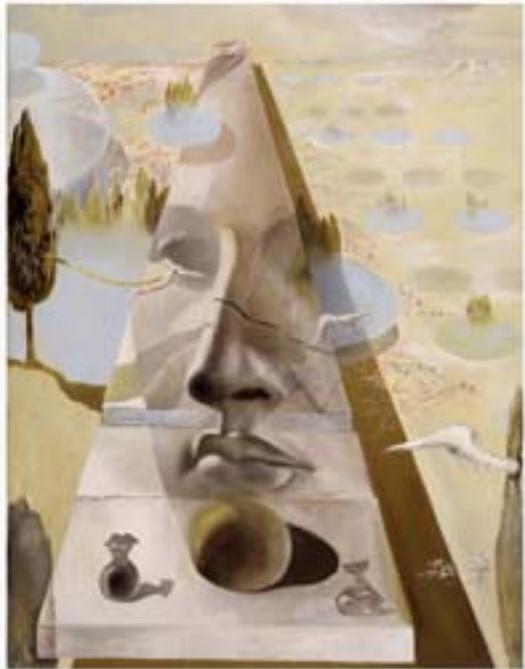


EECS 442 – Computer Vision – fall 2016



- Instructor
 - Matthew Johnson-Roberson
 - mattjr@umich.edu
 - Office: NAME - 201
 - Office hour: TBD
- GSI:
 - Katie Skinner kskin@umich.edu
 - Jeffery Hsu jeffyjhs@umich.edu
- Class Time & Location
 - Tu Th 3:00PM - 4:30PM –1670 BBB
- Discussion hour [it's part of the course!]

EECS 442 – Computer Vision – fall 2016



- **Text books:**
 - [FP] D. A. Forsyth and J. Ponce. *Computer Vision: A Modern Approach* (2nd Edition). Prentice Hall, 2011 (or first edition, 2003).
 - [HZ] R. Hartley and A. Zisserman. *Multiple View Geometry in Computer Vision*. Academic Press, 2002.
 - [R] R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2011
- Available online see piazza

If you plan to audit this class,
speak to us after class to get access to canvas

442/504

- **504 Taught by Professor Corso**
 - Mo Wed 12:00 – 1:30
 - You cannot take both must choose
 - This course is 4 units 504 is 3

Agenda

- **Administrative**
 - Grading policy
 - Project
- **What is computer vision?**
- **Syllabus**

Grading policy

- **Homeworks: 40%**
 - 5 homeworks
- **Mid term exam: 10%** [end of October]
- **Course project: 45%**
 - progress report 5%
 - final report 30%
 - presentation 10%
- **Attendance and class participation: 5%**
 - Questions, answers, remarks...
- **Late policy home works:**
 - If 1 day late, 50% off the grade for that homework
 - Zero credits if more than one day.
 - A "48-hours one-time late submission bonus" is available; that is, you can use this bonus to submit your HW late (i.e. after at most 48 hours). This is one time bonus: After you use your bonus, you must adhere to the standard late submission policy. You must notify us if you plan to use the late-bonus. No exceptions will be made.
- **Late policy project:**
 - If 1 day late, 25% off the grade for the project
 - If 2 days late, 50% off the grade for the project
 - Zero credits if more than 2 days
 - No "late submission bonus" is allowed when submitting your exam or project.
- **Collaboration policy**
 - Read the student handbook, understand what is 'collaboration' and what is 'academic infraction'.
 - Discussing project assignment with each other is allowed, but coding must be done individually
 - Home works or class project coding policy: using on line code or other students/researchers' code is not allowed in general. Exceptions can be made and individual cases will be discussed with the instructor.

Email Policy

- Technical questions about HW problems or projects must be asked through the forum Piazza!
- Only non technical questions should be directed through email.

Course 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 introduce projects in two weeks
- Important dates: look up class schedule

Course Project

- Form your team:
 - 1-3 people
 - the quality is judged regardless of the number of people on the team
 - be nice to your partner: do you plan to drop the course?
- Evaluation
 - Quality of the project (including writing)
 - Final ~15 minutes project presentation in class – students will vote your presentation!
 - For final code and paper due dates please consult ctools

Survey

- Background in Vision
- Linear Algebra
- MATLAB / C
- Year at School
- Why do you want to study vision?

Agenda

- **Administrative**
 - Grading policy
 - Project
- **What is computer vision?**
- **Syllabus**



Illustration by **Arthur Rackham**

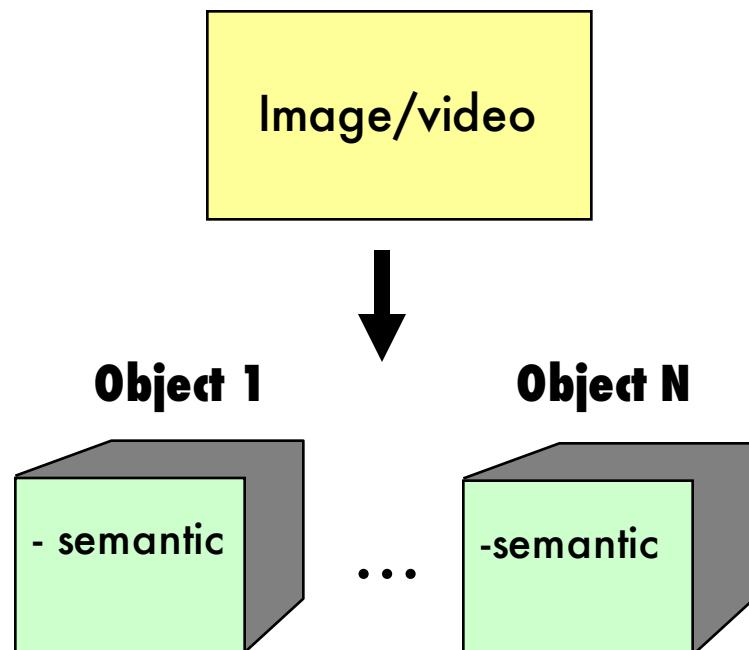
"There was a table set out under a tree in front of the house, and the March Hare and the Hatter were having tea at it."

