Introducción a la Fotografia 3D

UBA/FCEN Marzo 27 – Abril 12 2013

Clase 7 : Miercoles Abril 10

Gabriel Taubin

Brown University

BROWN

Course Schedule

- Structured Lighting
- Robust Pixel Classification
- ➢ ***Projector Calibration / Structured Light Reconstruction***
- Projector Calibration / Structured Light Reconstruction
- Surface Reconstruction from Point Clouds
- Elementary Mesh Processing

Summary of Camera Calibration

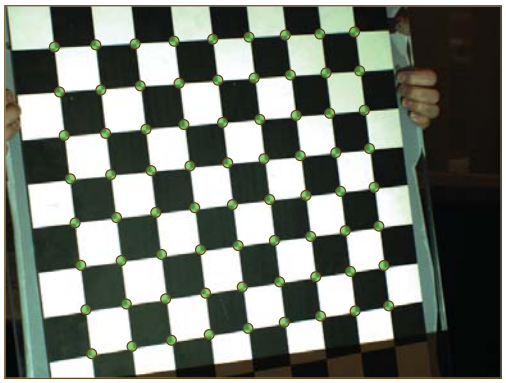
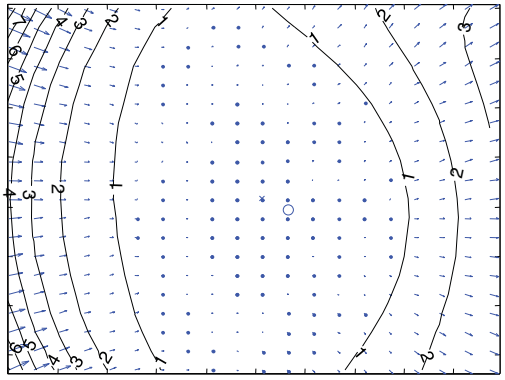


Image Sequence for Camera Calibration



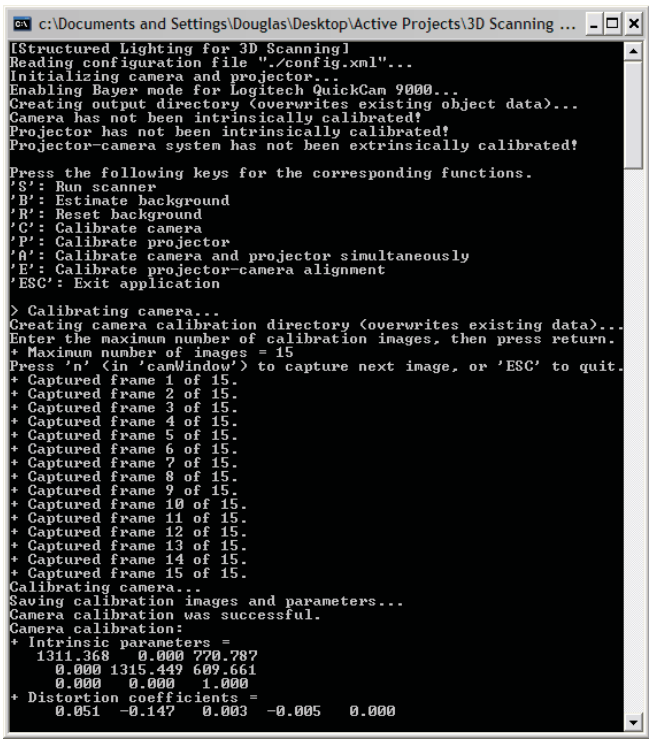
Estimated Camera Lens Distortion

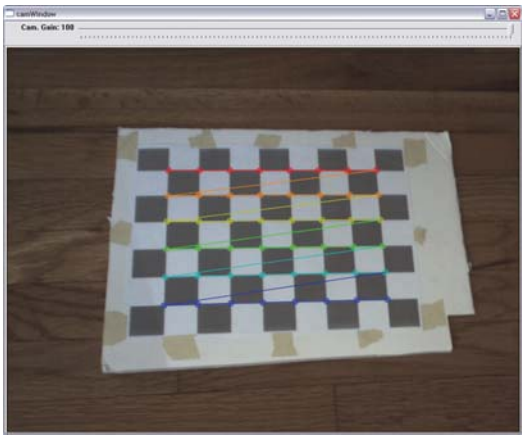
Camera Calibration Procedure

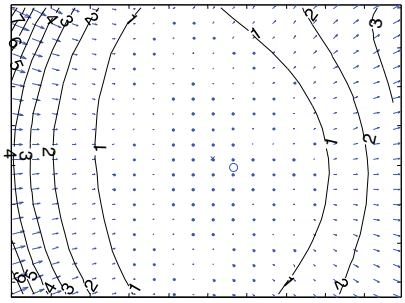
- Use the *Camera Calibration Toolbox for Matlab* or *OpenCV*

