CEE598 - Visual Sensing for Civil Infrastructure Eng. & Mgmt.

Session 1 - Introduction

Mani Golparvar-Fard
Department of Civil and Environmental Engineering
3129D, Newmark Civil Engineering Lab
e-mail: mgolpar@illinois.edu

Outline

- Introduction
- Class Logistics
- What is Visual Sensing?
  - Geometry
  - Low & Mid-level vision
  - High level vision
- Next Class

Mani Golparvar-Fard, Ph.D.

- Assistant Professor of Civil Engineering, Dec 12 - present
  - Dept. of Civil and Environmental Engineering
  - University of Illinois, Urbana-Champaign

- Director of the Real-time and Automated Monitoring and Control (RAAMAC) lab
  - http://raamac.cee.illinois.edu

- Co-founder
  - Vision Construction Monitoring Ltd., Aug11-present
  - PAR WORKS Inc., Jul 12-present
    - An Allied Minds Company

Mani Golparvar-Fard, Ph.D.

Education and Academic Background

- Assistant Professor of Civil Engineering, Aug10 – Dec 12
  - Via Dept. of Civil and Environmental Engineering
  - Myers-Lawson School of Construction

- Ph.D., Civil & Environmental Eng., Univ. of Illinois, Urbana-Champaign
  Construction Management, July 2010

- M.Cs., Computer Science, Univ. of Illinois, Urbana-Champaign
  Computer Vision and Machine Learning, May 2010

- M.A.Sc., Civil & Environmental Engineering, Univ. of British Columbia
  Project & Construction Management, 2006

- M.Sc., Civil & Environmental Engineering, IUST[1]
  Civil Engineering, 2005

- B.Sc., Civil & Environmental Engineering, IUST
  Civil Engineering, 2002

[1] Iran Univ. of Science & Technology

Mani Golparvar-Fard, Ph.D. (Cont'd)

Professional Experience

International Experience in Construction, Structure and Hydro-Structure Design, and Process Development

- Joint Venture of Perlit Construction Co. & Tehran-Berkeley Managers and Consulting Engineers
- Tehran-Berkeley Managers and Consulting Engineers
- Talan-Sazeh Construction
- Turner Construction (2.5 yrs)
  - Ikenberry Dining and Residential Hall Silver LEED Construction Projects, Champaign, IL.
- Giken Seisakusho Co., Ltd.

Mani Golparvar-Fard, Ph.D. (Cont'd)

Teaching and Research Experience

- Currently, Assistant Professor, Dept. of Civil & Env. Engrg. University of Illinois, Urbana-Champaign, Dec 2012 -Present

- Formerly
  - Assistant Professor, Dept. of Civil & Env. Engrg. and Myers-Lawson School of Construction, Virginia Tech, Aug 2010-Dec 2012
  - Research Assistant, Department of Civil & Env. Engrg., University of Illinois, Urbana-Champaign, 2006-2010

- Research Interest:
  - Computer Vision Sensing and Augmented Reality Visualization of Building and Construction Performance Metrics
  - Integrated As-Built Building Information Modeling
  - Rapid Energy Modeling of Existing Buildings Using Thermal and Digital Imagery
  - Remote Pre and Post-Disaster Analysis of Critical Physical Infrastructures

Mani Golparvar-Fard, Ph.D. (Cont'd)

Current & Previous Professional Services

- ASCE
  - Currently an Associate Member
  - Vice-Chair, Data Sensing and Analysis Committee, TCCIT, ASCE, 2011-present
  - Student Member, 2000-2010
  - Treasurer, UIUC ASCE Student Chapter, 2007-2008

- Construction Management Association of America
  - Faculty Advisor, Sustainable Construction Group, 2010-2012
  - Co-Founder and Vice-President, UIUC CMAA Student Chapter, 2008-2010

- UIUC Faculty-Student Senate
  - Elected by all graduate students from all disciplines on campus (three times for three years), 2007-2010

Youngjib Ham

Education

- Ph.D student, Dept. of Civil & Env. Engrg. University of Illinois at Urbana-Champaign (present)
- M.Sc., Architectural Engrg, Dept. of Architecture Engrg. Seoul National University, 2009-2011
- B.Sc., Civil Engineering, Dept. of Civil & Env. Engrg. Seoul National University, 2003-2009

Research Interest

- Energy Performance Augmented Reality (EPAR)
  - Vision based-building diagnostics and retrofit analysis

Office Hours & Locations

Mani Golparvar-Fard

- Tue & Thu 05:30 pm – 07:00 pm or by appointment
- 3129D Newmark Civil Engineering Laboratory

Youngjib Ham

- Mon & Wed 12:00 pm – 1:00 pm
- 2112 Newmark Civil Engineering Laboratory

Getting to Know You

- Introduce Yourself
  - Name
  - Your department and area of concentration
  - Your research topic (if any)
  - Tell us one interesting fact about yourself that no one knows

Readers

- Course Notes and Supplementary Material will be available for download from Compass2g
  - http://compass2g.illinois.edu

- Text Books

S	**Computer Vision: Algorithms and Applications**, by R. Szeliski, Springer, 2011.
HZ	**Multiple View Geometry in Computer Vision**, by R. Hartley and A. Zisserman, Academic Press, 2004.
FP	**Computer Vision, A Modern Approach**, by D.A. Forsyth and J. Ponce, Prentice Hall, 2003.

Readers

- Instructional Approach
  - Lectures/ Discussions in the classroom
- Assignment from a selected set of topics
- Paper presentation from a particular topic of interest
- Term Project
  - Project Proposal
  - Mid Semester Project Report and Presentation
  - Term Project Report and Presentation

Communication

- Course website http://compass2g.illinois.edu
  - Syllabus
  - Class Schedule
  - Course Content
  - Assignments & Assignment Solutions
  - Wikipage
  - Graded Assignments
  - Answer to your Questions

- Post all question on: Wikipage
  - All course related questions will only be answered on the Wikipage
  - You can also answer questions on the WikiPage
  - This is part of class participation

- For other course related issues or in case if you are not able to post your questions on the Wikipage, please send an email with subject line "[CEE598] …" directly to the instructor:
  - "Mani Golparvar" <mgolpar@illinois.edu>

Course Schedule

Session	Day	Date	Topic	Reading		Project Due	Assignment	
				Chapter	Due		Out	Due
1	Tue	150Jan	No Class					
2	Thu	17-Jan	Course Introduction & Administration					
3	Tue	22-Jan	Review of Linear Algebra and Geometric Transformations					
4	Thu	24-Jan	Camera Models and Projective Geometry	S30-98, FP1&2, HZ6&8				
5	Tue	29-Jan	Camera Calibration	FP3, HZ7				
6	Thu	31-Jan	Single View Metrology	HZ2,3&8				
7	Tue	5-Feb	Presentation by Prof. Niebles (UDC)				A1	
8	Thu	7-Feb	Review of Assignment #1, Single View Metrology					
9	Tue	12-Feb	Single View Metrology					
10	Thu	14-Feb	Pixels and Image Filtering	FP7&8			A2	
11	Tue	19-Feb	Linear Filters					A1
12	Thu	21-Feb	Feature Detectors, Descriptors			P1		
13	Tue	26-Feb	Feature Detectors, Descriptors	FP 8&9				
14	Thu	28-Feb	Feature Detectors, Descriptors II					
15	Tue	5-Mar	Segmentation and Clustering	FP14				
16	Thu	7-Mar	Epipolar Geometry	HZ4,9&11; FP10				A2
17	Tue	12-Mar	Stereo Systems and Volumetric Stereo	HZ11, FP11			A3	
18	Thu	14-Mar	Shape from Reflections					
19	Tue	19-Mar	No Class- Spring Break					
20	Thu	21-Mar	No Class- Spring Break					
21	Tue	26-Mar	Structure from Motion - Affine	HZ6,14&18; FP12				
22	Thu	28-Mar	Structure from Motion - Perspective	HZ10,18&19; FP13		P2		
23	Tue	2-Apr	Fitting and Matching	HZ4&11, FP16			A4	A3
24	Thu	4-Apr	Optical Flow and Tracking					
25	Tue	9-Apr	Introduction to Object Recognition - Single Instances					
26	Thu	11-Apr	Object Recognition - Bag of Words Models	S696-709	*		A5	
27	Tue	16-Apr	Object Recognition - 2D/3D Part Based Models		*			A4
28	Thu	18-Apr	D4AR Automated Monitoring		*			
29	Tue	23-Apr	Personnel and Equipment Tracking and Applications for Structural and Transportation Engineering		*			
30	Thu	25-Apr	Presentation by Dr. Furukawa (Google)		*			A5
32	Tue	30-Apr	Final Project Presentation			P3		

Course Evaluation

- Class participation 5%
- Assignments 40%
  - The grade for written assignments and submitted codes (5 assignments)
- Paper Presentation 10%
  - 1 Presentation (1 or 2 papers)
- Final term project
  - Project proposal and progress report 5%
  - Project report 30%
  - Project presentation 10%

Grading Policy

- Late policy for machine problems and project
  - 0-24 hours late – deduct 50%.
  - More than 24 hours late – deduct 100%.

- Collaboration policy
  - Read the Honor system, understand what is 'collaboration' and what is 'academic infraction'
  - Discussing project assignment with each other is allowed, but coding must be done individually

Paper Presentations

- To help you master a specific topic on application of visual sensing for AEC industry.
- Your presentation should present the key ideas of the assigned works and explain important technical aspects.
- On the wikipage, there will be a separate section for each presentation, where students will be able to post their comments.

Term Project

- Replicate an interesting paper
- Comparing different methods to a test bed
- A new approach to an existing problem
- Original research

- Write a 10-page paper summarizing your results
- Release the final code
- Give a presentation

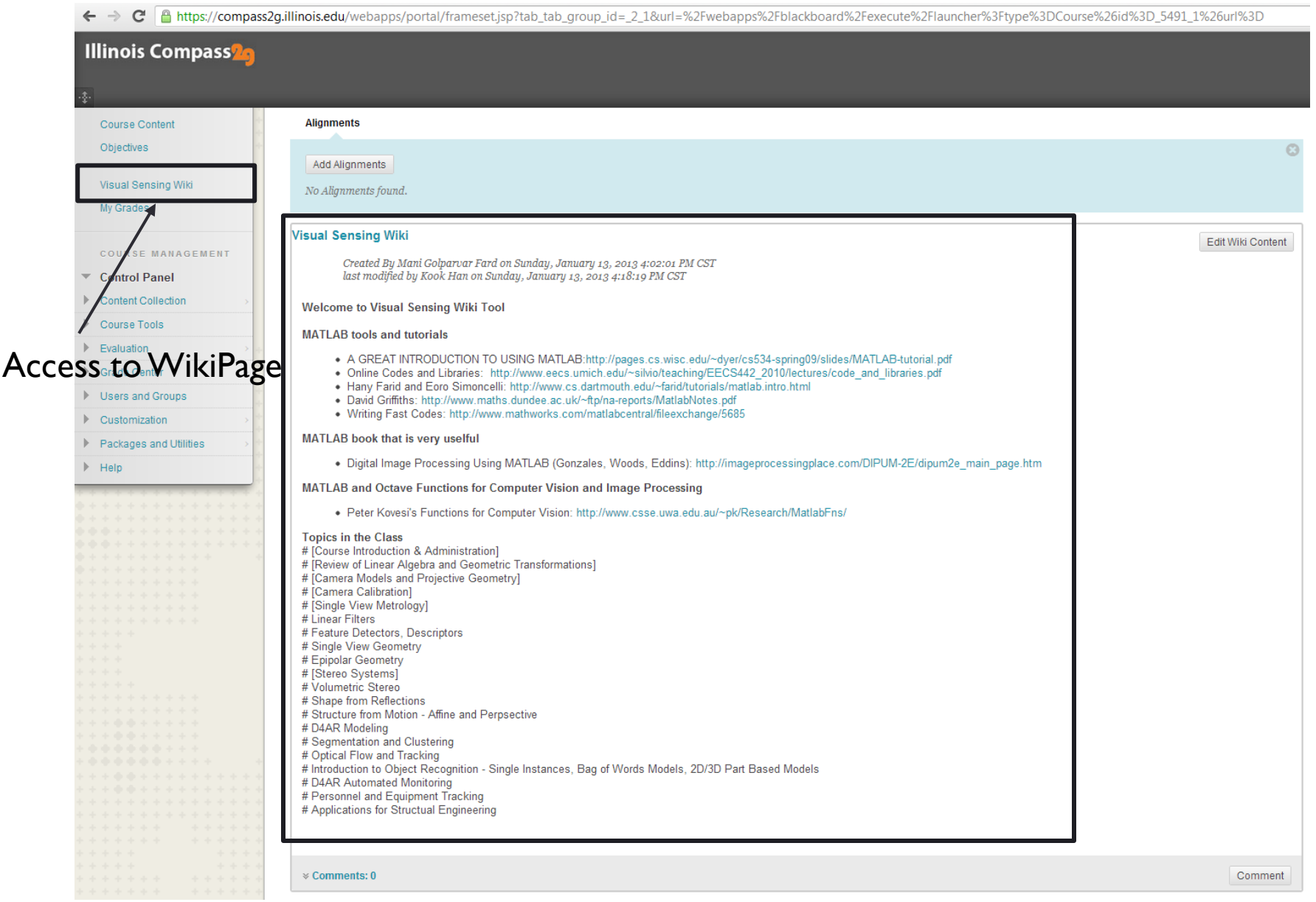
- We will discuss projects in the next class
- Important dates: look up class schedule