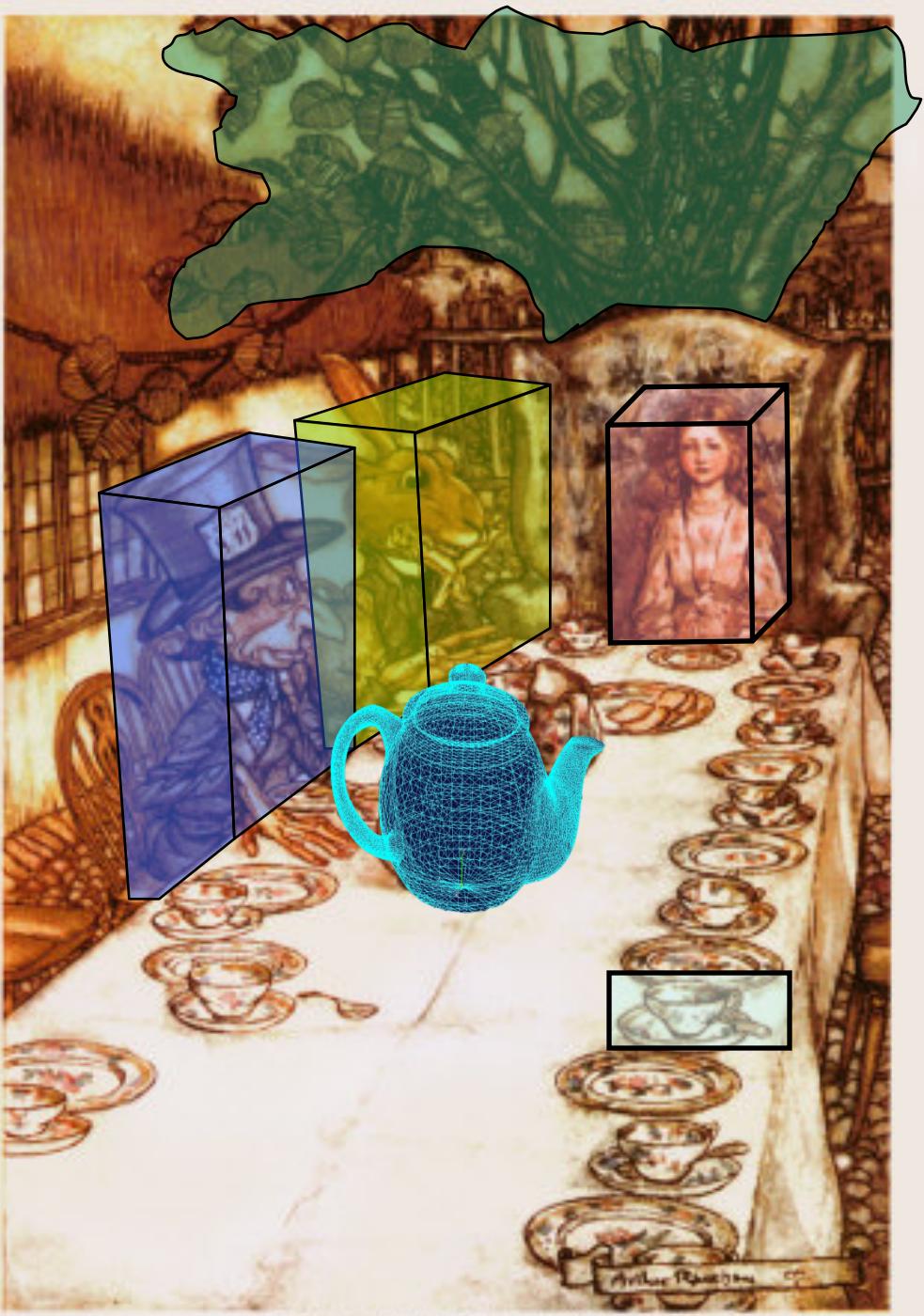
"The table was a large one, but the three were all crowded together at one corner of it ..."