Normalized Ray	Distorted Ray (4th-order radial + tangential)	Predicted Image-plane Projection
$x_n = \begin{bmatrix} X_c/Z_c \\ Y_c/Z_c \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix}$	$x_d = \begin{bmatrix} x_d(1) \\ x_d(2) \end{bmatrix} = \left(1 + kc(1)\,r^2 + kc(2)\,r^4 + kc(5)\,r^6\right) x_n + dx$ $dx = \begin{bmatrix} 2\,kc(3)\,x\,y + kc(4)\left(r^2 + 2x^2\right) \\ kc(3)\left(r^2 + 2y^2\right) + 2\,kc(4)\,x\,y \end{bmatrix}$	$x_p = fc(1)\left(x_d(1) + alpha\_c * x_d(2)\right) + cc(1)$ $y_p = fc(2)\,x_d(2) + cc(2)$

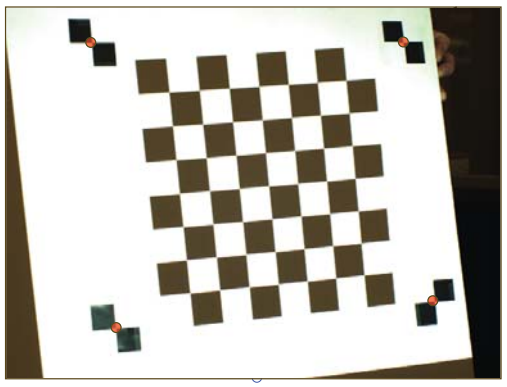
Demo: Camera Calibration in OpenCV





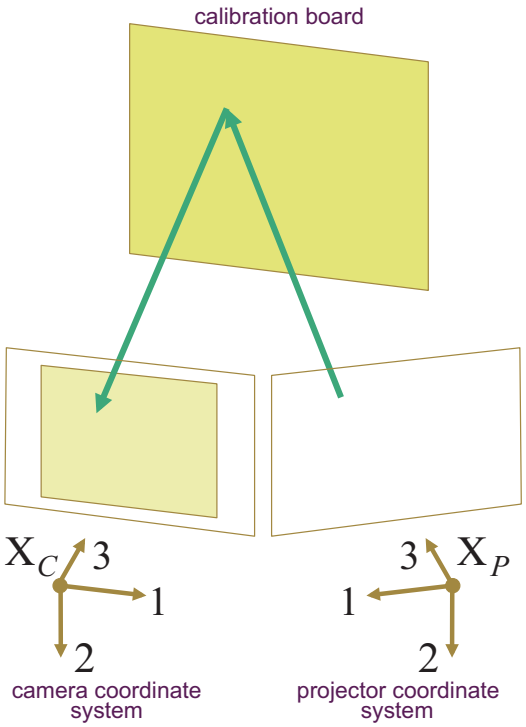


Projector Calibration

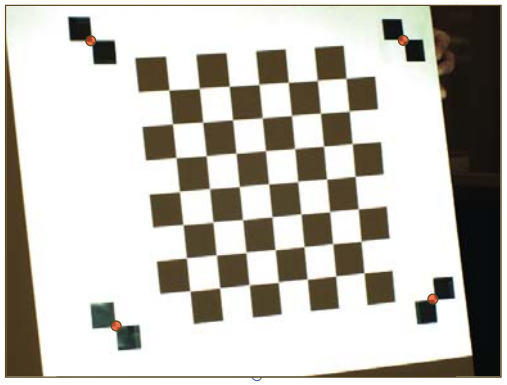


Calibration Procedure

- Consider projector an inverse camera (maps intensities to 3D rays)