Term Project

- Form your teams
  - 1-3 people
  - The quality is judged regardless of the number of people on a team

- Evaluation
  - Quality of the project (including writing)
  - Final ~20 minutes project presentation in class – students will vote your presentation
  - For final code and paper due dates please consult webpage

Wikipage



Access to WikiPage

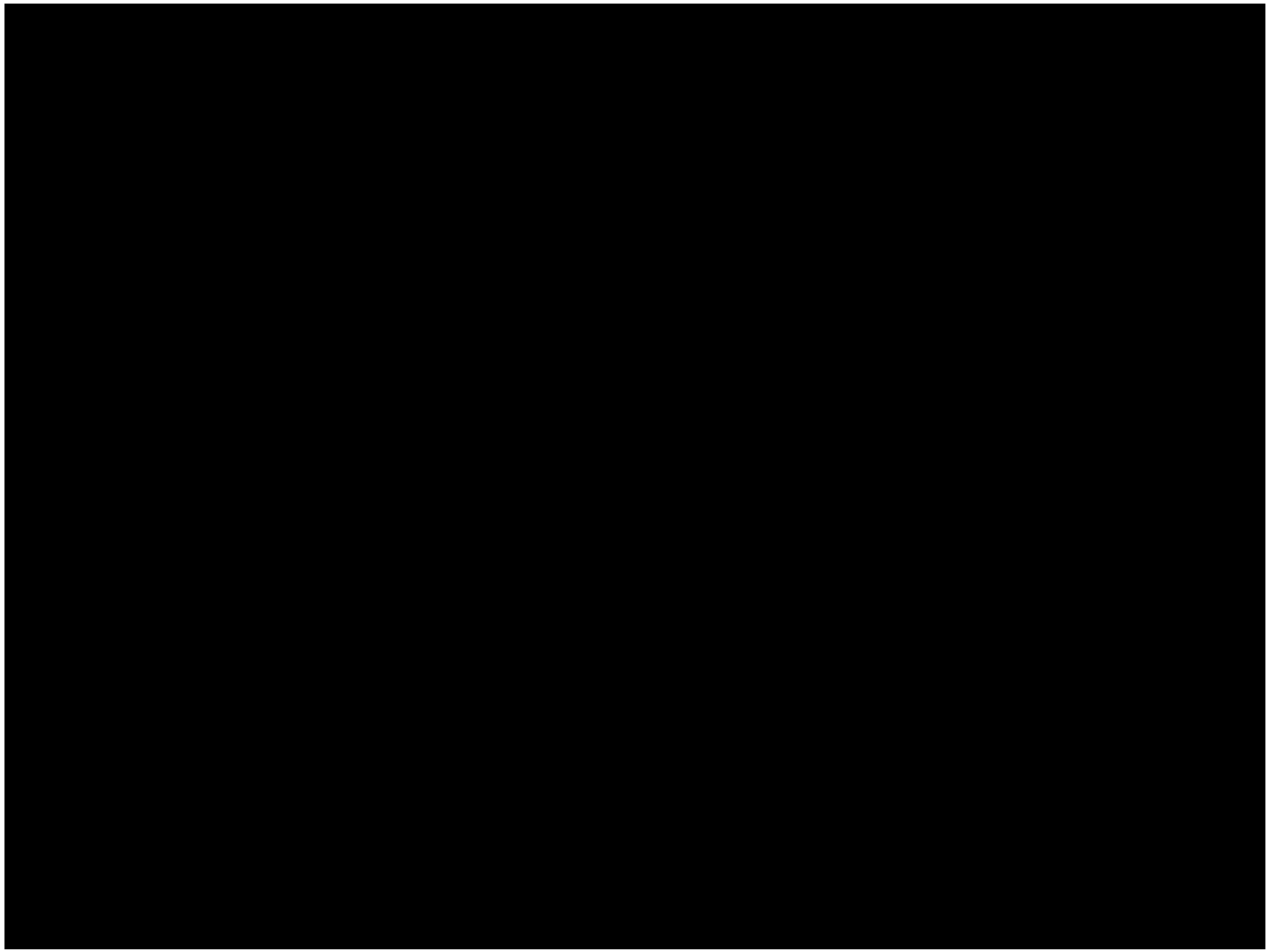
Reminders

- Please check Wikipage for answers before emailing the instructor.
- Email Subject line: [CEE598] …
- You must attend project sessions.
- Acknowledge of any help received should be noted on the cover-page of assignments.
- Not all aspects of the text will be discussed during the course.

Photosynth

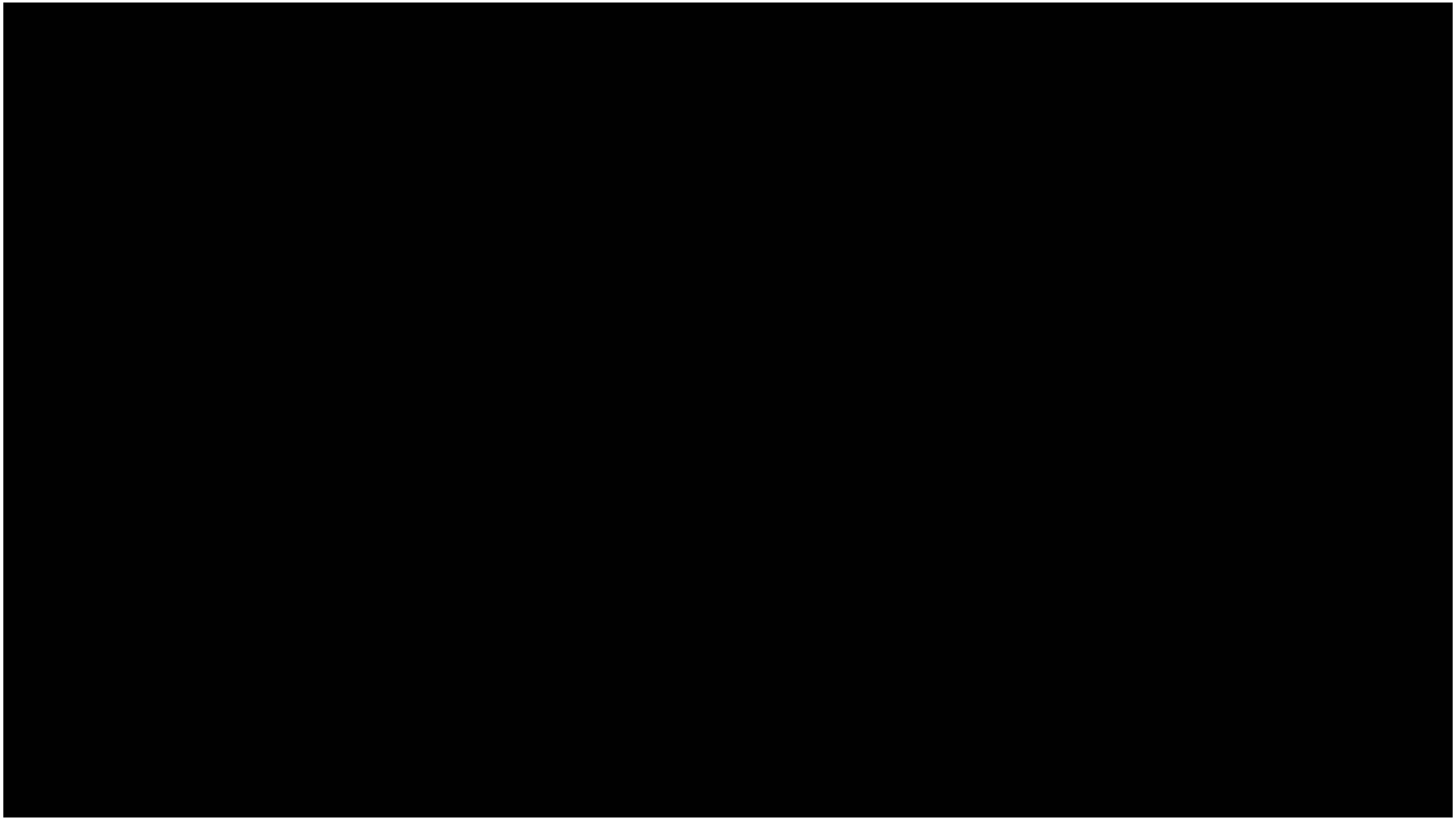
http://www.youtube.com/watch?v=s-DqZ8jAmv0

