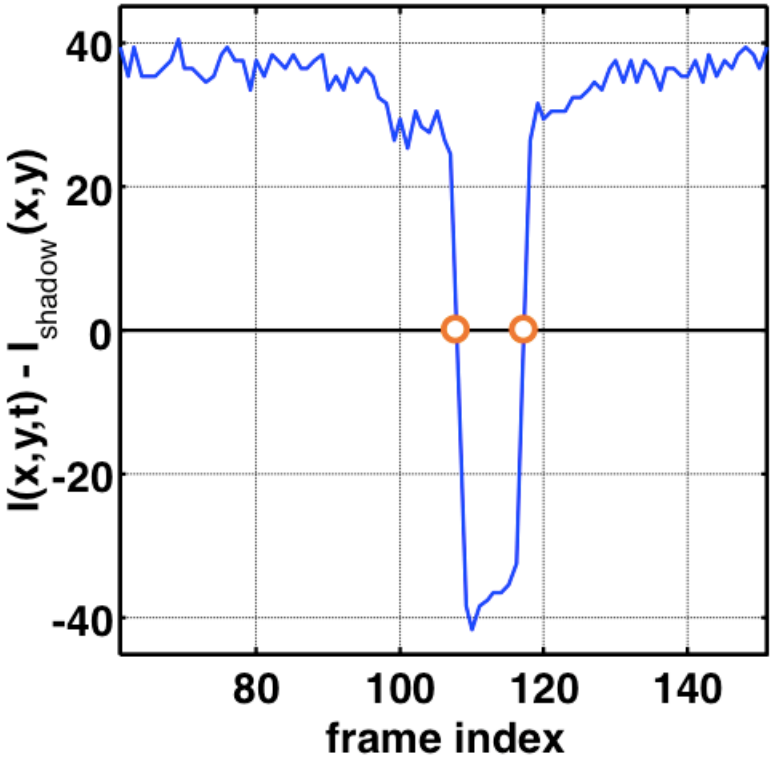
Temporal Shadow Edge Localization



crossing frame index for trailing shadow



- Tabulate per-pixel temporal sequence (minus shadow threshold)
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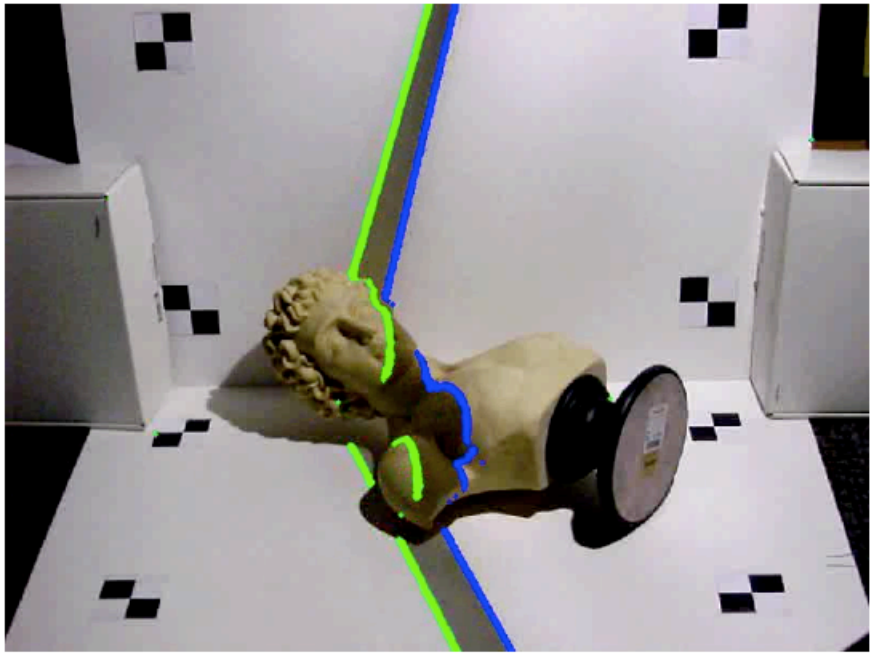
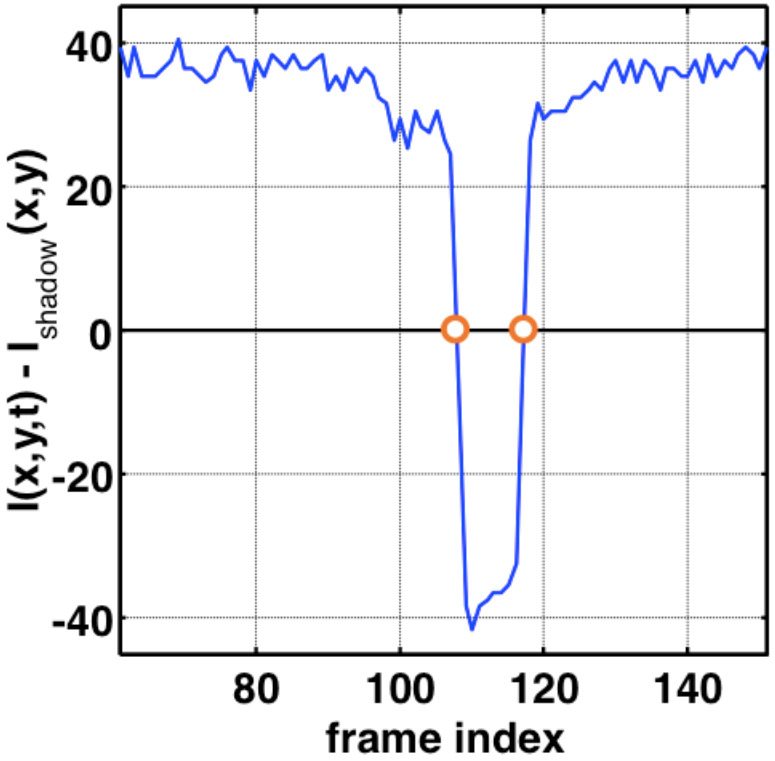
Video Processing:
Temporal Shadow Edge Localization





- Tabulate per-pixel temporal sequence (minus shadow threshold)
- Estimate zero-crossings to find shadow-crossing times

➔ **Result: Use shadow-crossing time to lookup corresponding 3D plane**

Course Schedule

- Introduction
- The Mathematics of 3D Triangulation
- 3D Scanning with Swept-Planes
- ***Camera and Swept-Plane Light Source Calibration***
- Reconstruction and Visualization using Point Clouds