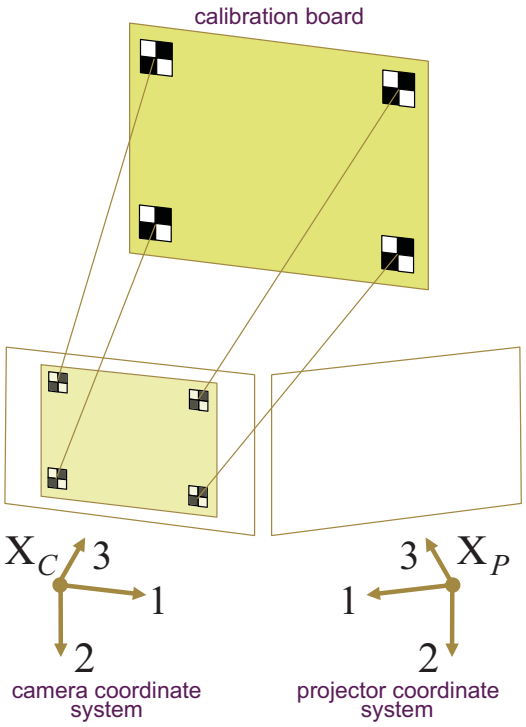


Projector Calibration

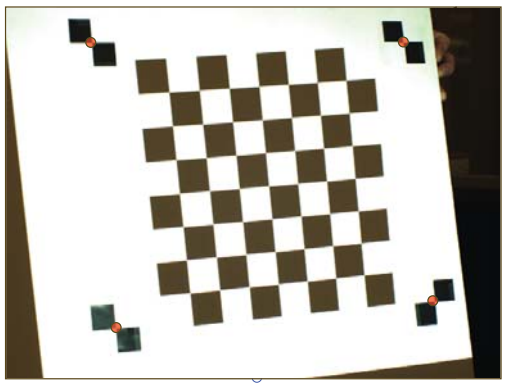


Calibration Procedure

- Consider projector an inverse camera (maps intensities to 3D rays)
- Identify printed fiducials in each image

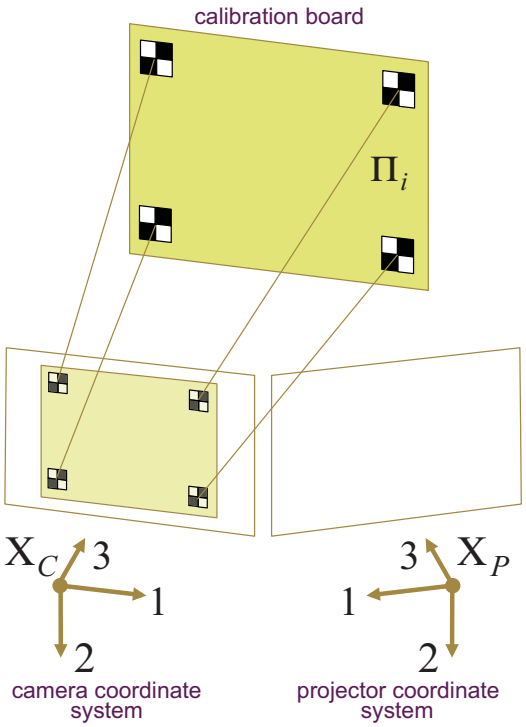


Projector Calibration

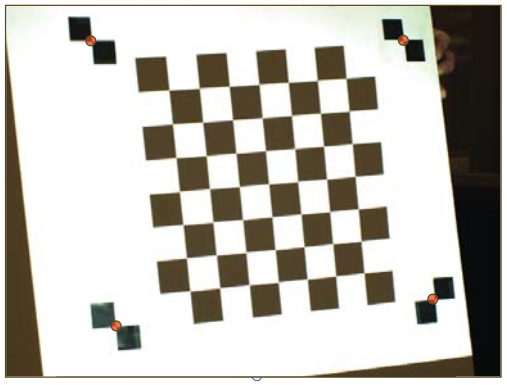


Calibration Procedure

- Consider projector an inverse camera (maps intensities to 3D rays)
- Identify printed fiducials in each image
- Use fidicials to find 3D calibration plane