Augmented Reality maps



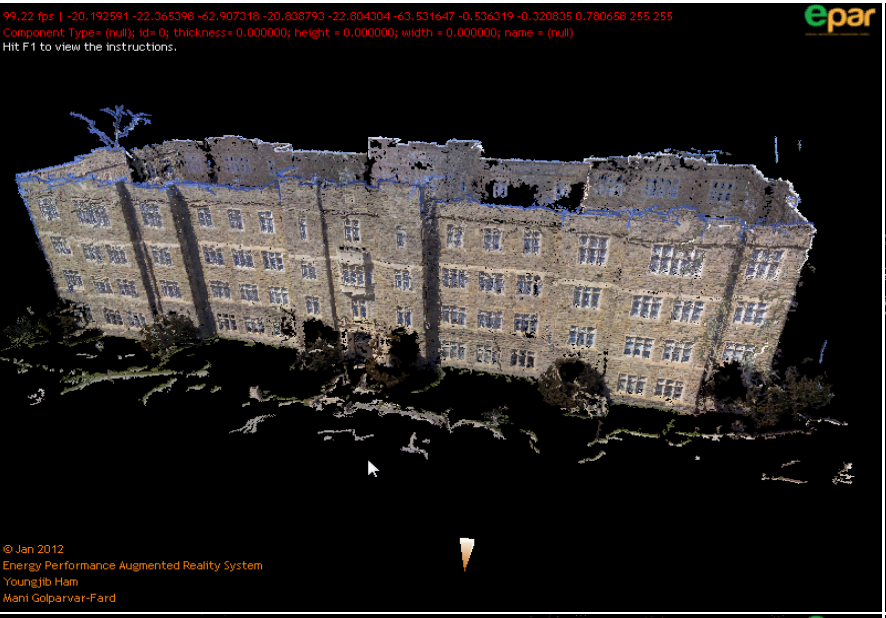
http://youtu.be/9QFvfHXkd2o?t=1m41s

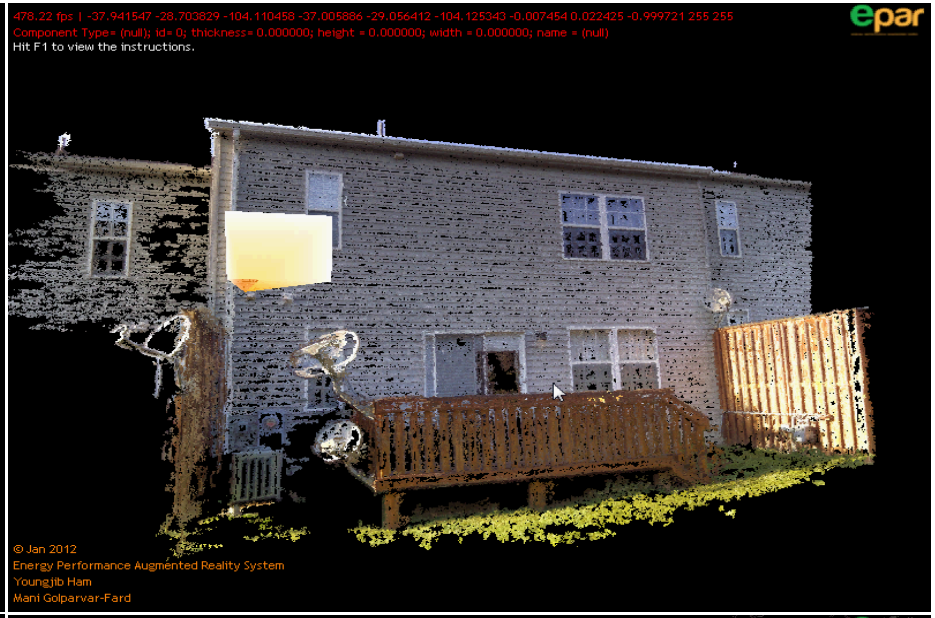
Volvo Safety System

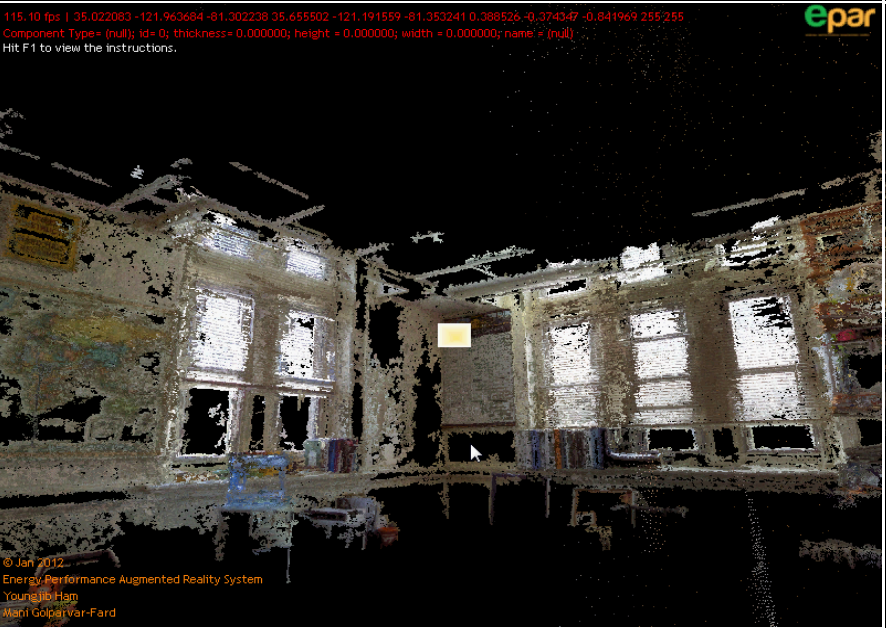


Tracking Pedestrians in Real-time

Energy Performance Modeling







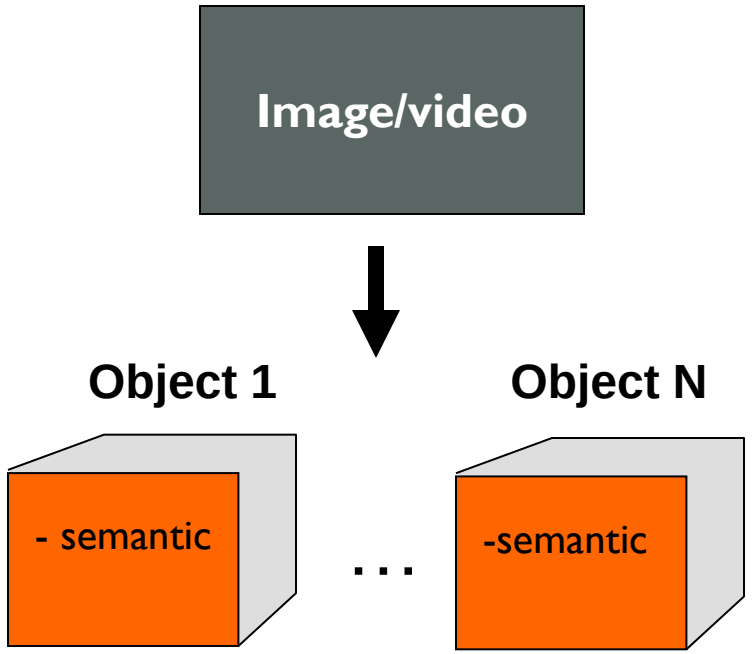
Mobile Augmented Reality System

Construction Activity Analysis

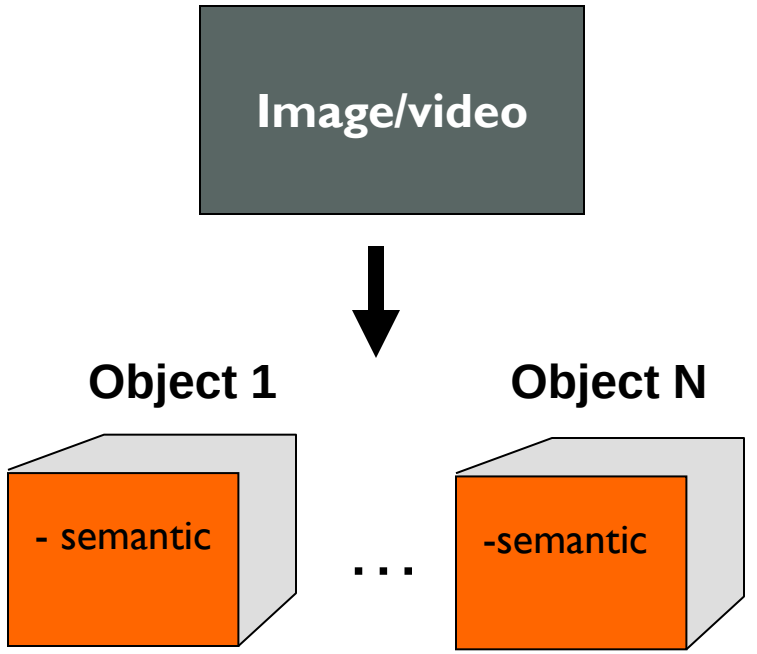
What do you see in this picture?

Student Dining Hall Construction Project, Champaign, IL – August 2008

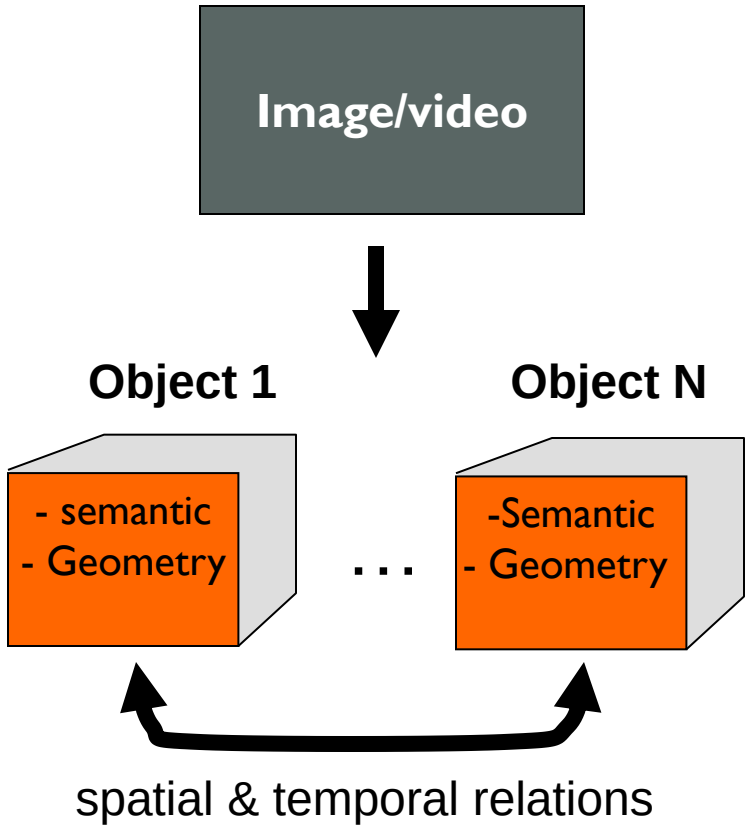
Visual Sensing for Civil Infra. Eng & Mgmt.



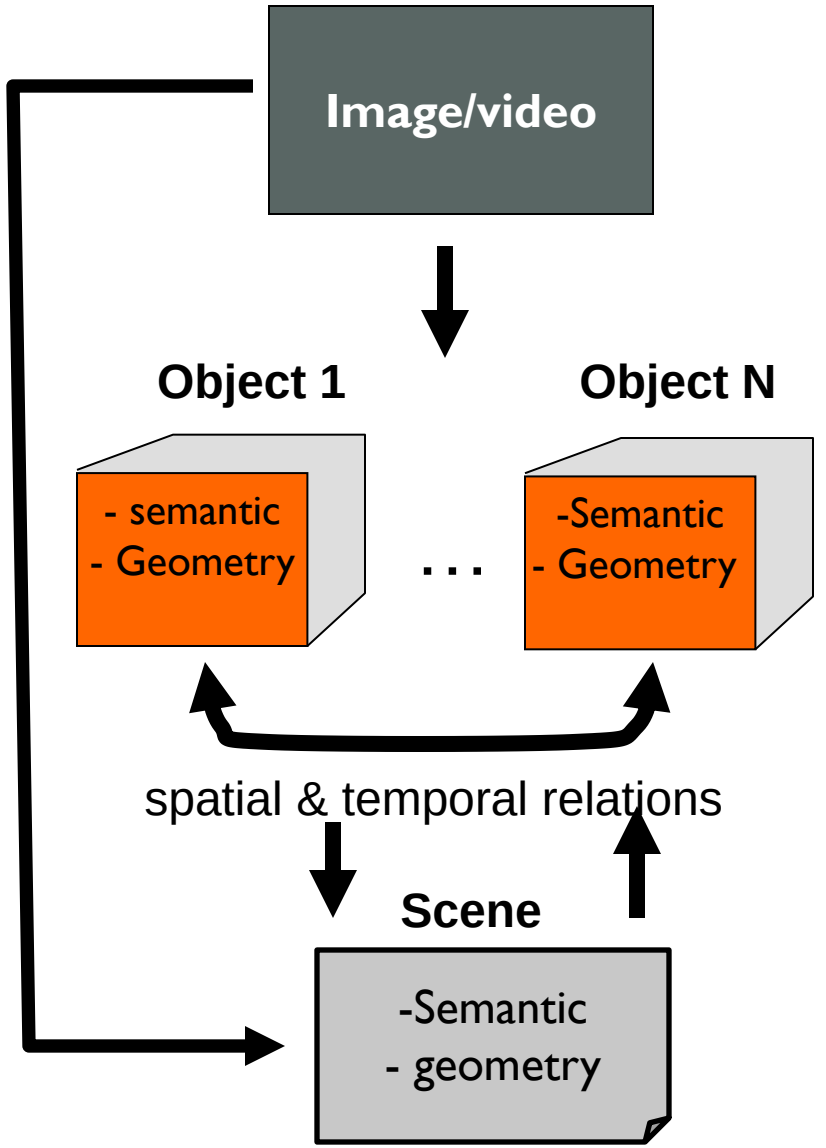
Visual Sensing for Civil Infra. Eng & Mgmt.



Visual Sensing for Civil Infra. Eng & Mgmt.



Visual Sensing for Civil Infra. Eng & Mgmt.



Visual Sensing

- Studying the tools and theories that enable the design of machines that can extract useful information from imagery data
- (Images and videos) toward the goal of interpreting a scene

- Scene
- Objects
- People
- Actions

Sensing device

Computational device

- Extract information
- Interpretation

Information: visual cues, 3D structure, motion flows, etc…
Interpretation: recognize objects, scenes, actions, events

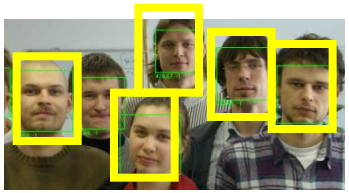
Have we reached humans?

… not yet

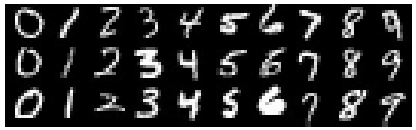
- computer vision is still no match for human perception
- but catching up, particularly in certain areas

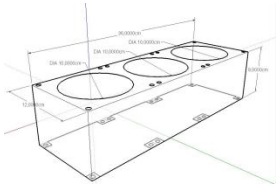
Actions, Events

Categorization



Object Recognition





3D modeling

3D scenes

Semantic ≈

Physical attributes

Source: S. Savarese

Is it useful to study how the visual system works?