**From "A Mad Tea-Party"
Alice's Adventures in Wonderland
by
Lewis Carroll**

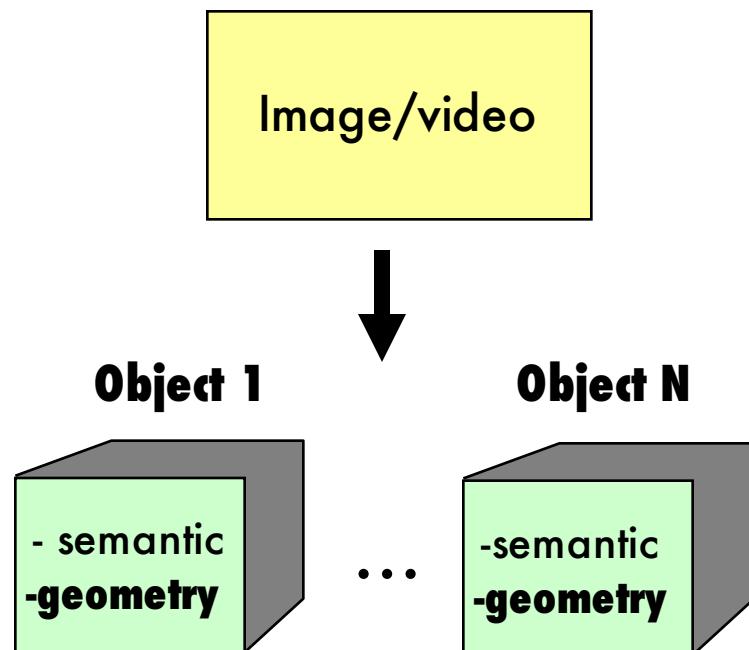


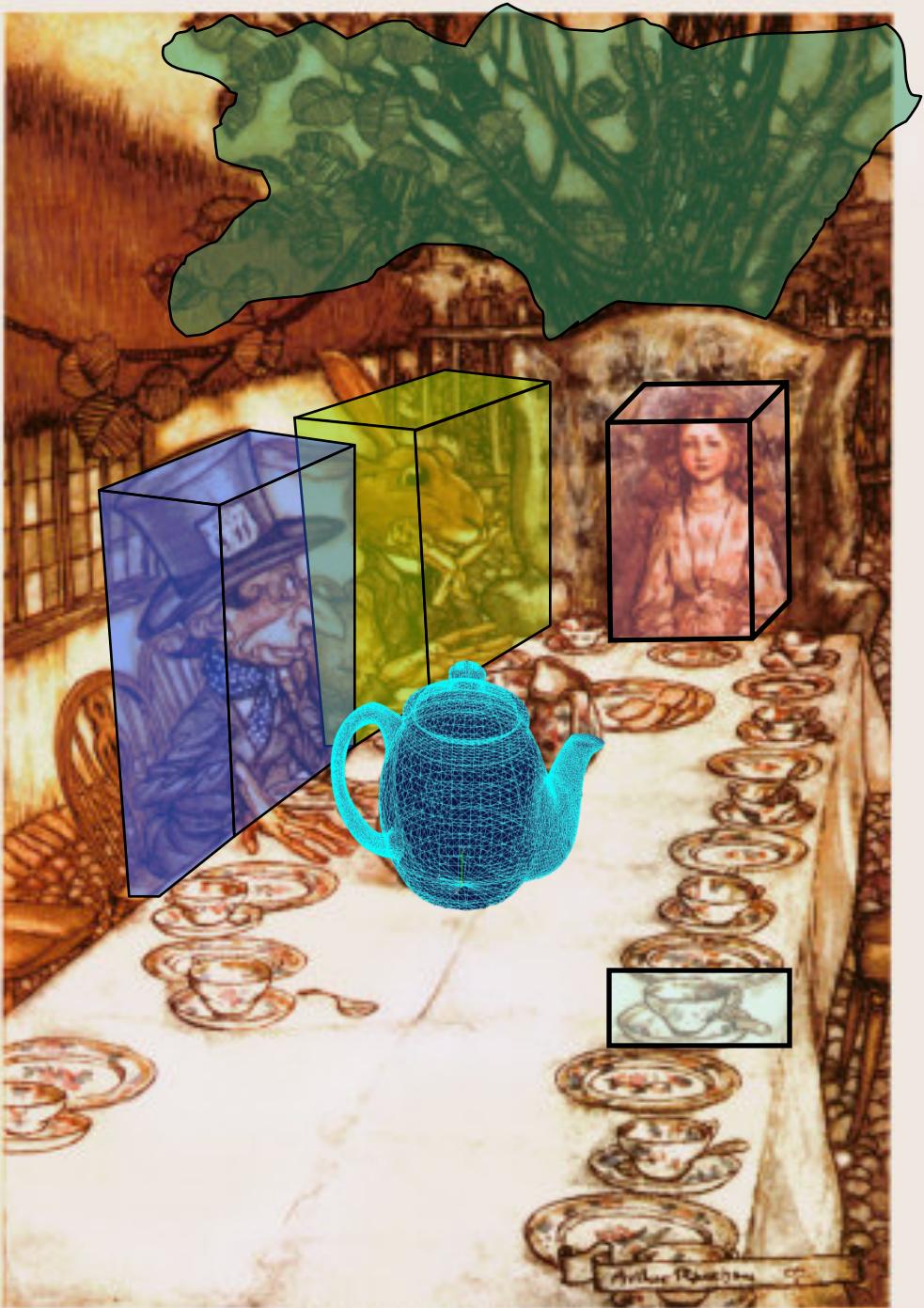
Computer vision



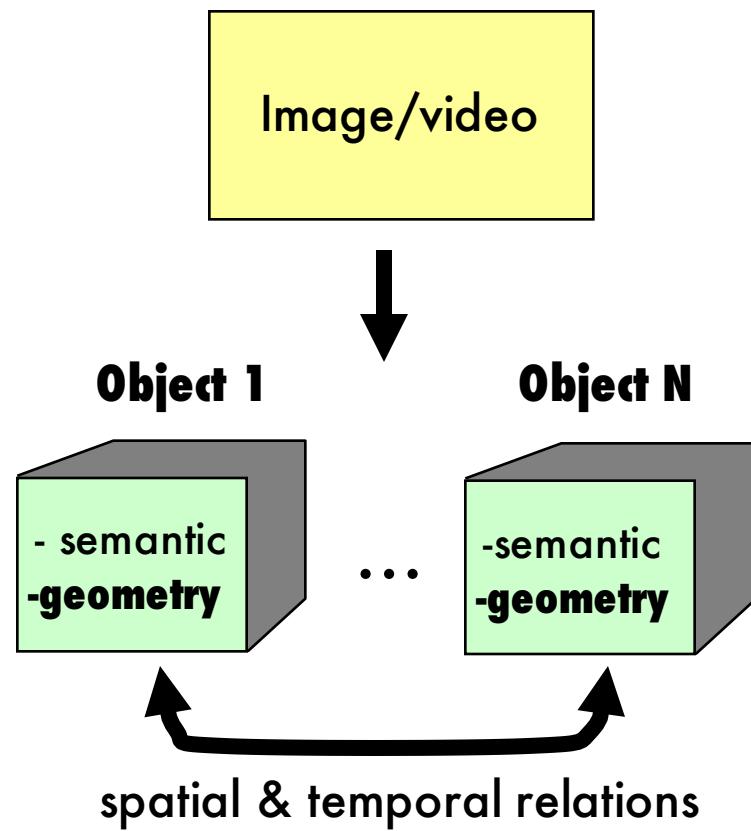


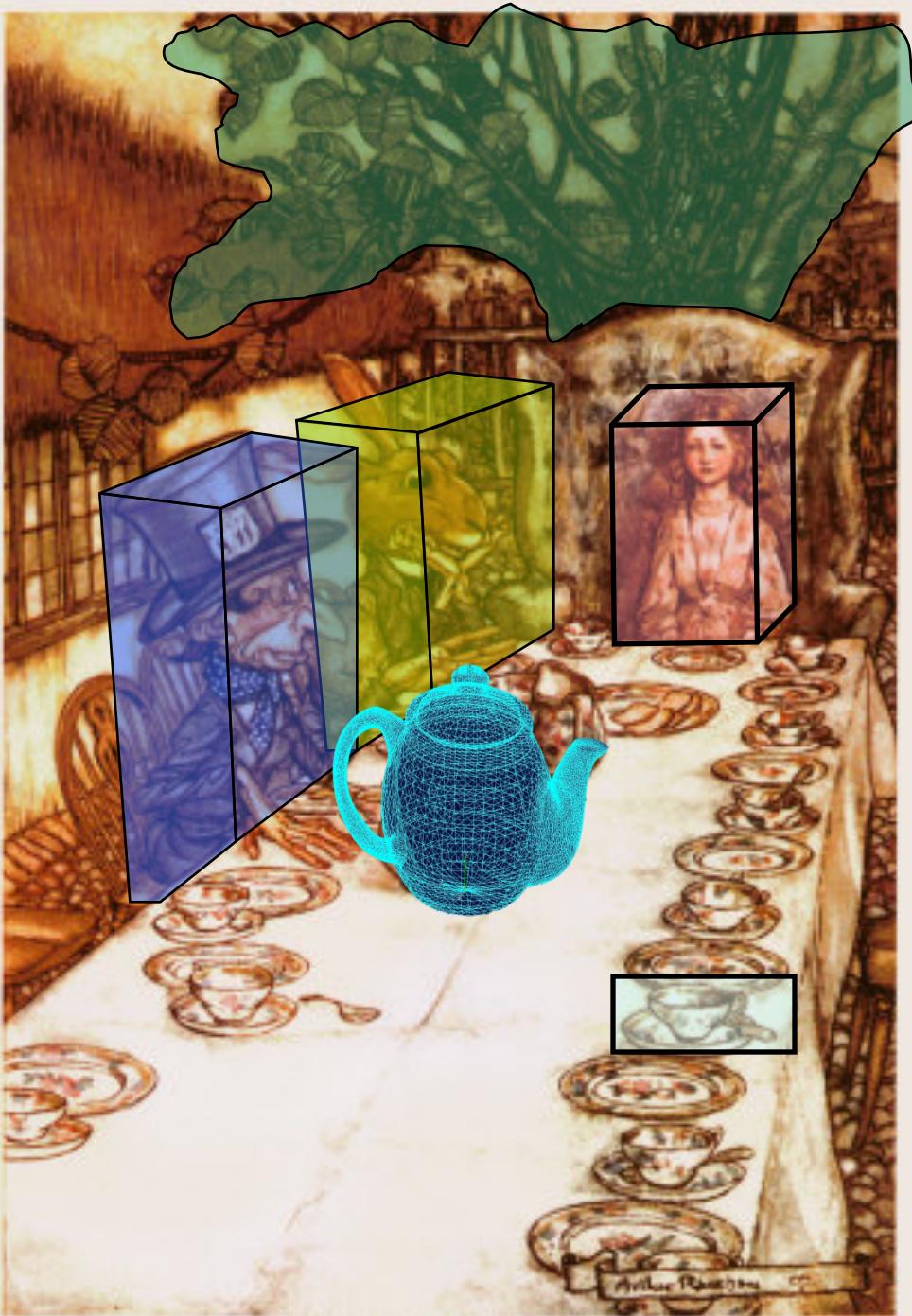
Computer vision



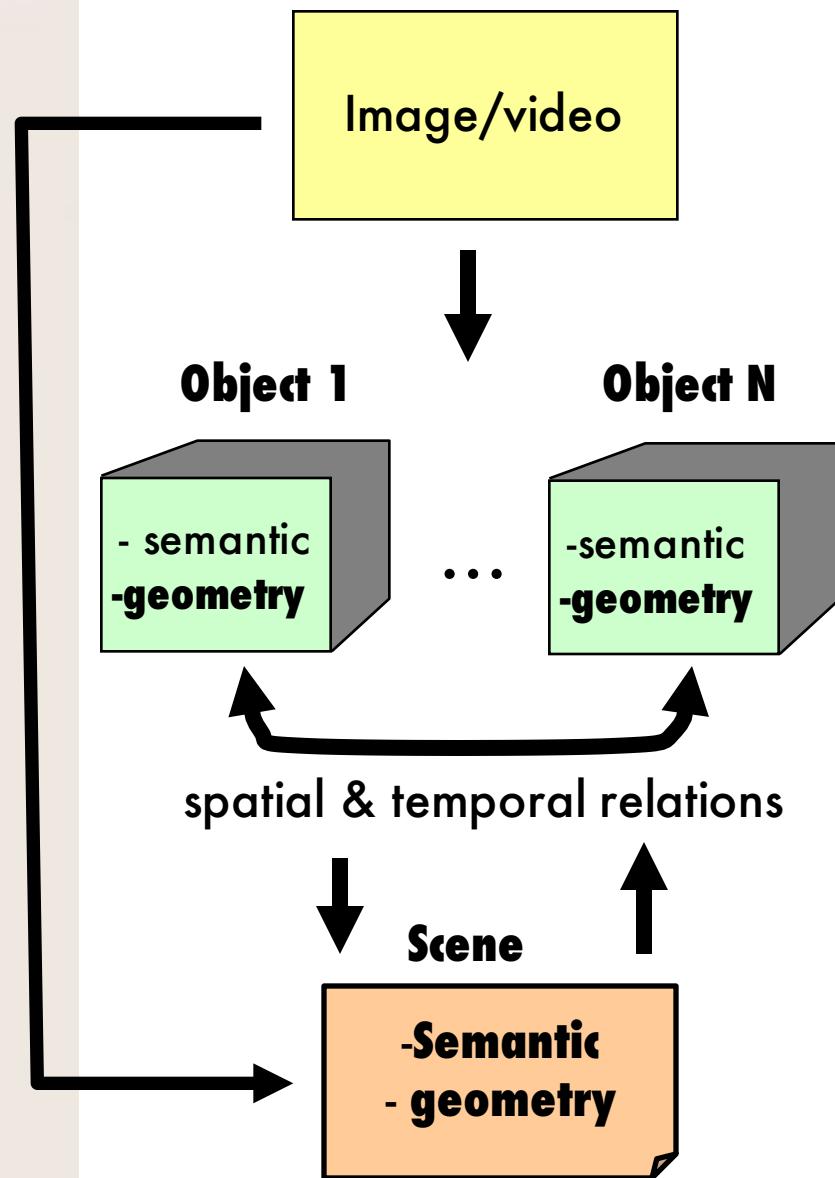


Computer vision



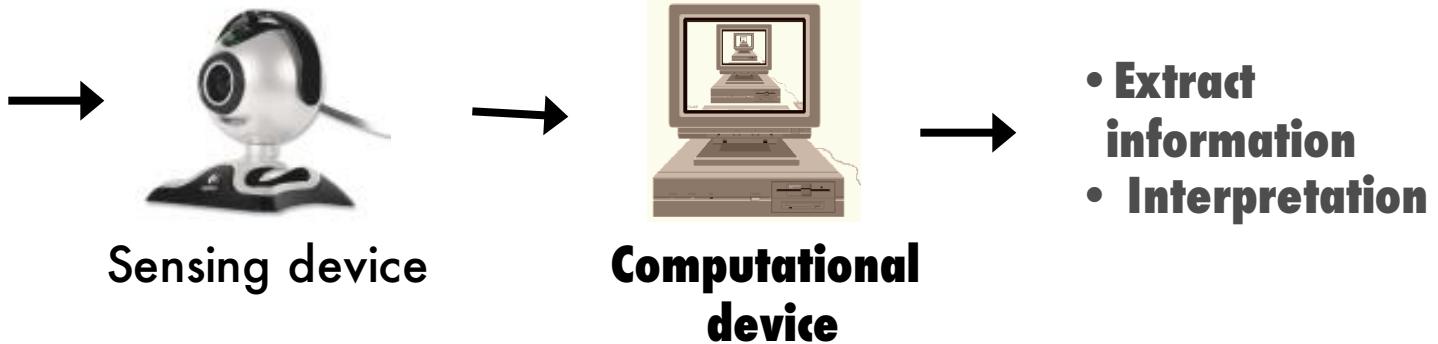


Computer vision



Computer vision

Computer vision studies 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 the world**



- Scene
- Objects
- People
- Actions

Information: visual cues, 3D structure, motion flows, etc...