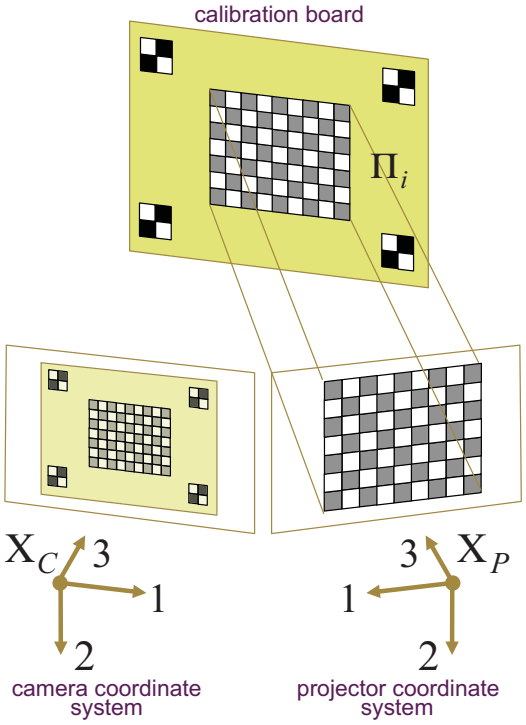


Projector Calibration

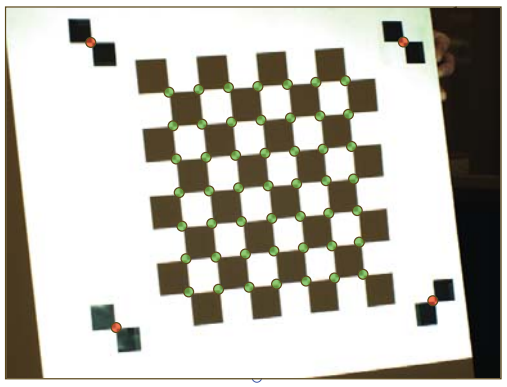


Calibration Procedure

- Consider projector an inverse camera (maps intensities to 3D rays)
- Identify printed fiducials in each image
- Use fidicials to find 3D calibration plane
- Project checkerboard on calibration board

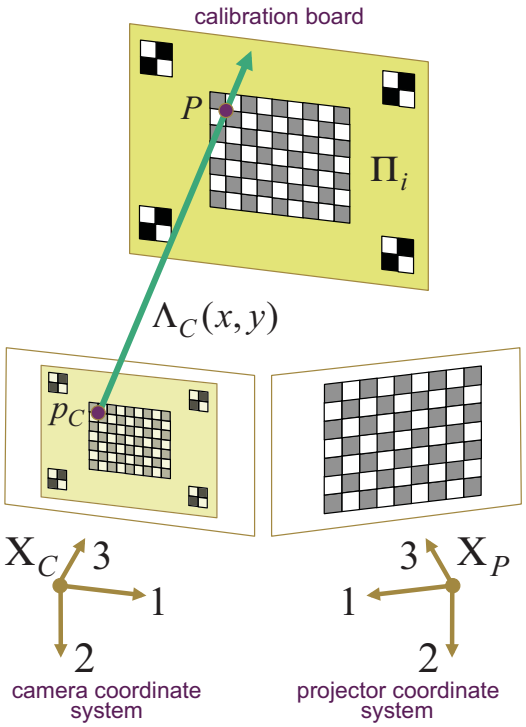


Projector Calibration

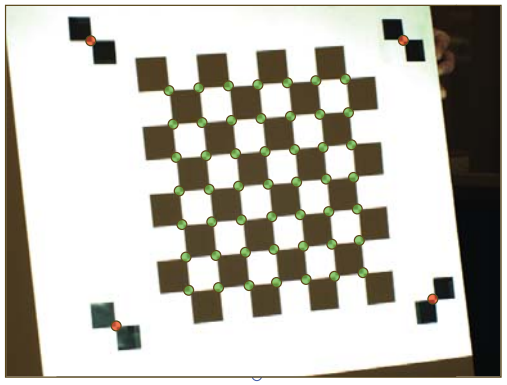


Calibration Procedure

- Consider projector an inverse camera (maps intensities to 3D rays)
- Identify printed fiducials in each image
- Use fidicials to find 3D calibration plane
- Project checkerboard on calibration board
- Find ray-plane intersection for each corner