After all:

However:

The goals of computer vision are intimately related to what humans care about.

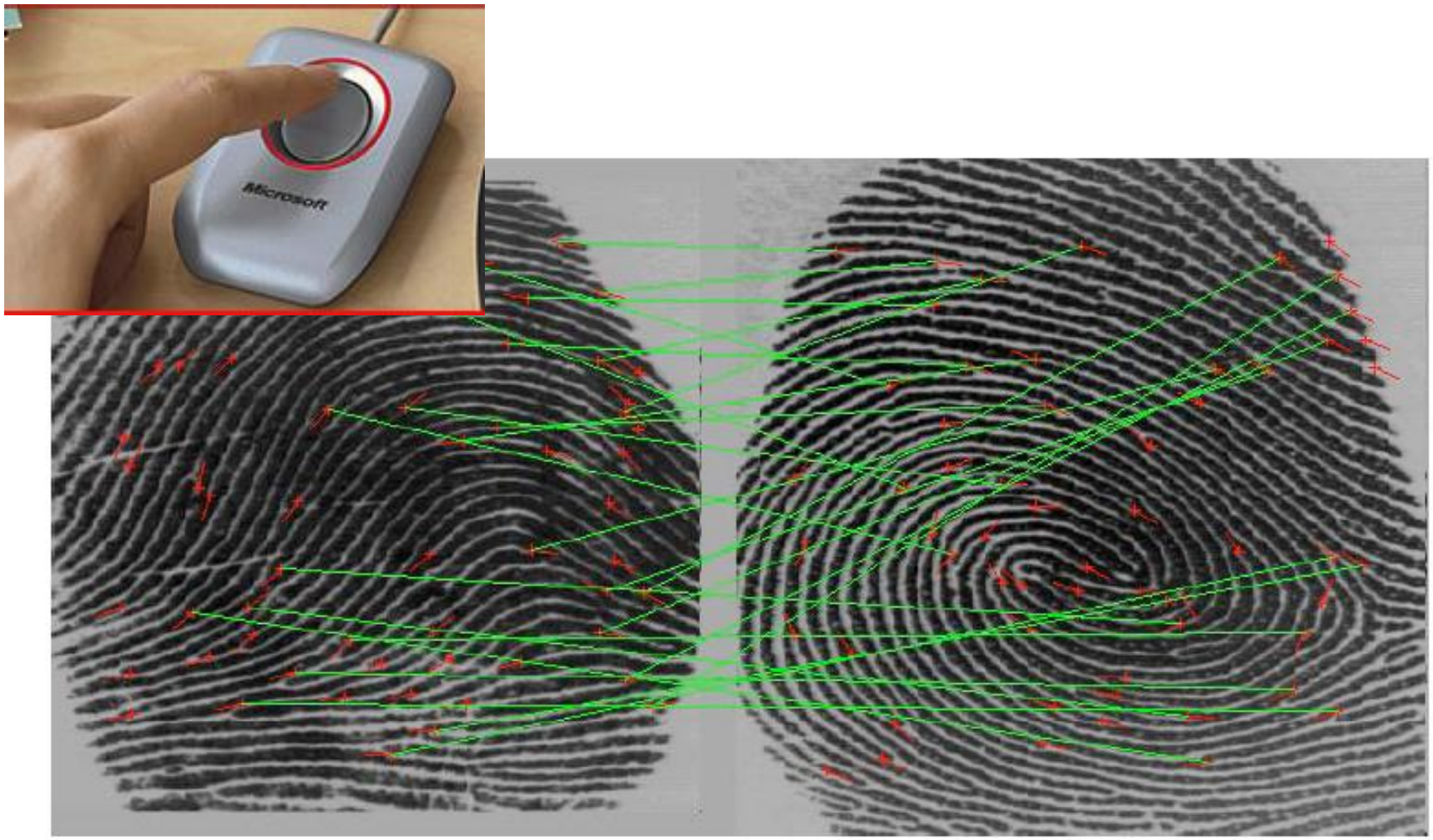
-Study visual system to inspire ideas for algorithmic solutions in computational vision

- Half of primate cerebral cortex is devoted to visual processing!

-Use computer vision as a benchmark for computational theories in human vision

Sources: S. Savarese

Successful Applications
Finger prints recognizer



Sources: L. Fei-Fei

Medical Imaging

Special effects movies - videogames

Sources: L. Fei-Fei

Consumer applications

BBC NEWS

Watch One-Minute World News

News Front Page

Africa
Americas
Asia-Pacific
Europe
Middle East
South Asia
UK
Business
Market Data
Economy
Companies
Health
Science &

Last Updated: Monday, 6 February 2006, 14:29 GMT

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Face-hunting cameras boost Nikon

Japanese camera maker Nikon has tripled its profits on the back of strong sales of digital cameras that automatically focus on human faces.

Face recognition cameras like the Coolpix L1 are popular

Operating profit for the three months to 31 December was 19.8bn yen ($167m; £95m), up from 5.9bn yen in 2004.

Nikon said that sales of compact digital cameras had been boosted by the success of new face recognition models.

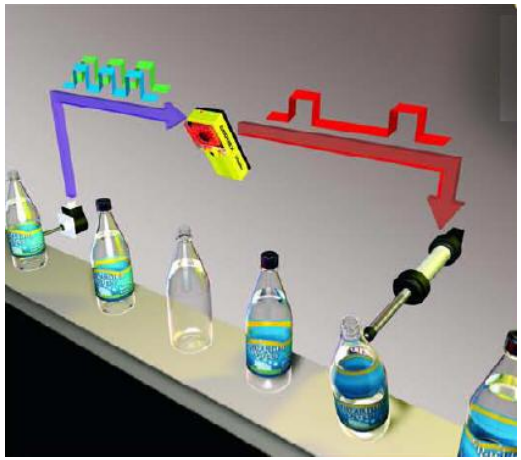
Nikon S60 ads about the Face Detection Feature

Robotics

http://www.youtube.com/watch?feature=player_embedded&v=w1ThnwJcm-o

http://www.youtube.com/watch?feature=player_embedded&v=DMJ2kpiUno0

Applications of computer vision



Factory inspection

Assistive technologies

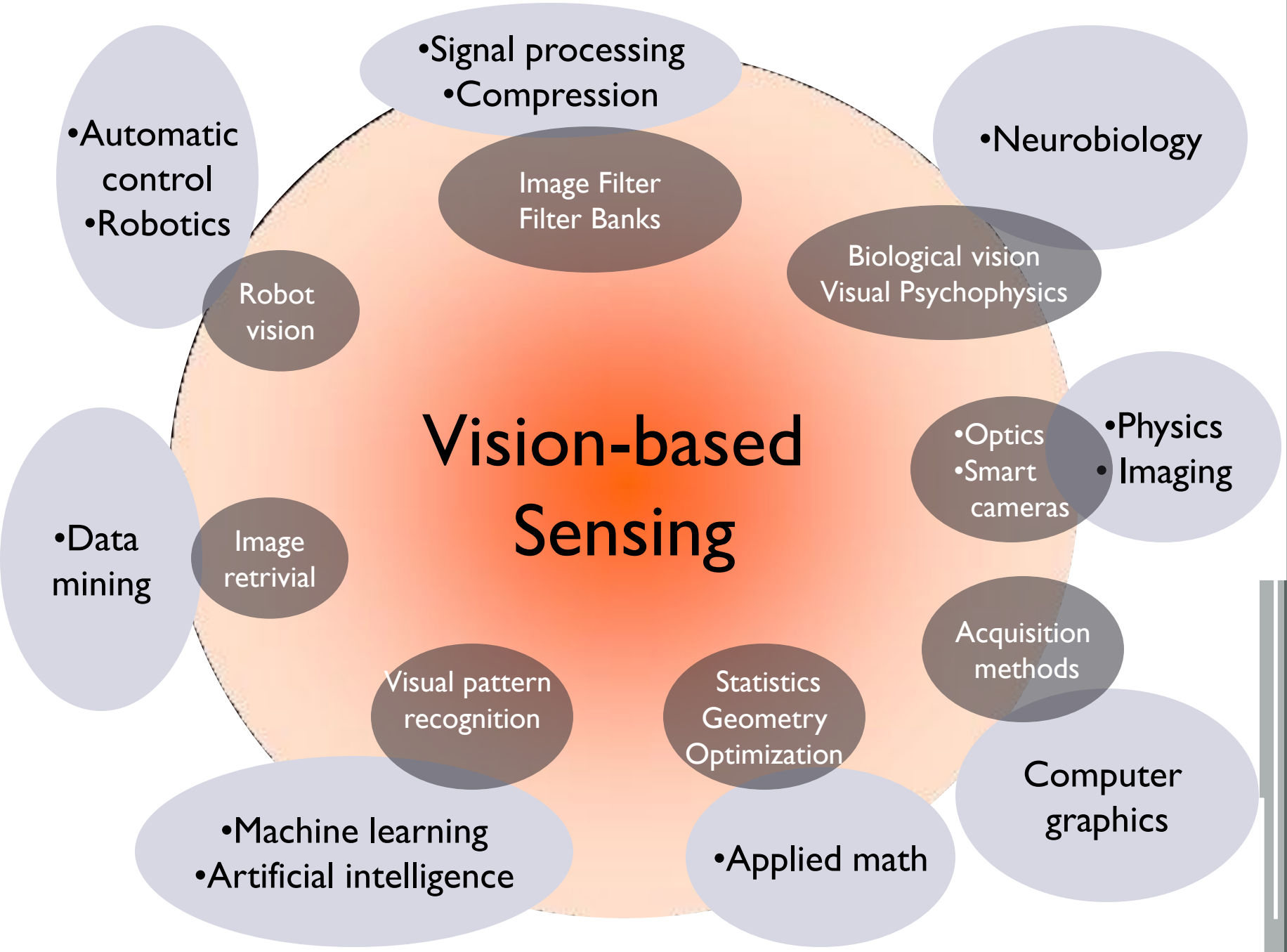
Surveillance

Autonomous driving,
robot navigation

Driver assistance
(collision warning, lane departure warning, rear object detection)

Security

Sources: S. Savarese, K. Grauman, L. Fei-Fei, S. Laznebick


•Signal processing
•Compression
•Automatic control
•Robotics
•Neurobiology
Image Filter
Filter Banks
Biological vision
Visual Psychophysics
Robot vision
Vision-based Sensing
•Optics
•Smart cameras
•Physics
• Imaging
•Data mining
Image retrivial
Acquisition methods
Visual pattern recognition
Statistics
Geometry
Optimization
Computer graphics
•Machine learning
•Artificial intelligence
•Applied math

CEE598 Course Overview

1. Geometry
2. Low & Mid-level vision
3. High level vision

CEE598 Course Overview

1. Geometry
2. Low & Mid-level vision
3. High level vision

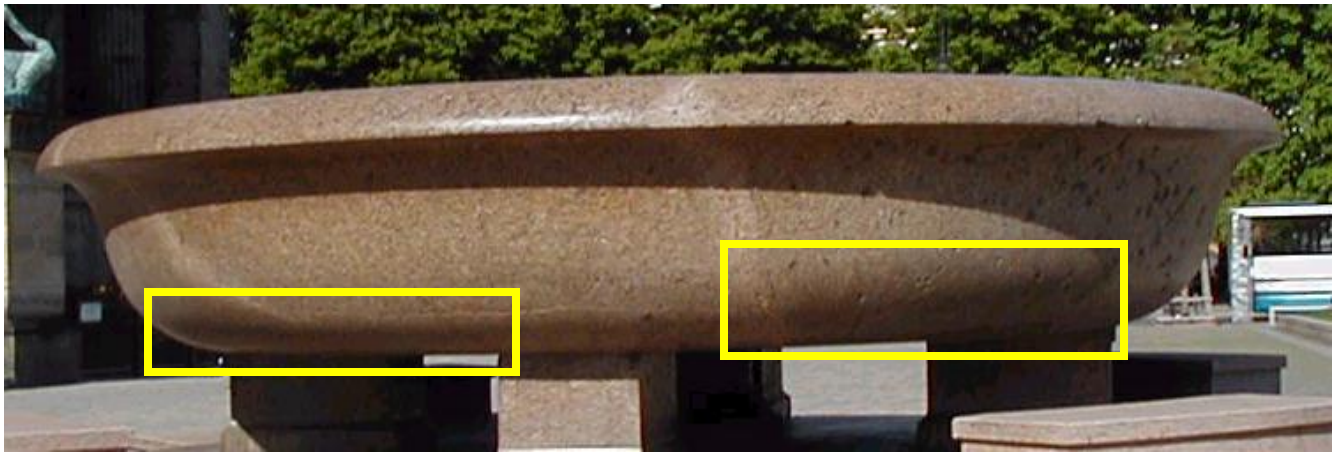
Geometry:

- How to extract 3D information?
- Which cues are useful?
- What are the mathematical tools?