Interpretation: recognize objects, scenes, actions, events

Have we reached humans?

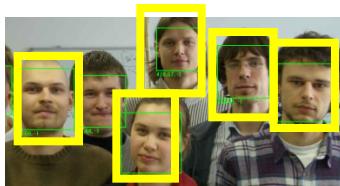
... not yet

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

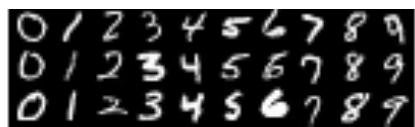
Actions, Events



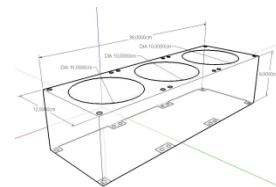
Categorization



Object Recognition



Physical attributes



3D modeling

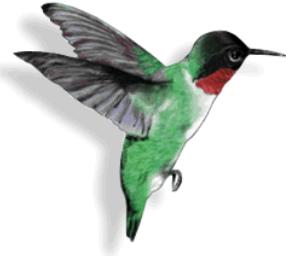


3D scenes



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 bench mark for computational theories in human vision

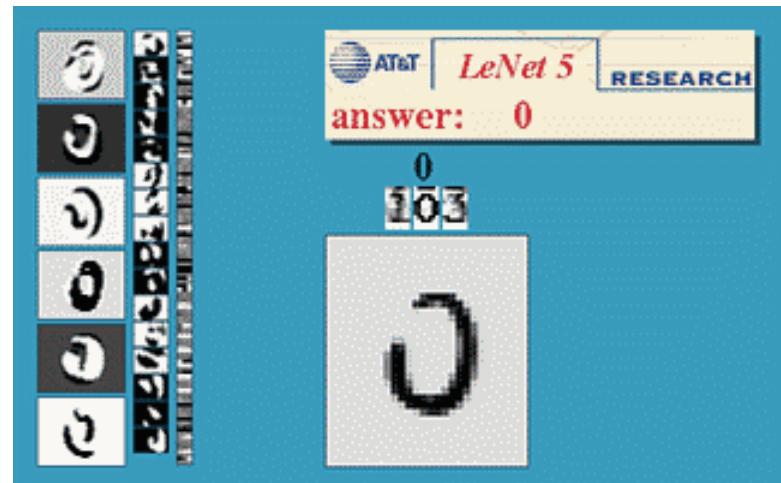
Optical character recognition (OCR)