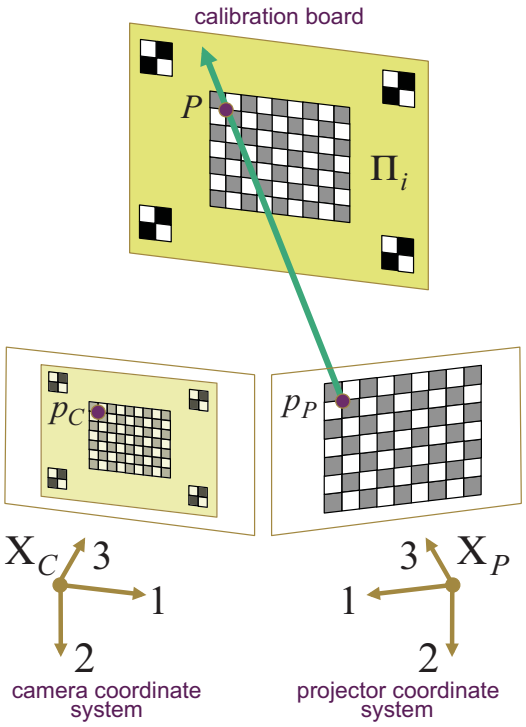


Projector Calibration

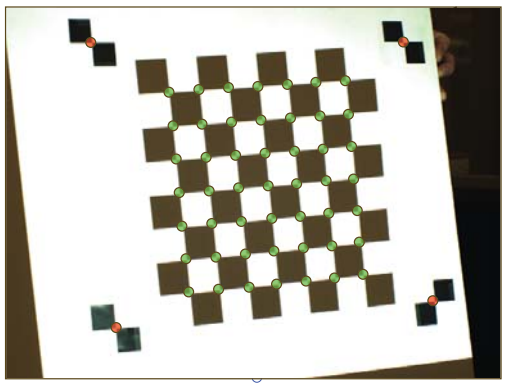


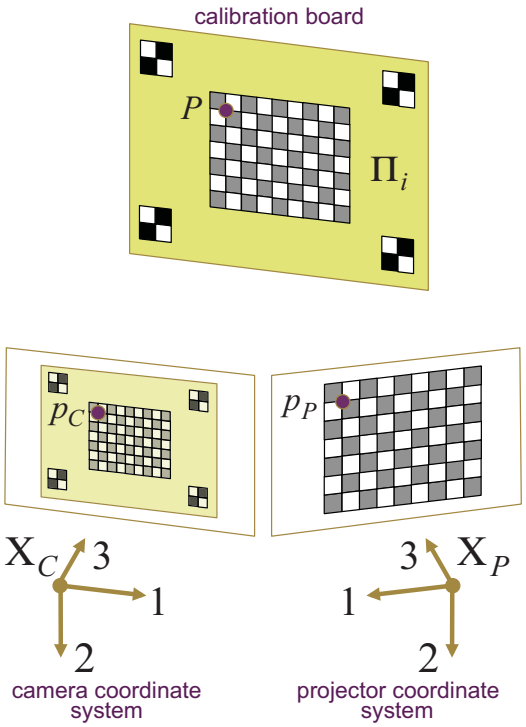
Calibration Procedure

- Consider projector an inverse camera (maps intensities to 3D rays)
- Identify printed fiducials in each image
- Use fidicials to find 3D calibration plane
- Project checkerboard on calibration board
- Find ray-plane intersection for each corner



Projector Calibration

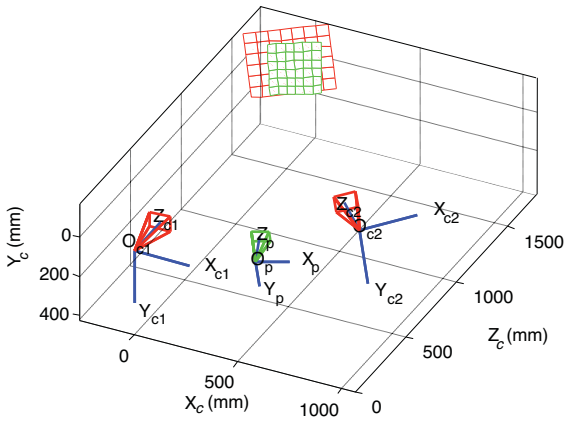




Calibration Procedure

- Consider projector an inverse camera (maps intensities to 3D rays)
- Identify printed fiducials in each image
- Use fidicials to find 3D calibration plane
- Project checkerboard on calibration board
- Find ray-plane intersection for each corner
- Use 2D→3D correspondences to estimate intrinsic/extrinsic projector calibration (and radial distortion model)