Visual cues: texture • shading • contours • shadows • reflections

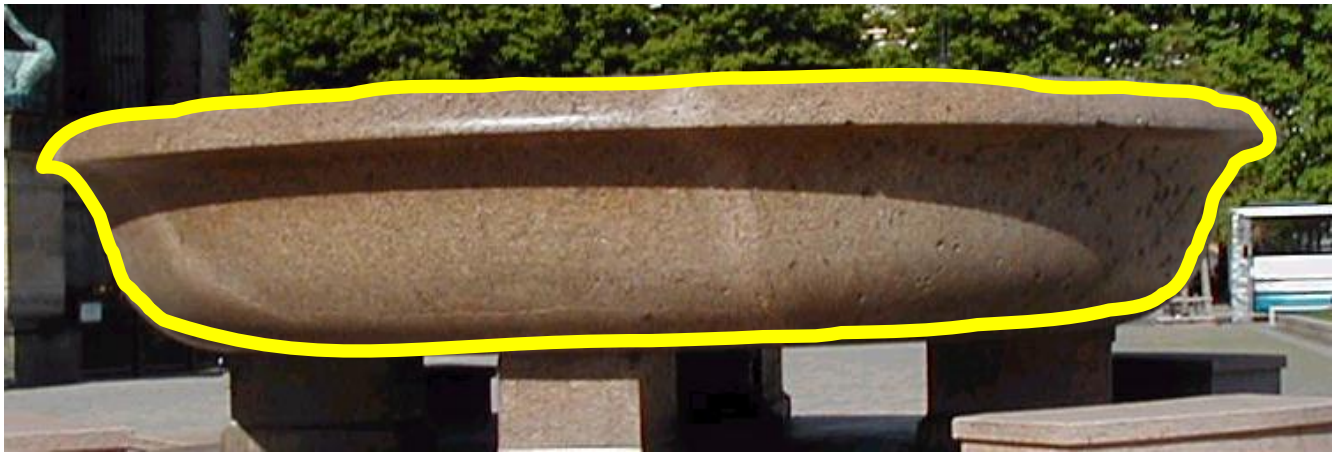
Sources: S. Savarese

Visual cues: texture • shading • contours • shadows • reflections



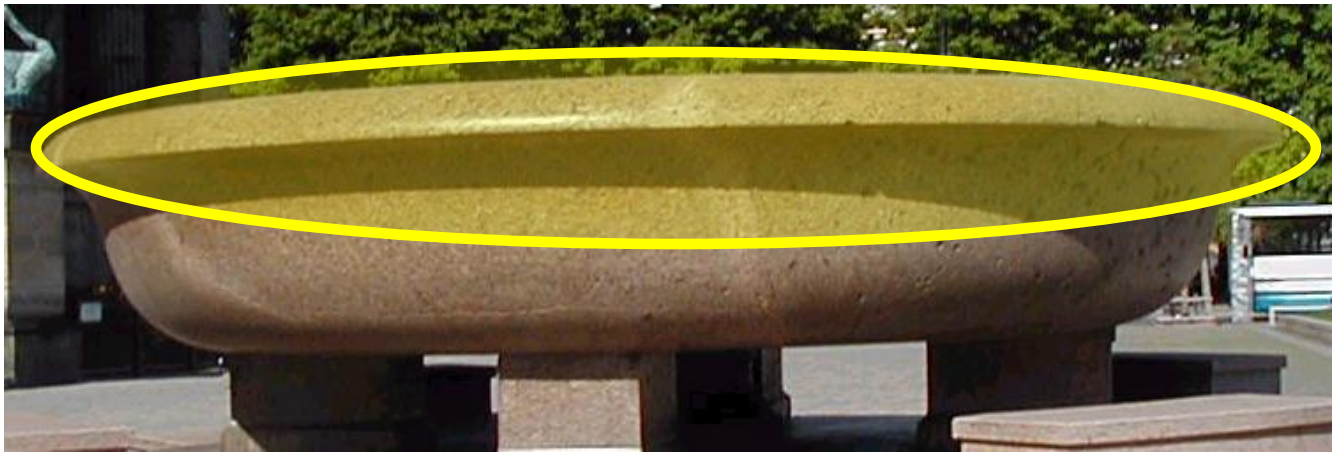
Sources: S. Savarese

Visual cues: texture • shading • contours • shadows • reflections



Sources: S. Savarese

Visual cues: texture • shading • contours • shadows • reflections



Sources: S. Savarese

Visual cues: texture • shading • contours • shadows • reflections

Sources: S. Savarese

Visual cues: texture • shading • contours • shadows • reflections

Number of observers: monocular • multiple views

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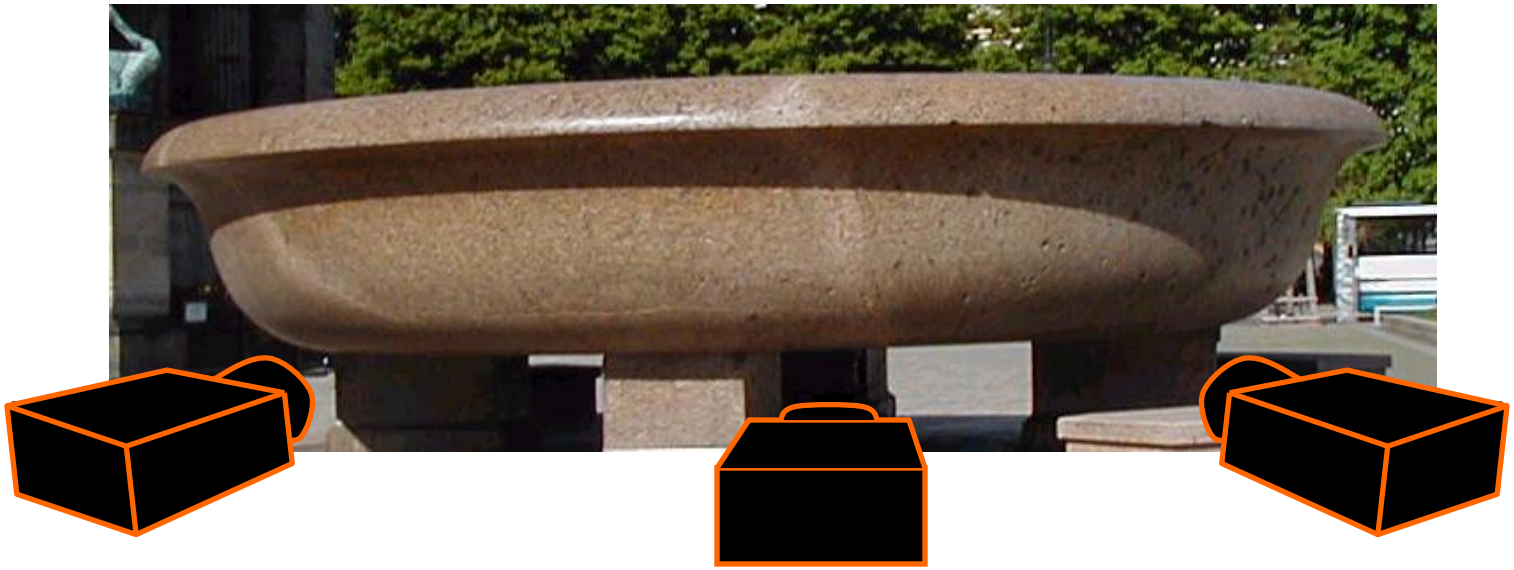
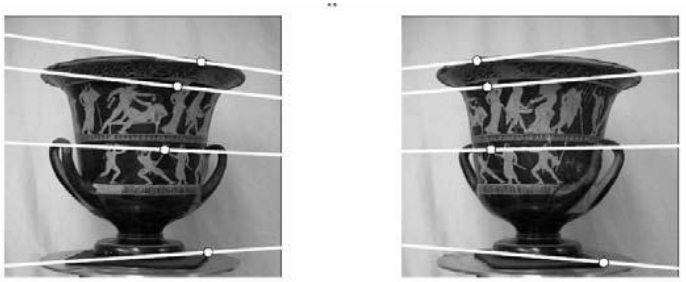
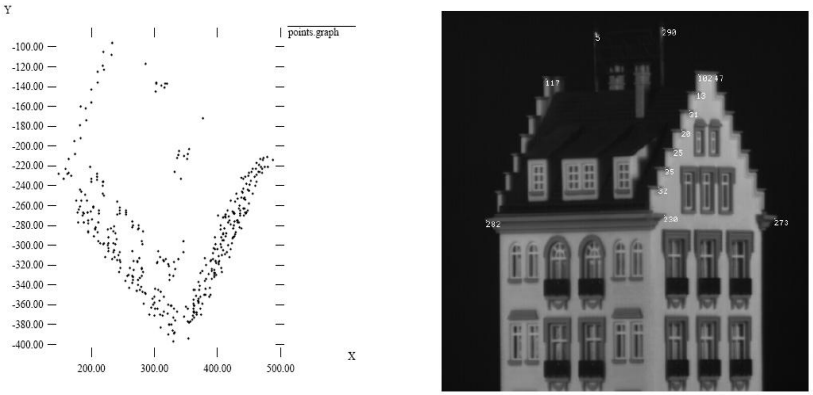


Sources: S. Savarese

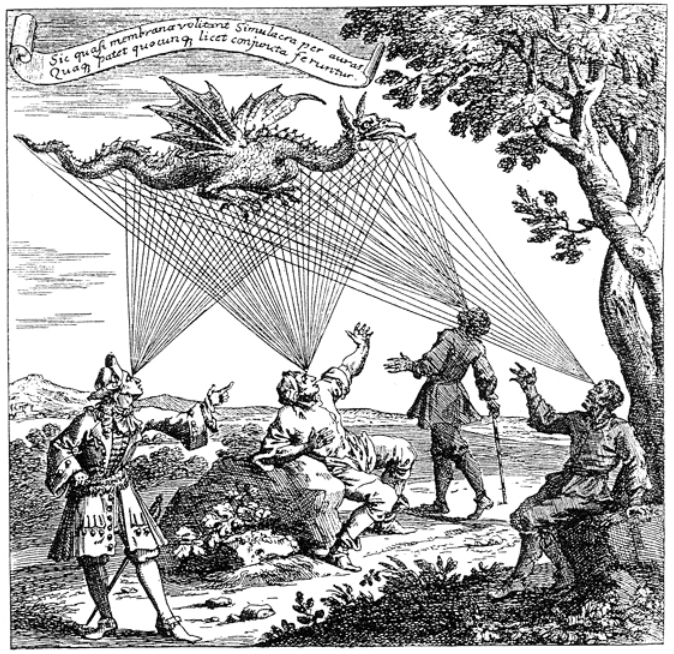
Stereo



Epipolar geometry



Tomasi & Kanade (1993)

