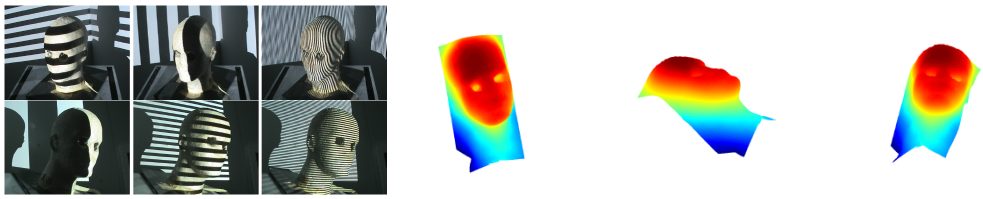
3D Computer Vision

Computing properties of our 3-D world from passive and active sensors

CS Catalog Number 6320
Fall Semester 2008
T,H 12.25 - 1.45 WEB 110

Guido Gerig (gerig@sci.utah.edu)



Syllabus

Goal and Objectives:

- To introduce the fundamental problems of 3D computer vision.
- To introduce the main concepts and techniques used to solve those.
- To enable participants to implement solutions for reasonably complex problems.
- To enable participants to understand basic methodology that is discussed in the computer vision literature.

Computer Vision (*following Tomaso Poggio, MIT*) : Computer Vision, formerly an almost esoteric corner of research and regarded as a field of research still in its infancy, has emerged to a key discipline in computer science. Vision companies have emerged and commercial applications become available, ranging from industrial inspection and measurements to security database search, surveillance, multimedia and computer interfaces. Computer Vision is still far from being a solved problem, and most exciting developments, discoveries and applications still lie ahead of us. Understanding the principles of vision has implications far beyond engineering, since visual perception is one of the key modules of human intelligence.

Who should attend this course? Graduate students who are interested in learning the fundamental concepts of 3D computer vision or desire to use compute vision techniques in their research. Research in 3D computer vision is closely related to computer graphics, to image analysis, but also to areas like machine/robot vision, surgical planning and more.

Prerequisites: Most of the knowledge required should be part of the standard background in Computer Science and undergraduate/graduate Mathematics and Geometry. The undergraduate CS course 5320 may help with familiarity to the topics. The graduate course *cs6640 Image Processing* or an equivalent graduate level image analysis or graphics/imaging course is highly recommended since this course builds on some fundamental image processing methodology and Matlab/C++ code development. Students with different background and curriculum best discuss suitability and options with the teacher.

Overview of the Course

- Introduction
- Image Formation and Image Models
  - Projective Geometry, Modeling Cameras, Projection Matrix
  - Camera distortions and artifacts
  - Camera calibration
- Early Vision: Multiple Images
  - The geometry of multiple views
  - Stereo Vision, epipolar constraints, disparity
  - Shape from stereo, correspondence
- Shape from X
  - Reflectance map
  - Shape from shading
  - Photometric stereo
  - Shape from optical flow (moving camera, moving objects)
  - Rotating camera, Silhouettes, Space carving
  - Light stripe encoding
  - Laser range systems (TOF)
- High Level Vision
  - Model-based Vision
  - Aspect graphs
  - Tracking
  - Finding Templates and Recognition

Textbook

The textbooks for this course are "Computer and Robot Vision" by Haralick&Shapiro and "Computer Vision: a modern approach" by David Forsyth and Jean Ponce (http://www.cs.berkeley.edu/~daf/book.html). The first is a well-known classic textbook by two leaders in the field, and the second one of the most recent books on computer vision, authored by two very well respected researchers in the field.
Additional material (scientific papers, chapters from other textbooks etc.) will be distributed during the course and made available via the UofU webct/blackboard system (https://webct.utah.edu/).

Learning approach

- Students should preferably read the relevant chapters of the books and/or reading assignments before the class.
- In the course, the material will then be discussed in detail and motivated with real world examples and applications.
- will be assignments with theoretical/programming questions to provide students with practical experience of some computer vision techniques.
- There will be on short class lecture where a student introduces one of the topics.
- will also be a final programming project where students will solve a real world problem using computer vision techniques.

Organization

Teaching:	Guido Gerig email: gerig@sci.utah.edu Tel: (801) 585-0327
Lecture time and place:	T,H 12.25 - 1.45 / room WEB 110
Material:	Book (Ponce / Haralick & Shapiro) and handouts
Assignments:	Programming work with Matlab/C++, practical examples with real multi-camera images and range image data
TA:	tbd

Some useful links

- The Computer Vision Homepage (http://www-2.cs.cmu.edu/afs/cs/project/cil/ftp/html/vision.html)
- CVonline (http://www.dai.ed.ac.uk/CVonline/)
- Middlebury Stereo Vision Page (http://cat.middlebury.edu/stereo/)
- CV publications (http://iris.usc.edu/Vision-Notes/bibliography/contents.html)

Bibliography

1. *Computer Vision: a modern approach* by David Forsyth and Jean Ponce
2. *Computer and Robot Vision, Vol II* by Haralick & Shapiro
3. *Emerging topics in computer vision*, by Gérard Medioni and Sing Bing Kang
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5. *Three-Dimensional Computer Vision*, Olivier Faugeras, The MIT Press, 1993.
6. *Computer Vision: Three-Dimensional Data from Images*, Reinhard Klette, Karsten Schlüns, Andreas Koschan, Springer 1998.
7. *Invariant and Calibration-Free Methods in Scene Reconstruction and Object Recognition*, Richard Hartley and Joe Mundy, ARPA No. 8228, 1998. (http://www.balltown.cma.com/hartley/index.html, ftp://ftp.balltown.cma.com/pub/hartley/arpa-report.ps.gz)

8. *Geometric Computation for Machine Vision*, Kenichi Kanatani, Oxford Science Publications, 1995.
9. *Machine Vision: Theory, Algorithms, Practicalities*, E.R. Davies, Academic Press, 1997.
10. *Robot Vision*, B.K.P. Horn, MIT Press 1986.