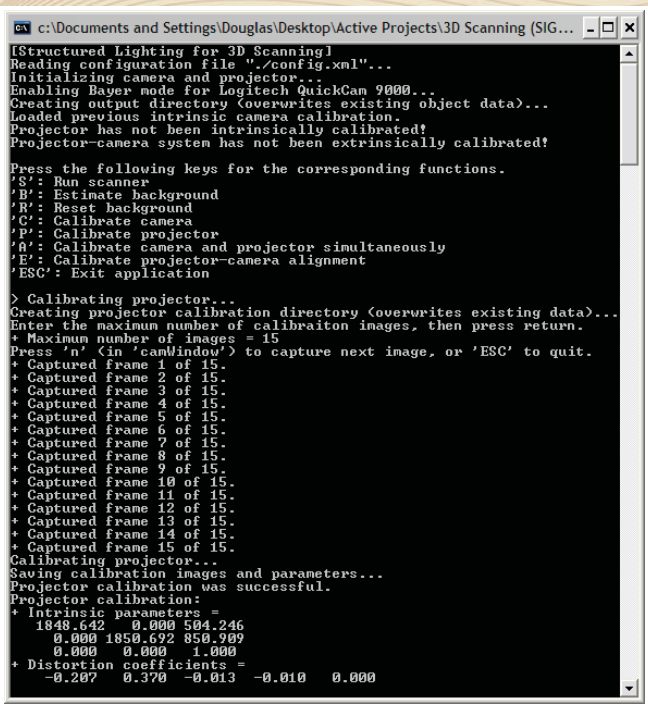
Projector-Camera Calibration Results

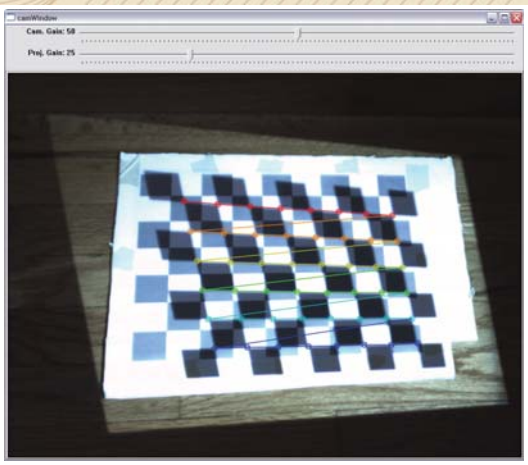


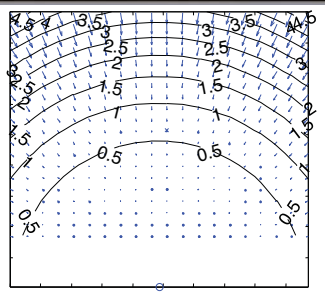
Projector-Camera Calibration Results

- Implemented complete toolbox for projector-camera calibration (available for *Matlab* and *OpenCV*)
- Sufficient accuracy for structured lighting applications
- Software and documentation available on the course website

