Course Syllabus

A. 8:30 - 8:50, 20 min
Introduction (Curless)
1. Overview of area and the course
2. Acquiring 3D models from images
3. Applications to computer graphics

B. 8:50 - 9:35, 45 min
Acquiring Images (Curless and Seitz)
1. Image formation
   - The lens law
   - Aberrations
2. Media and Sensors
   - Film
   - CCD's
3. Cameras as radiometric tools
4. Camera calibration

C. 9:35 - 10:15, 40 min
Overview of passive vision techniques (Seitz)
1. Cues for 3D inference (parallax, shading, focus, texture)
2. Reconstruction techniques
   - Stereo
   - Structure from motion
   - Shape from shading
   - Photometric stereo
   - Other approaches
3. Strengths and Limitations

<> 10:15 - 10:30 **Break**

D. 11:20 - 12:00, 40 min
Voxel-based techniques for reconstruction (Seitz)
1. Reconstructing discretized scenes from images
   - Complexity and computability
2. Volume intersection
   - Shape from silhouettes
3. Voxel coloring
   - Plane-sweep visibility
   - Reconstructing small objects and panoramic scenes
4. Space carving
   - Toward 3D photorealistic walkthroughs
   - Ambiguities in scene reconstruction
   - Convergence properties
5. Related approaches

E. 10:30 - 11:20, 50 min

Façade: modeling architectural scenes (Debevec)

1. Capabilities and Limitations of passive stereo
   - Immersion '94 project, Interval Research Corporation
2. Constrained structure recovery
   - Architectural primitives
3. Photogrammetry
   - Recovering camera parameters
   - Making use of user-interaction
4. Refining structure with Model-based stereo
5. Connections to image-based rendering
   - Impact of geometric accuracy on rendering quality
   - Local vs. global 3D models
   - Geometry's role in view interpolation, virtual environment construction, and reflectance recovery.

<> 12:00 - 1:30 **Lunch**

E. 1:30 - 2:10, 40 min

Overview of active vision techniques (Curless)

1. Imaging radar
   - Time of flight
   - Amplititude modulation
2. Optical triangulation
   - Scanning with points and stripes
   - Spacetime analysis
3. Interferometry
   - Moire
4. Structured light applied to passive vision
   - Stereo
   - Depth from defocus
5. Reflectance capture
   - From shape-directed lighting
   - Using additional lighting

F. 2:10 - 2:50, 40 min

Desktop 3D Photography (Bouguet)

1. Traditional scanning is expensive, but...
   desklamp + pencil = structured light
2. Geometry of shadow scanning
   - Indoor: on the desktop
   - Outdoor: the sun as structured light
3. Image processing: Spacetime analysis for better accuracies
4. Calibration issues
   - Camera calibration
   - Light source calibration
5. Experimental results (indoor and outdoor)
6. Error analysis and Real-time implementation

G. 2:50 - 3:35, 45 min

Shape and appearance from images and range data (Curless)

1. Registration
2. Reconstruction from point clouds
3. Reconstruction from range images
   - Zippering
   - Volumetric merging
4. Modeling appearance

<> 3:35 - 3:50 **Break**

H. 3:50 - 4:40, 50 min

Application: The Digital Michelangelo Project (Levoy)

1. Goals
   - Capturing the shape and apperance of:
     - Michelangelo's sculptures
     - Renaissance architecture
2. Motivation
   - Scholarly inquiry
   - Preservation through digital archiving
   - Virtual museums
   - High fidelity reproductions
3. Design requirements
   - Geometry: from chisel marks to building facades
   - Appearance: reflectance of wood, stone, marble
4. Custom scanning hardware
5. Capturing appearance with high resolution photographs

I. 4:40 - 5:00, 20 min

Discussion: 3D cameras and the future of photography (Everyone)

1. What are the killer apps for 3D photography?
2. When are passive vs. active techniques appropriate?
3. How will consumer-grade technology influence 3D photography?
4. Will 3D photography itself become a consumer product?