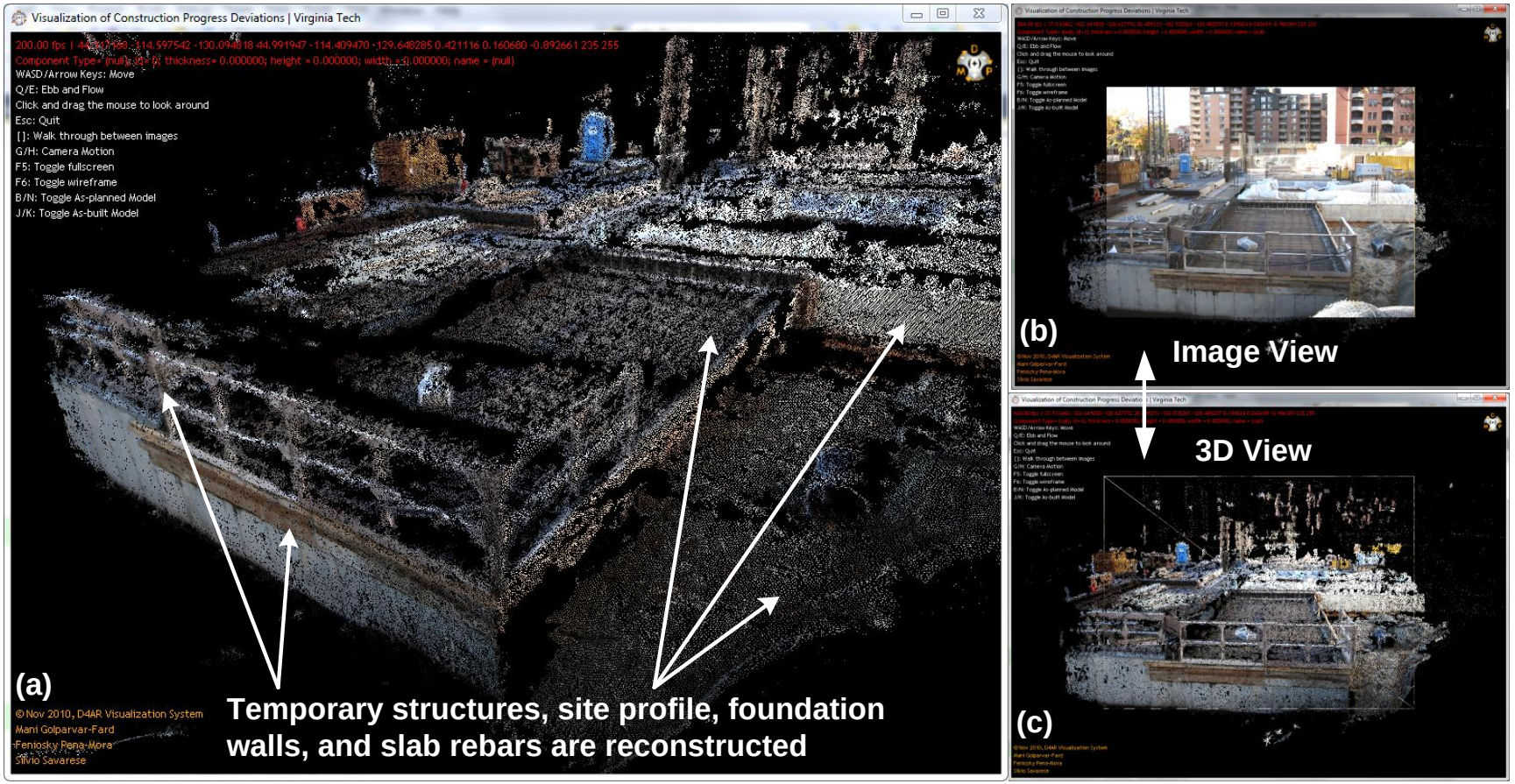


Дракон, видимый подъ различными углами зрѣнія
По гравюрѣ на мѣди изъ „Oculus artificialis teledioptricus“ Цана. 1702 года.

Image sources: S. Laznebick

Structure from motion

Structure from Motion



3D reconstruction of a building skeleton elements using **12** existing images with **2Mpixel** resolution (Golparvar-Fard 2011)

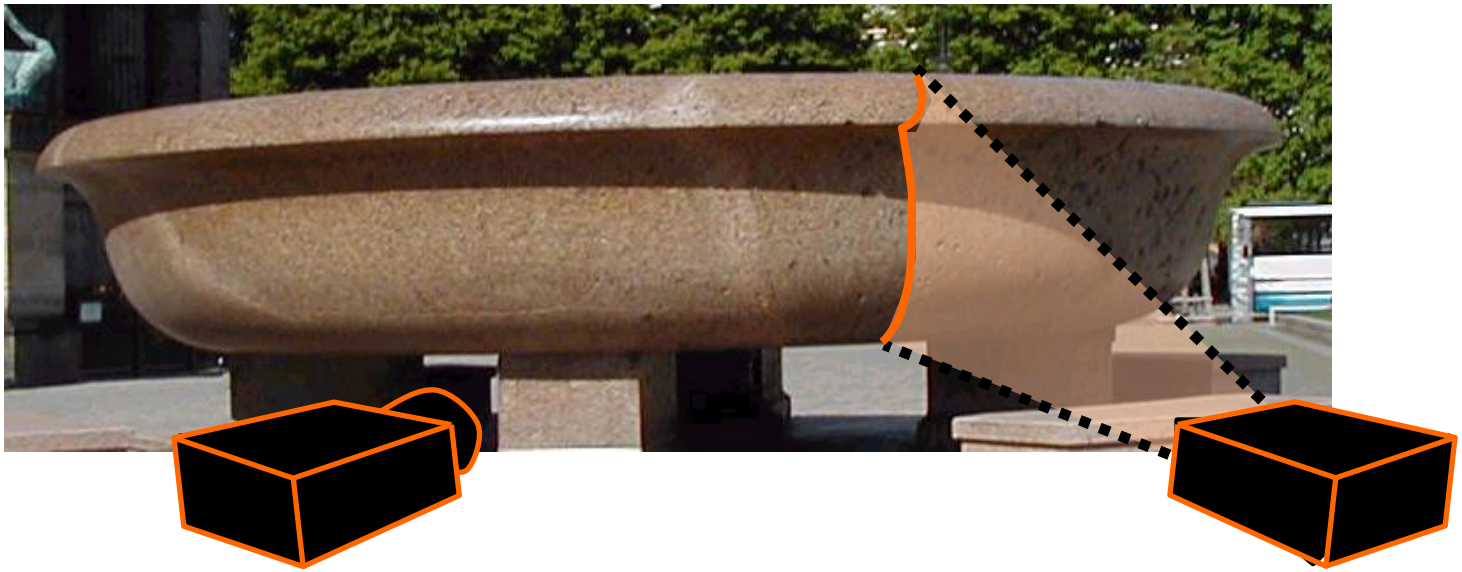
Camera Tracking and VR insertion

Courtesy of Oxford Visual Geometry Group

Visual cues: texture • shading • contours • shadows • reflections

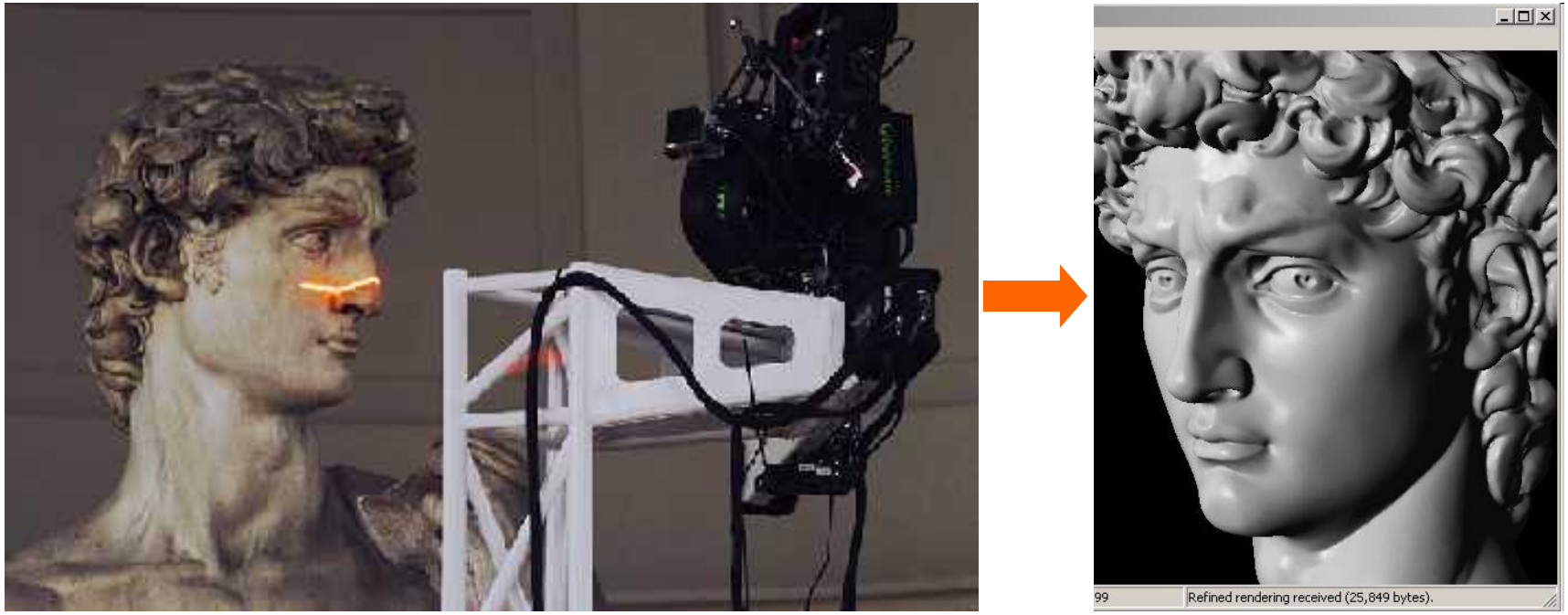
Number of observers: monocular • multiple views

Active lighting: laser stripes • structured lighting patterns



Sources: S. Savarese

3D Laser Scanning



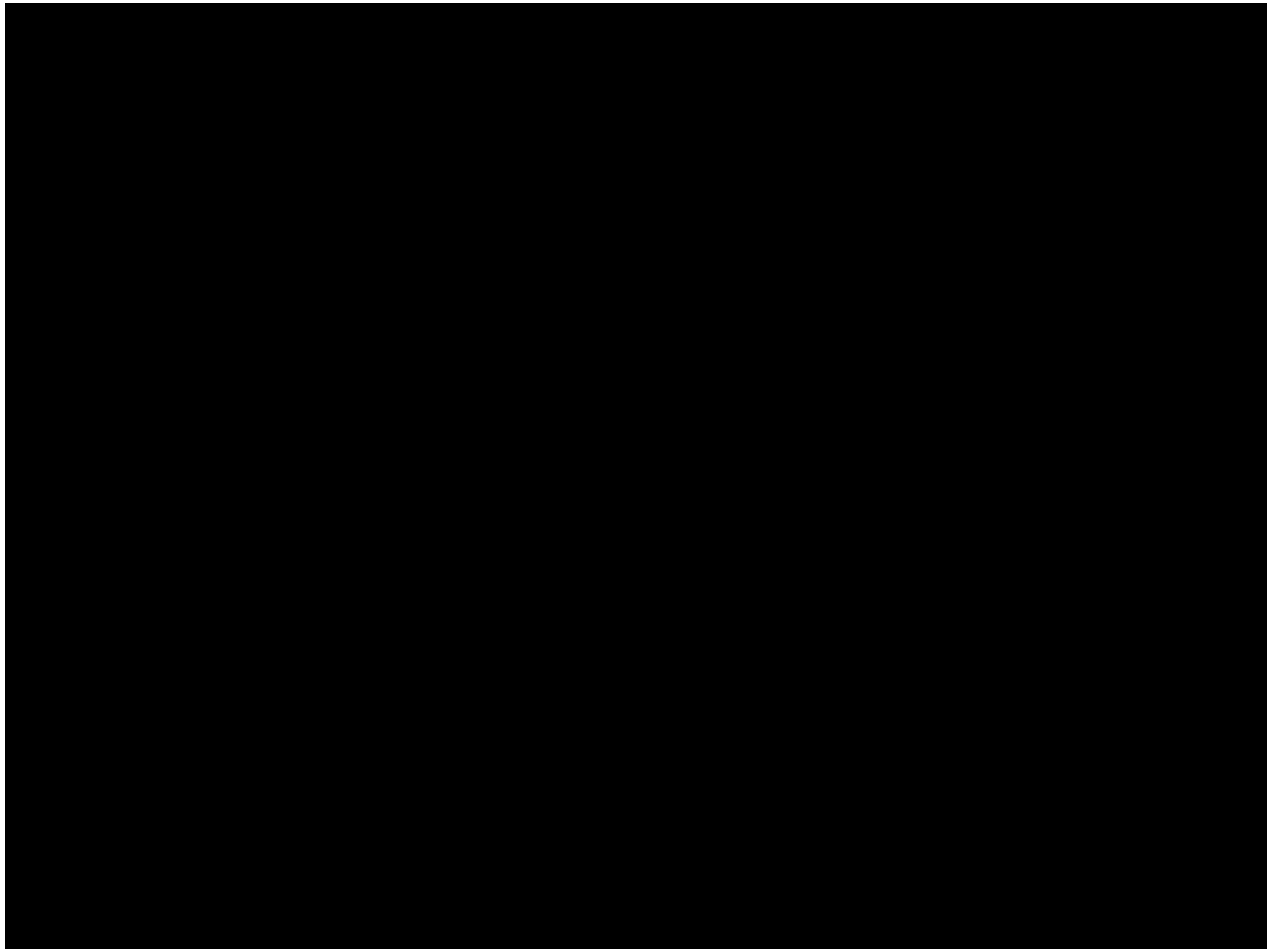
Scanning Michelangelo's *"The David"*

- The Digital Michelangelo Project
  - http://graphics.stanford.edu/projects/mich/
- 2 BILLION polygons, accuracy to .29mm