Technology to convert scanned docs to text



License plate readers

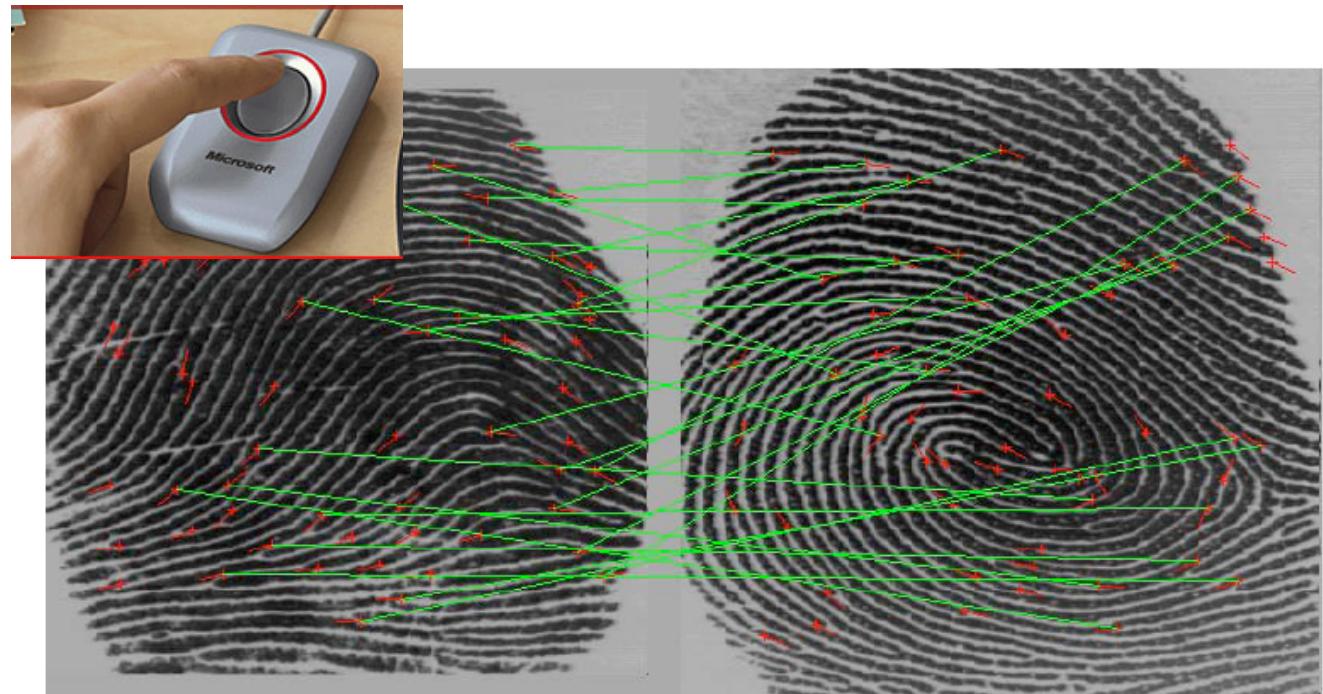
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition



Digit recognition, AT&T labs

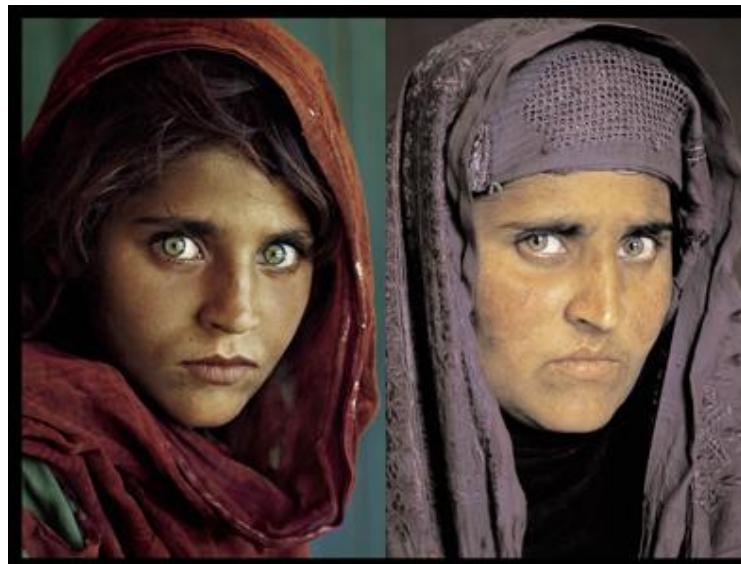
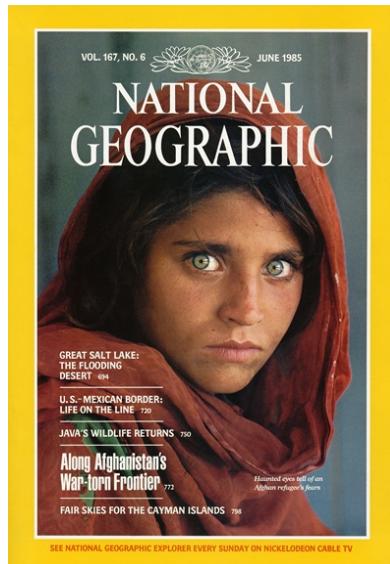
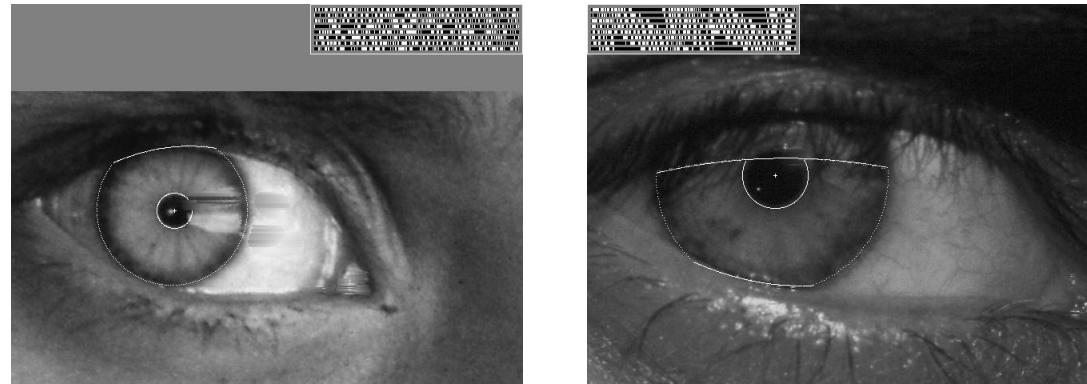
Biometrics

Fingerprint recognition



Biometrics

Iris Patterns recognition



Source: S. Seitz

How the Afghan Girl was Identified by Her Iris Patterns

Biometrics

Face recognition systems

<http://www.sensiblevision.com/>



Source: S. Seitz

Consumer applications

 BBC NEWS

• UK version • International version About the versions | L

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

[E-mail this to a friend](#) [Printable version](#)

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

News Front Page

World

UK

England

Northern Ireland

Scotland

Wales

Business

Market Data

Your Money

E-Commerce

Economy

Companies

Politics

Health

Education

Consumer applications

Face detection



- **Many new digital cameras now detect faces**
 - Canon, Sony, Fuji, ...

<http://www.apple.com/ilife/iphoto/>

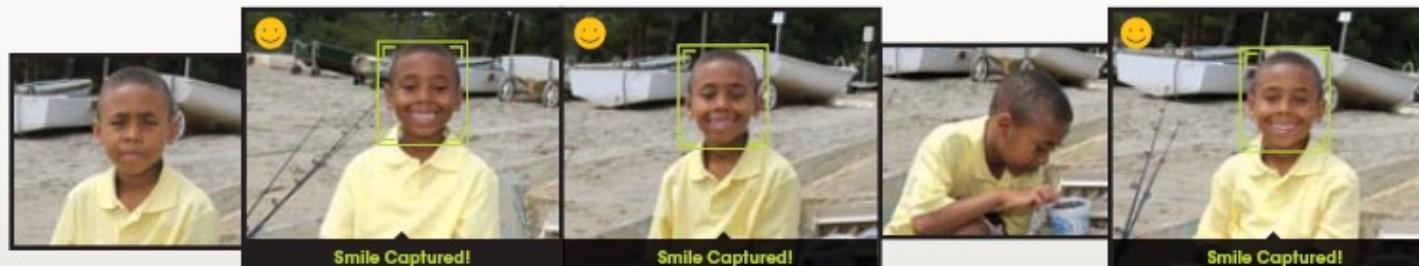
Source: S. Seitz

Consumer applications

Smile detection

The Smile Shutter flow

Imagine a camera smart enough to catch every smile! In Smile Shutter Mode, your Cyber-shot® camera can automatically trip the shutter at just the right instant to catch the perfect expression.