<> **Adjourn**

Contents

1. *Introduction (Steve Seitz and Brian Curless)*

Abstract

2. *Acquiring Images (Brian Curless)*

Slides

3. *Overview of passive vision techniques (Steve Seitz)*

Extended Abstract

Papers (printed version only)

A Versatile Camera Calibration Technique for High Accuracy 3D Machine Vision Metrology Using Off-the-Shelf TV Cameras and Lenses
R. J. Tsai

Shape and Motion from Image Streams under Orthography: A Factorization Method
C. Tomasi and T. Kanade

A Multiple-Baseline Stereo
M. Okutomi and T. Kanade

Photometric Method for Determining Surface Orientation from Multiple Images
R. J. Woodham

4. *Voxel-based techniques for reconstruction (Steve Seitz)*

Slides

Papers

Photorealistic Scene Reconstruction by Voxel Coloring
S. M. Seitz and C. R. Dyer

A Theory of Shape by Space Carving
K. N. Kutulakos and S. M. Seitz

5. *Façade: modeling architectural scenes (Paul Debevec)*

Introduction

Paper

Modeling and Rendering Architecture from Photographs: A Hybrid Geometry- and Image-Based Approach
P. E. Debevec, C. J. Taylor, and J. Malik

Paper

Recovering Arches in Facade using Ray-Plane Intersections in 3D
G. D. Borshukov and P. Debevec

Slides

6. *Overview of active vision techniques (Brian Curless)*

Slides

Paper

Better Optical Triangulation through Spacetime Analysis
B. Curless and M. Levoy

7. *Desktop 3D photography (Jean-Yves Bouguet)*

Slides

Paper

3D Photography on Your Desk
J. Y. Bouguet and P. Perona

VRML models (on CDROM only)

8. Shape and appearance from images and range data (Brian Curless)

Slides

Papers

Zippered Polygon Meshes from Range Images
G. Turk and M. Levoy

Surface Reconstruction from Unorganized Points
H. Hoppe, T. DeRose, and T. Duchamp

Mesh Optimization
H. Hoppe, T. DeRose, T. Duchamp, J. McDonald, and W. Stuetzle

A Volumetric Method for Building Complex Models from Range Images
B. Curless and M. Levoy

9. Application: The Digital Michelangelo Project (Marc Levoy)

Extended Abstract

Bibliography of papers included in this volume

- R. J. Tsai, *A Versatile Camera Calibration Technique for High Accuracy 3D Machine Vision Metrology Using Off-the-Shelf TV Cameras and Lenses*, IEEE Journal of Robotics and Automation, Vol. 3, No. 4, 1987, pp. 323-344.
- C. Tomasi and T. Kanade, *Shape and Motion from Image Streams under Orthography: A Factorization Method*, International Journal of Computer Vision, Vol. 9, No. 2, 1992, pp. 137-154.
- M. Okutomi and T. Kanade, *A Multiple-Baseline Stereo*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 15, No. 4, 1993, pp. 353-363.
- R. J. Woodham, *Photometric Method for Determining Surface Orientation from Multiple Images*, Journal of Optical Engineering, Vol. 19, No. 1, 1980, pp. 138-144.
- S. M. Seitz, *Photorealistic Scene Reconstruction by Voxel Coloring*, Proc. IEEE Conf. on Computer Vision and Pattern Recognition, 1997, pp. 1067-1073.
- K. N. Kutulakos and S. M. Seitz, *A Theory of Shape by Space Carving*, Technical Report 692, Computer Science Department, University of Rochester, Rochester, NY, May 1998.
- P. E. Debevec, C. J. Taylor, and J. Malik, *Modeling and Rendering Architecture from Photographs: A Hybrid Geometry- and Image-Based Approach*, Proc. ACM SIGGRAPH 96, 1996, pp. 11-20.
- B. Curless and M. Levoy, *Better Optical Triangulation through Spacetime Analysis*, IEEE International Conference on Computer Vision, 1995, pp. 987-994.
- J. Y. Bouguet and P. Perona, *3D photography on your desk*, Proc. IEEE International Conference on Computer Vision, 1998, pp. 43-50.
- G. Turk and M. Levoy, *Zippered Polygon Meshes from Range Images*, Proc. ACM SIGGRAPH 94, 1994, pp. 311-318.
- H. Hoppe, T. DeRose, and T. Duchamp, *Surface Reconstruction from Unorganized Points*, Proc. ACM SIGGRAPH 92, 1992, pp. 71-78.
- H. Hoppe, T. DeRose, T. Duchamp, J. McDonald, and W. Stuetzle, *Mesh Optimization*, Proc. ACM SIGGRAPH 93, 1993, pp. 19-26.
- B. Curless and M. Levoy, *A Volumetric Method for Building Complex Models from Range Images*, Proc. ACM SIGGRAPH 96, 1996, pp. 303-312.