Courtesy of Stanford computer graphics lab

Virtual Replay

EyeVision Technology introduced in 2001



http://www.youtube.com/watch?v=ohdhYEcCGVo

Courtesy of EyeVision

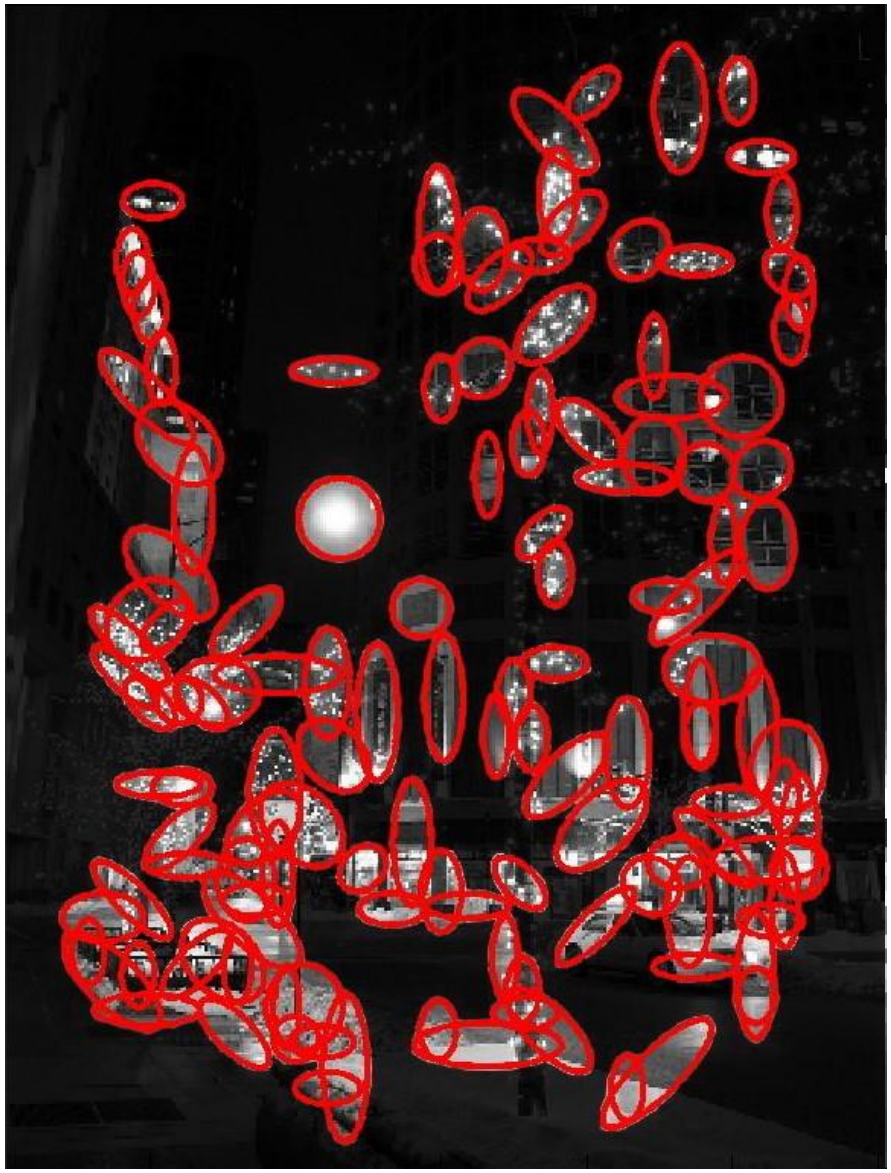
CEE598 Course Overview

1. Geometry
2. Low & Mid-level vision
3. High level vision

Mid-level vision:

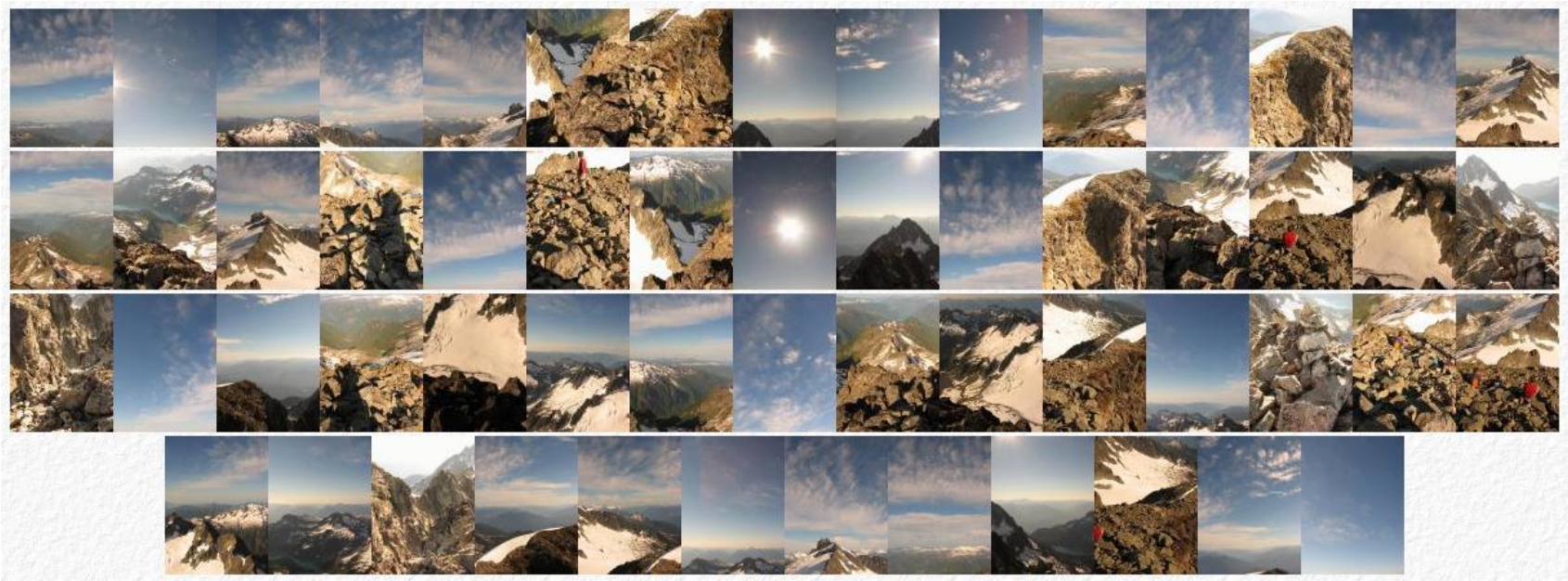
- Extract useful building blocks
- Region segmentation
- Motion flows

Extract Useful Building Blocks



Sources: S. Savarese

Automatic Panorama Stitching

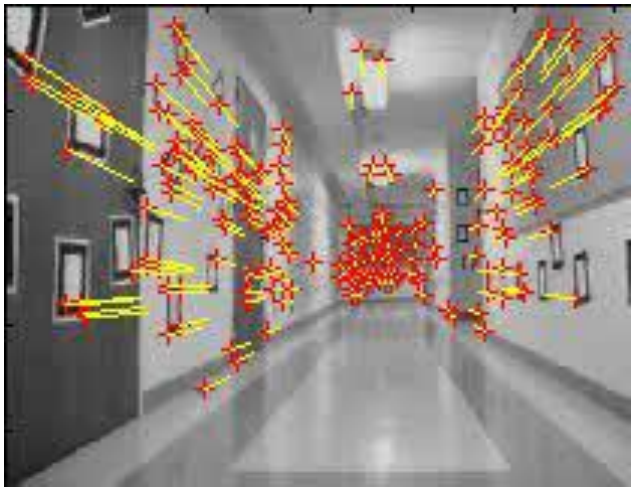


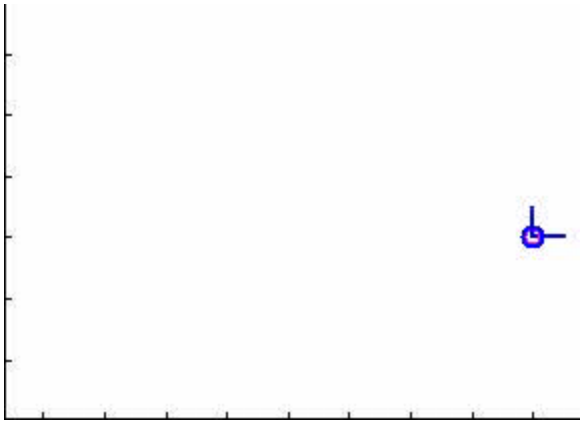
Sources: M. Brown

Automatic Panorama Stitching

Sources: M. Brown

Feature Detection and Tracking





Courtesy of Jean-Yves Bouguet – Vision Lab, CalTech

CEE598 Course Overview

1. Geometry
2. Low & Mid-level vision
3. High level vision

High level operations:

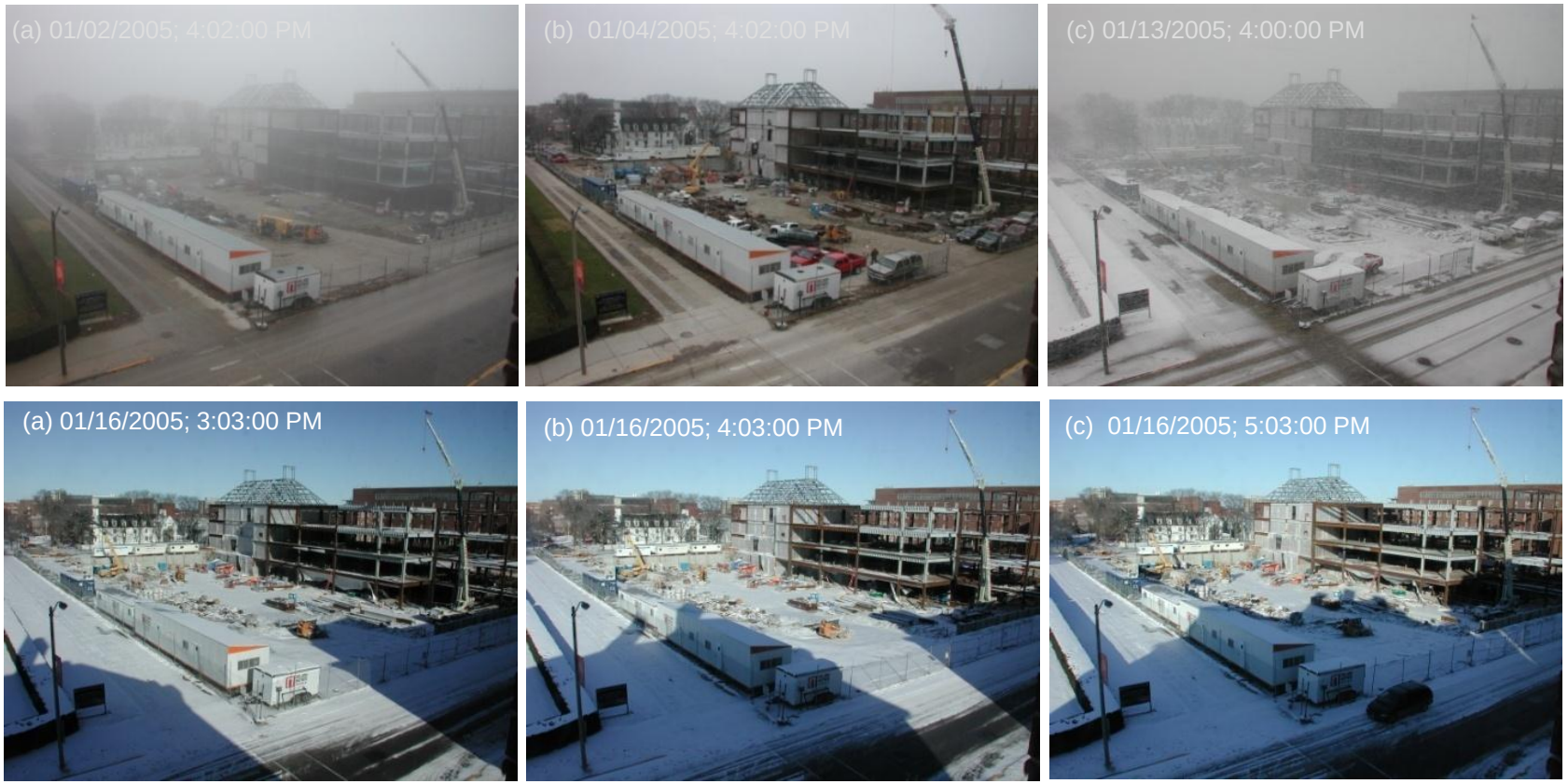
- Recognition of objects and people
- Places
- Actions and events