[Sony Cyber-shot® T70 Digital Still Camera](#)

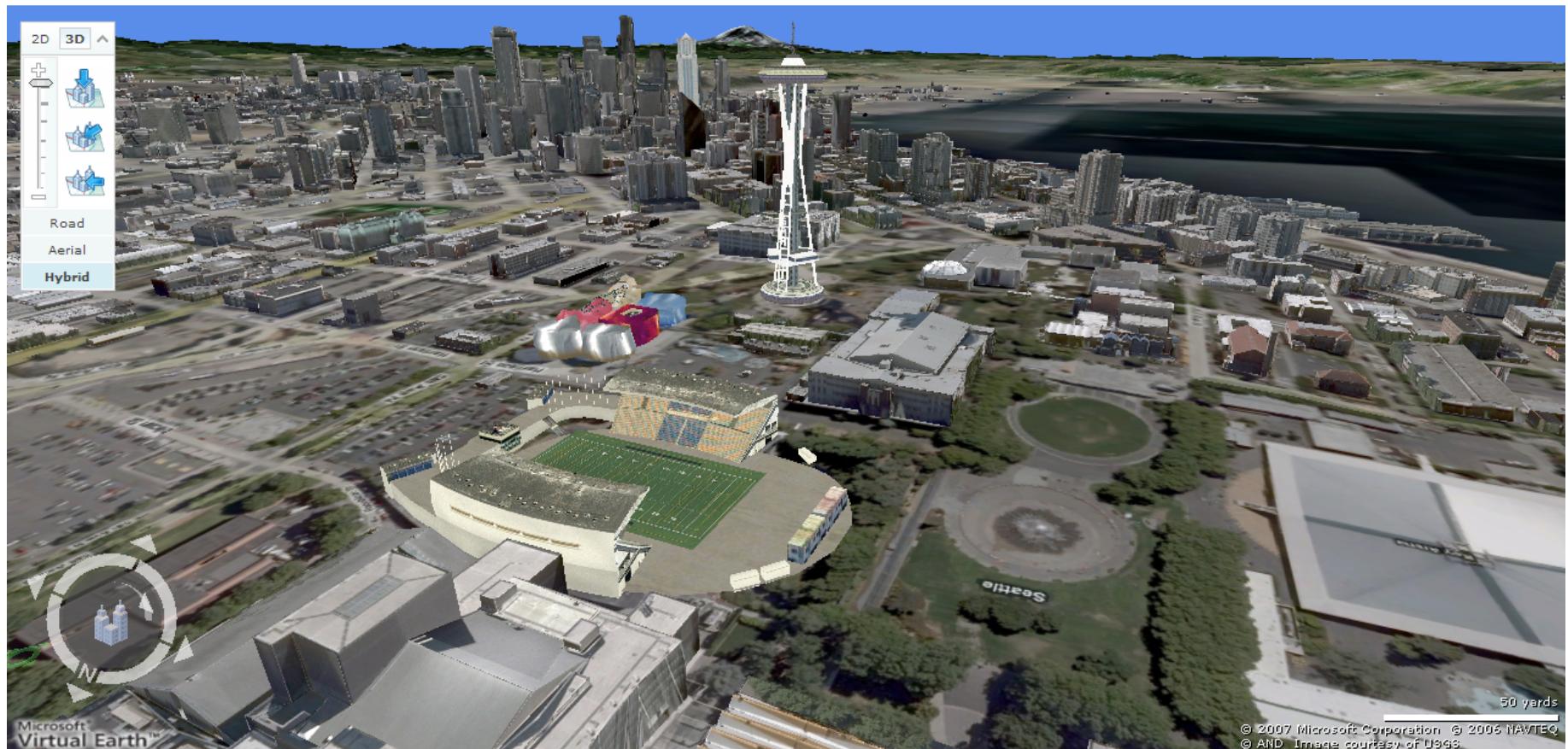
Source: S. Seitz

Special effects movies - videogames



Source: S. Seitz

3D urban modeling



Bing maps, Google Streetview

Source: S. Seitz

3D urban modeling: Microsoft Photosynth



<http://labs.live.com/photosynth/>

Source: S. Seitz

Toy & Robots



Mobile visual search: Google goggles labs

Google Goggles in Action

Click the icons below to see the different ways Google Goggles can be used.



[Landmark](#)



[Book](#)



[Contact Info.](#)



[Artwork](#)



[Places](#)



[Wine](#)



[Logo](#)



Vision in supermarkets



[LaneHawk by EvolutionRobotics](#)

Source: S. Seitz

Vision-based interaction (and games)



Microsoft's Kinect

Sony EyeToy

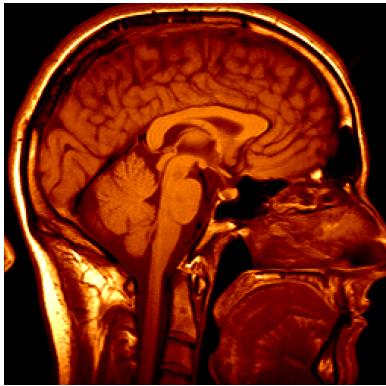
Vision for robotics, space exploration



Vision systems (JPL) used for several tasks

- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read “[Computer Vision on Mars](#)” by Matthies et al.