Demo: Projector Calibration in OpenCV

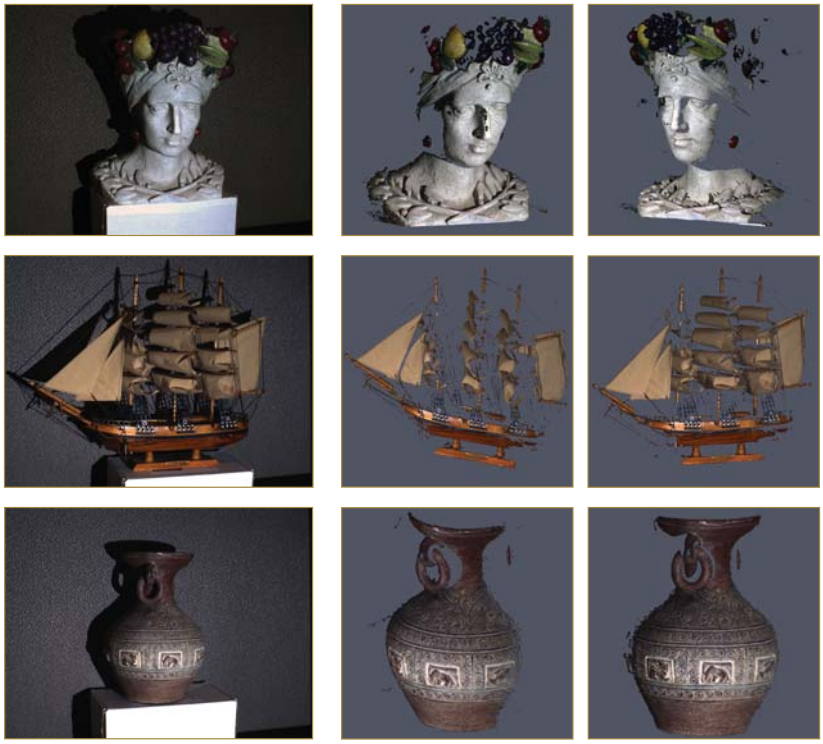




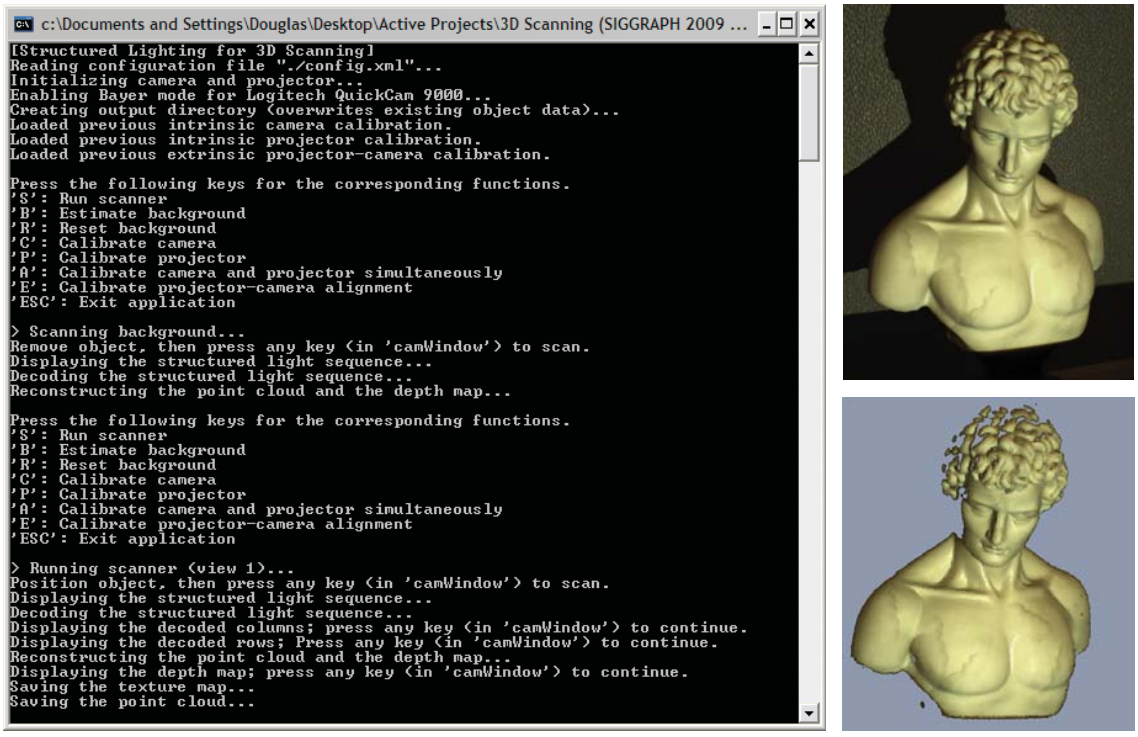


Structured Lighting Reconstruction Results

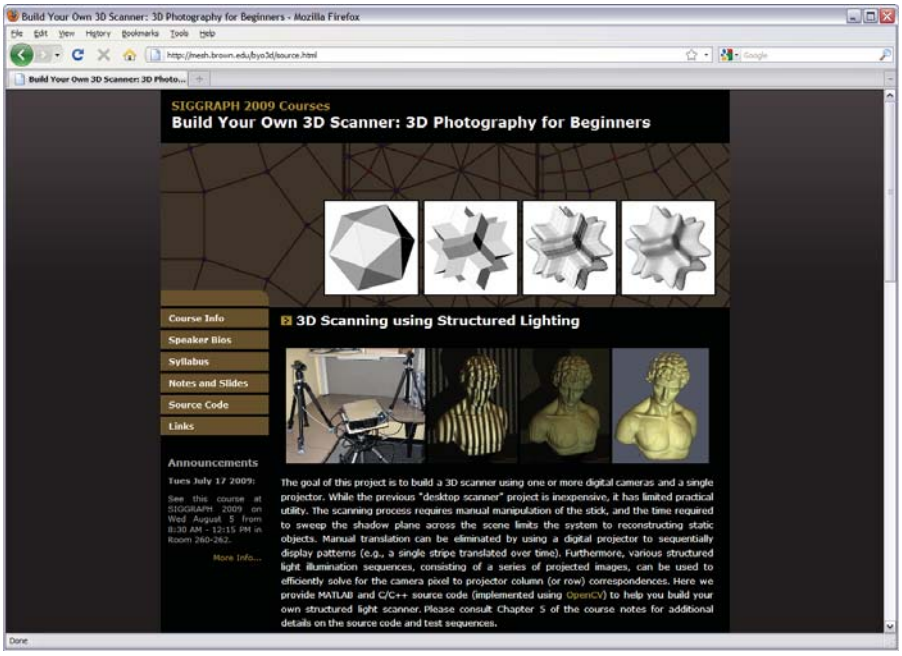
Additional Reconstruction Examples



Demo: Putting it All Together

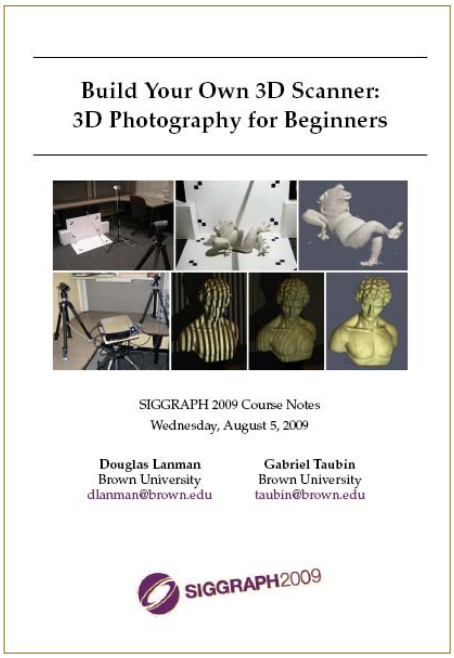


How to Get the Source Code



http://mesh.brown.edu/byo3d

For More Details



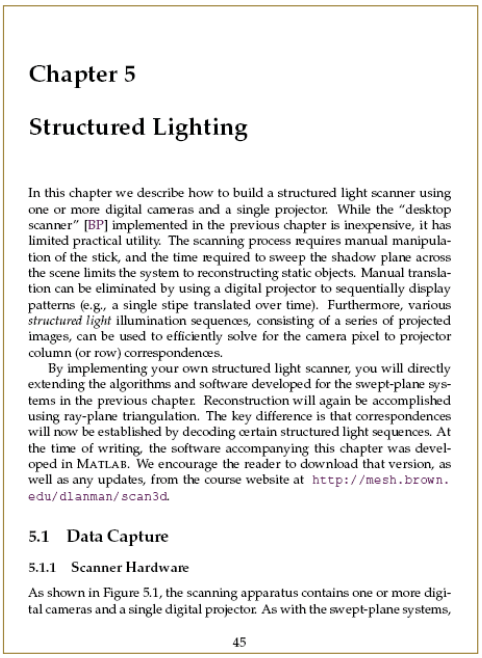
Build Your Own 3D Scanner:
3D Photography for Beginners

SIGGRAPH 2009 Course Notes
Wednesday, August 5, 2009

Douglas Lanman
Brown University
dlanman@brown.edu

Gabriel Taubin
Brown University
taubin@brown.edu

SIGGRAPH2009



Chapter 5

Structured Lighting

In this chapter we describe how to build a structured light scanner using one or more digital cameras and a single projector. While the "desktop scanner" [BP] implemented in the previous chapter is inexpensive, it has limited practical utility. The scanning process requires manual manipulation of the stick, and the time required to sweep the shadow plane across the scene limits the system to reconstructing static objects. Manual translation can be eliminated by using a digital projector to sequentially display patterns (e.g., a single stipe translated over time). Furthermore, various *structured light* illumination sequences, consisting of a series of projected images, can be used to efficiently solve for the camera pixel to projector column (or row) correspondences.

By implementing your own structured light scanner, you will directly extending the algorithms and software developed for the swept-plane systems in the previous chapter. Reconstruction will again be accomplished using ray-plane triangulation. The key difference is that correspondences will now be established by decoding certain structured light sequences. At the time of writing, the software accompanying this chapter was developed in MATLAB. We encourage the reader to download that version, as well as any updates, from the course website at `http://mesh.brown.edu/dlanman/scan3d`.

5.1 Data Capture

5.1.1 Scanner Hardware

As shown in Figure 5.1, the scanning apparatus contains one or more digital cameras and a single digital projector. As with the swept-plane systems,

45

http://mesh.brown.edu/byo3d