Challenges: viewpoint variation

Michelangelo 1475-1564

slide credit: Fei-Fei, Fergus & Torralba

Challenges: illumination



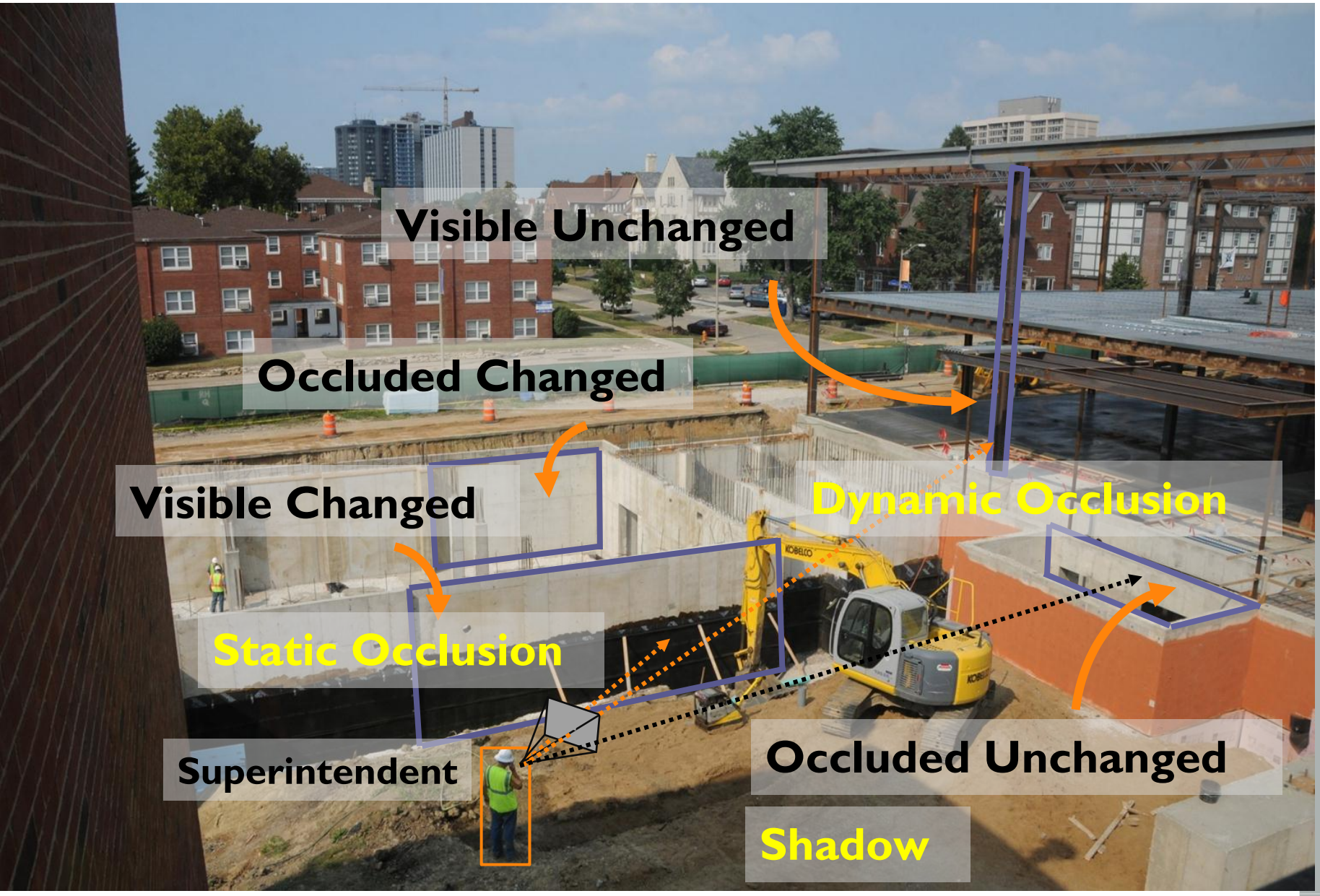
Project: Institute of Genomic Biology, Courtesy of College of ACES, UIUC

Sources: Golparvar-Fard et al. (2009)

Challenges: scale

Challenges: deformation

Challenges: occlusion



Student Dining Hall Construction Project, Champaign, IL - 8/27/2008

Challenges: background clutter

Challenges: object intra-class variation

Learn to categorize motion

Ramanan, D., Forsyth, D.A., Zisserman, A. "**Tracking People by Learning their Appearance**"*IEEE Pattern Analysis and Machine Intelligence* (PAMI). Jan 2007.

Learn to categorize motion

Ramanan, D., Forsyth, D. A., Zisserman, A. "**Tracking People by Learning their Appearance**"*IEEE Pattern Analysis and Machine Intelligence* (PAMI). Jan 2007.

What do you see in this picture?

Student Dining Hall Construction Project, Champaign, IL – August 2008

What is Available to you?

- Microsoft Kinect

- What Can you use it for?
  - Real-time 3D Reconstruction of Building Interior
  - Automated Productivity, Safety, and Occupational Health Assessment of Workers

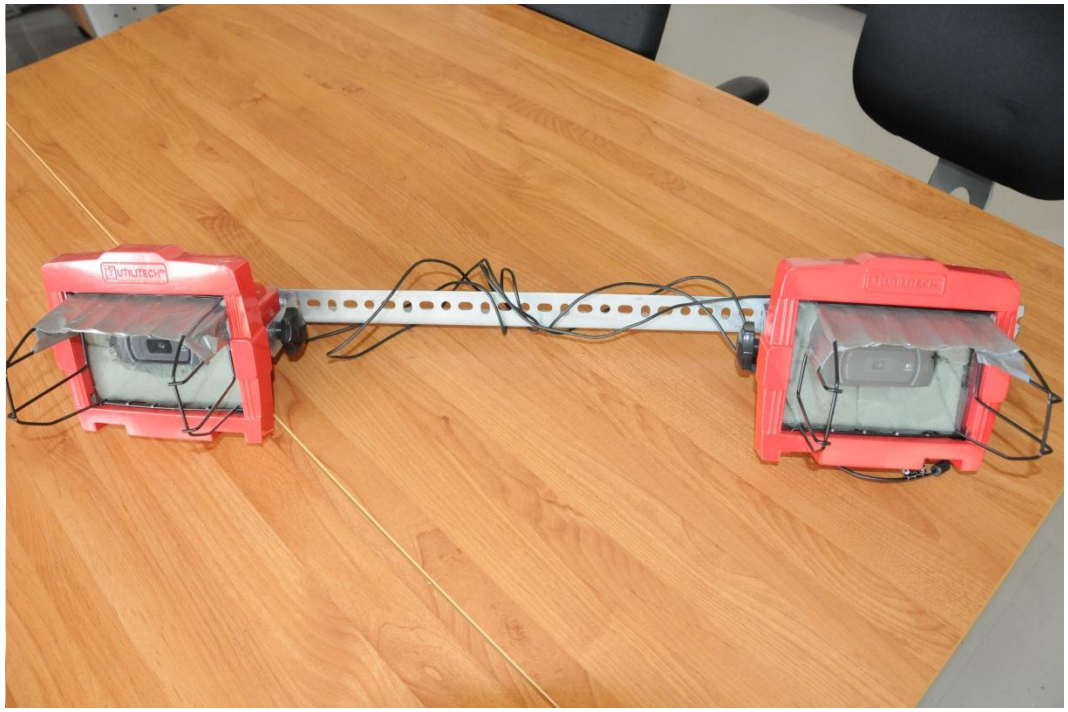
What is Available to you?

- Mobile Workstation Chariot

- What Can you use it for?
  - Rapid 3D Reconstruction of Building Interior
  - Automated Building Stability Assessment and Rescue Operations

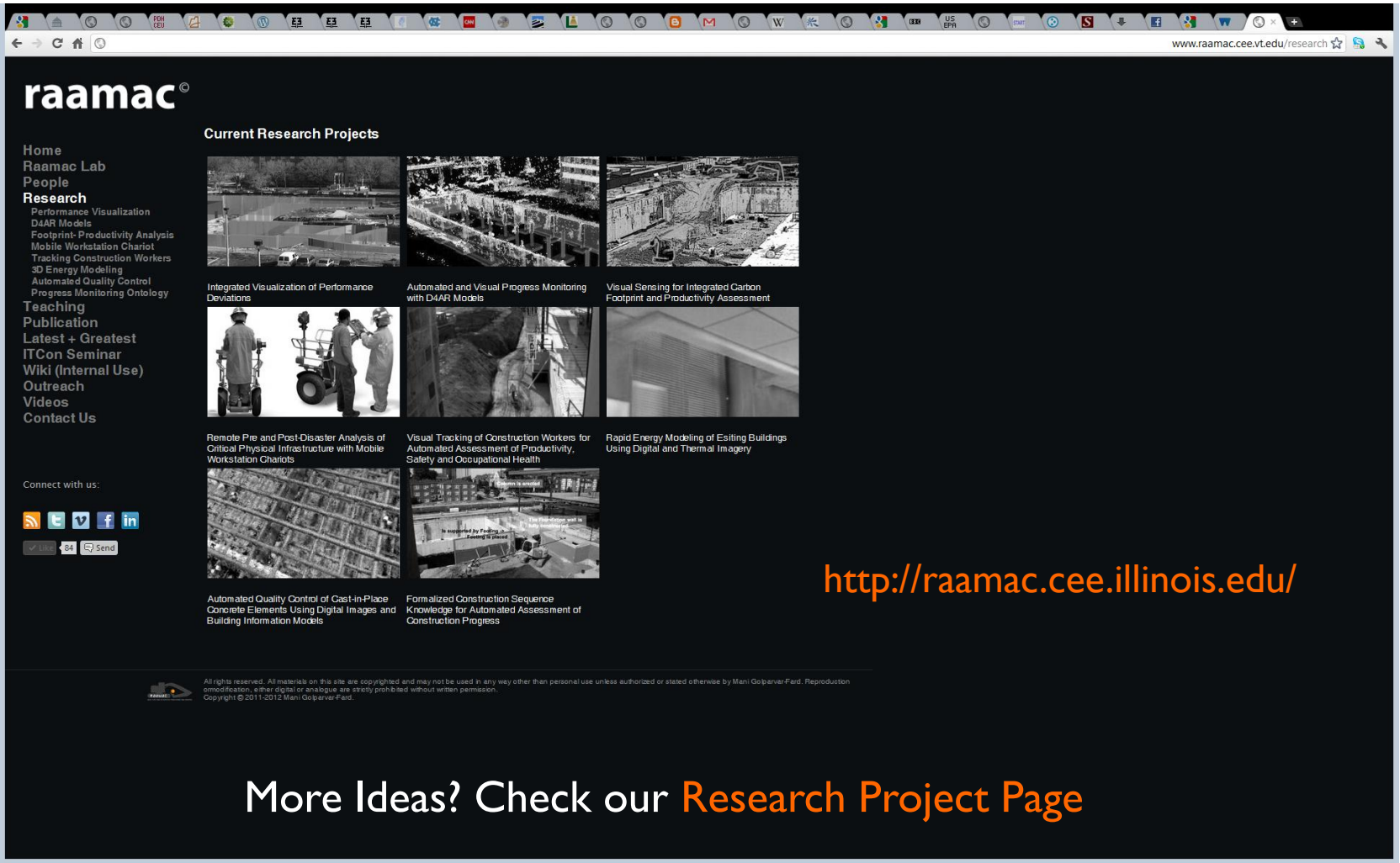
What is Available to you?

- Cameras!!!



- What Can you use it for?
  - All kinds of Applications
- Where Can I find these? Raamac Lab

Raamac Lab



http://raamac.cee.illinois.edu/

More Ideas? Check our Research Project Page

Next lecture

- Review of linear algebra for multi-view geometry
- Basic image transformations
- Mini-Assignments
  - Watch the following video

    Illinois Compass2g Site> Resources> Supplementary Documents> 3DVision.avi
  - Study Matlab Tutorials and get familiar with available resources for coding -> Wiki> Matlab > First Two Links