Applications of computer vision



Medical Imaging



Assistive technologies



Surveillance



Autonomous driving,
robot navigation



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



Security

Computer vision

- Machine learning
- Artificial intelligence

- Automatic control
- Robotics

- Data mining

- Signal processing
- Compression

Non linear SP
Multi-variate SP

Robot vision

Image retrieval

Visual pattern
recognition

Statistics
Geometry
Optimization

- Applied math

- Neurobiology

Biological vision
Visual Psychophysics

• Optics
• Smart cameras

- Physics
- Imaging

Acquisition
methods

- Computer
graphics

EECS 442 course overview

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

EECS 442 course overview

1. Geometry
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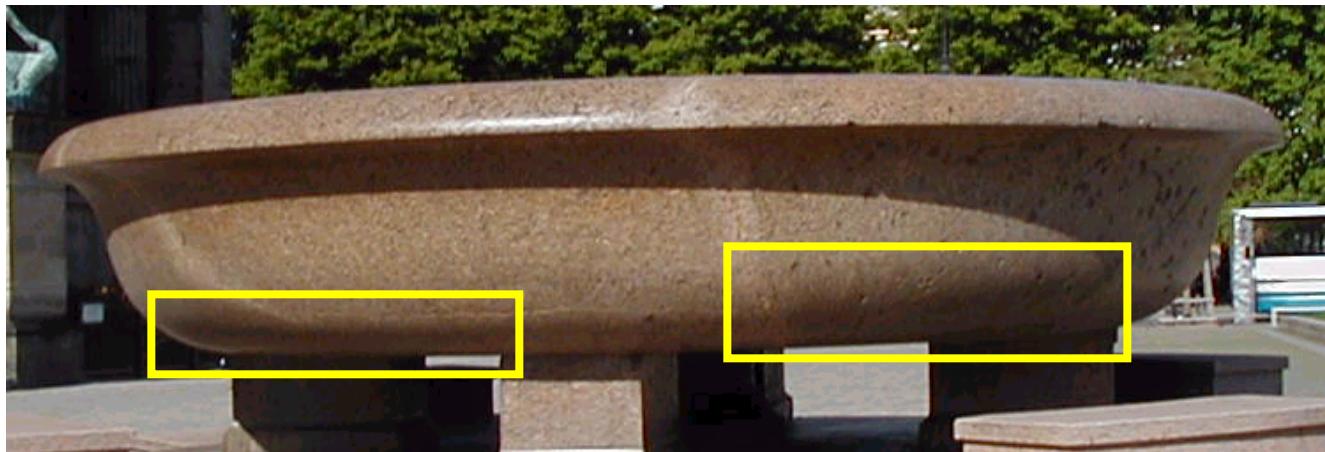
Geometry:

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

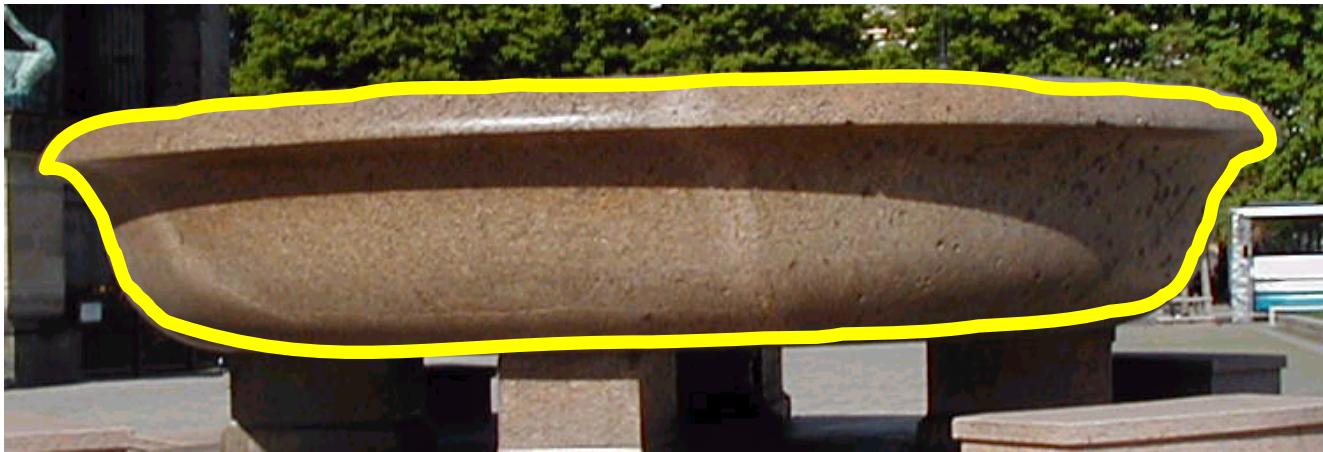
Visual cues: **texture** shading contours shadows reflections



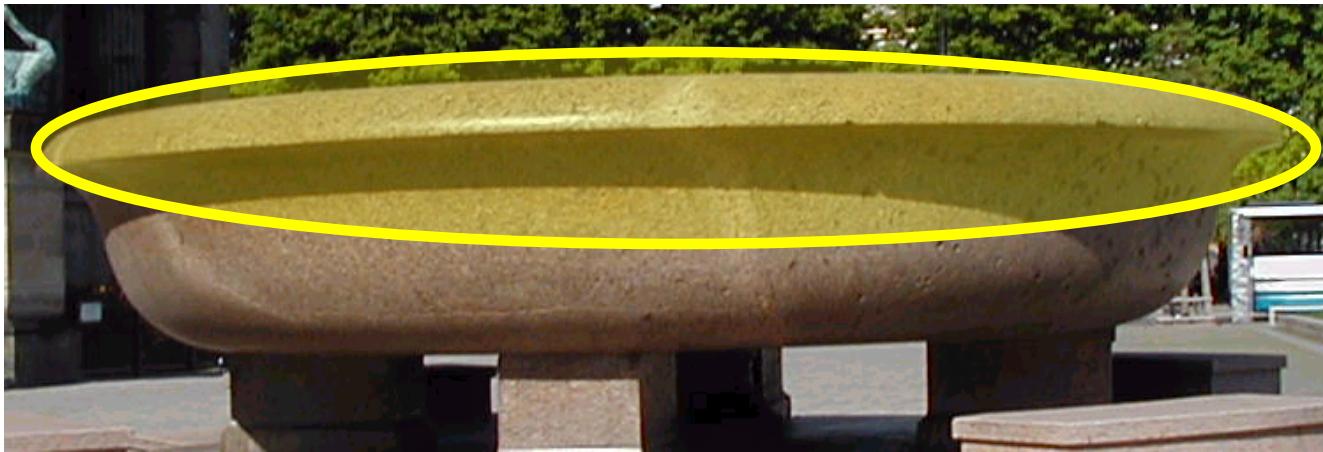
Visual cues: texture  shading  contours  shadows  reflections



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



Visual cues: texture shading contours shadows reflections



Visual cues: texture shading contours shadows reflections



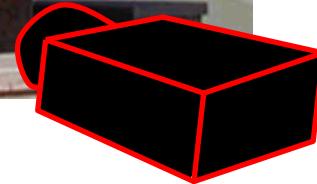
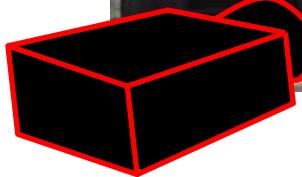
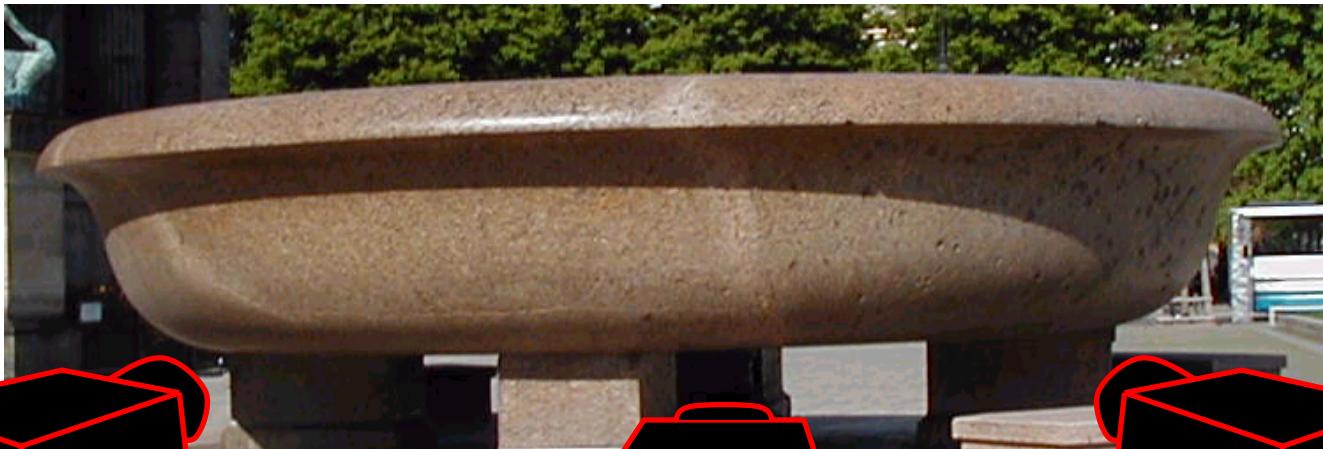
Visual cues: texture shading contours shadows reflections

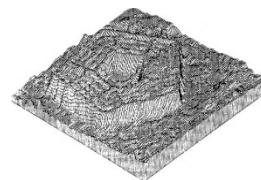
Number of observers: monocular multiple views



Visual cues: texture shading contours shadows reflections

Number of observers: monocular multiple views

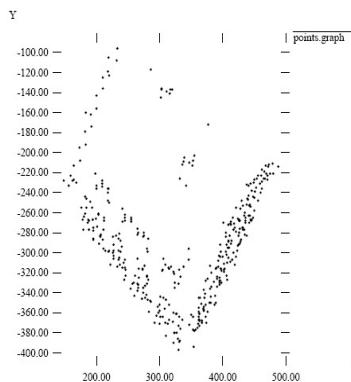




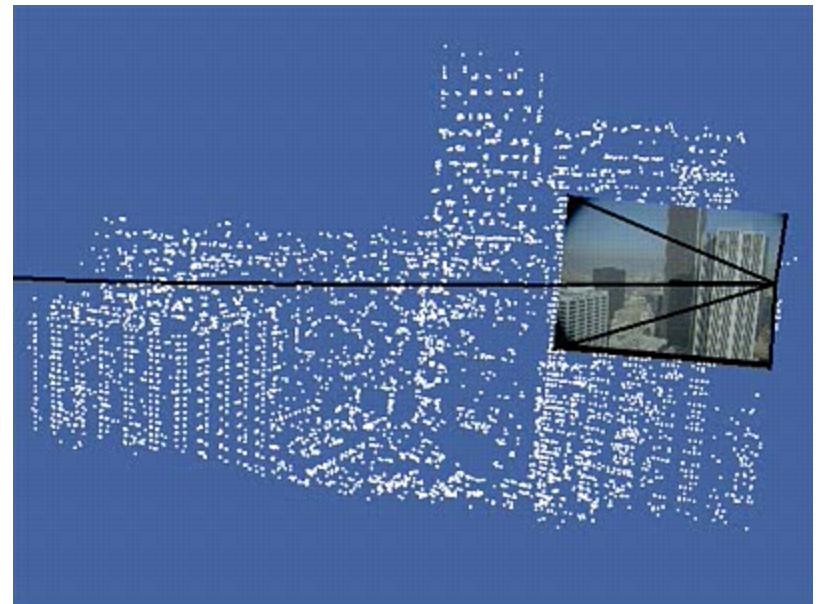
Stereo



Epipolar geometry



Structure from motion

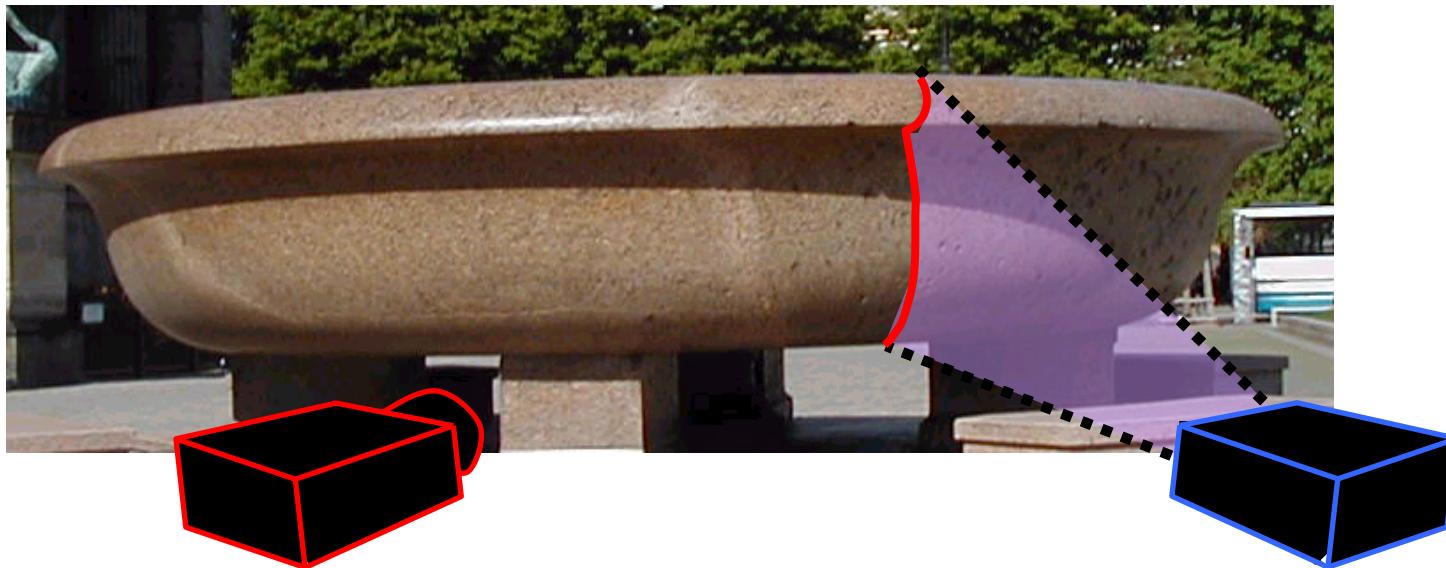


Courtesy of Oxford **Visual Geometry Group**

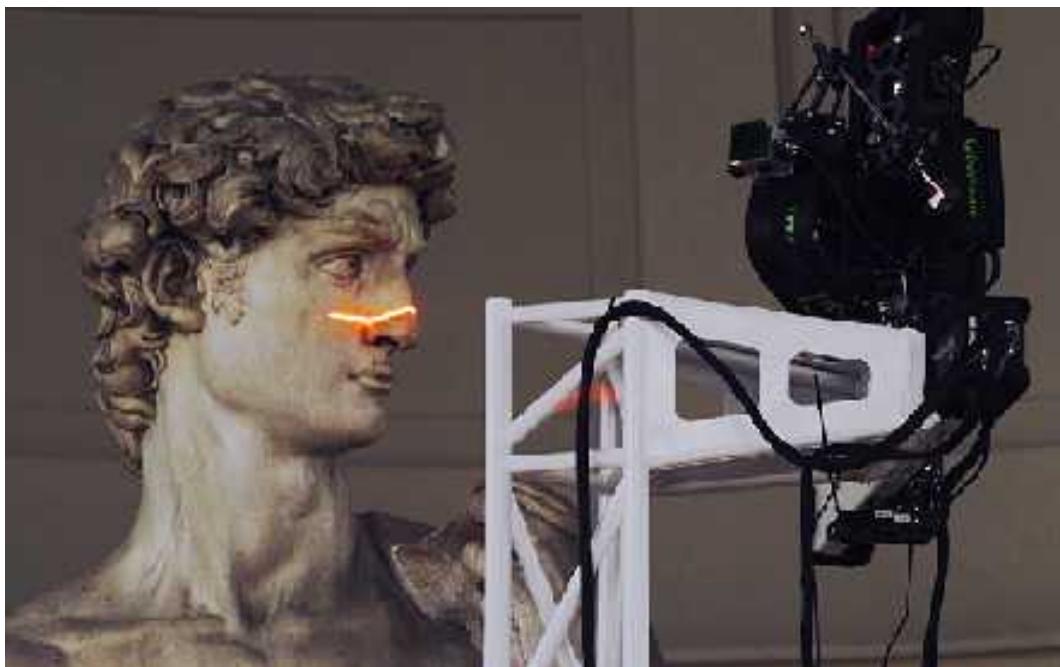
Visual cues: texture shading contours shadows reflections

Number of observers: monocular multiple views

Active lighting: laser stripes structured lighting patterns



3D Scanning



Scanning Michelangelo's "*The David*"

- [The Digital Michelangelo Project](#)
 - <http://graphics.stanford.edu/projects/mich/>
- **2 BILLION polygons, accuracy to .29mm**

3D Digital models



Architecture

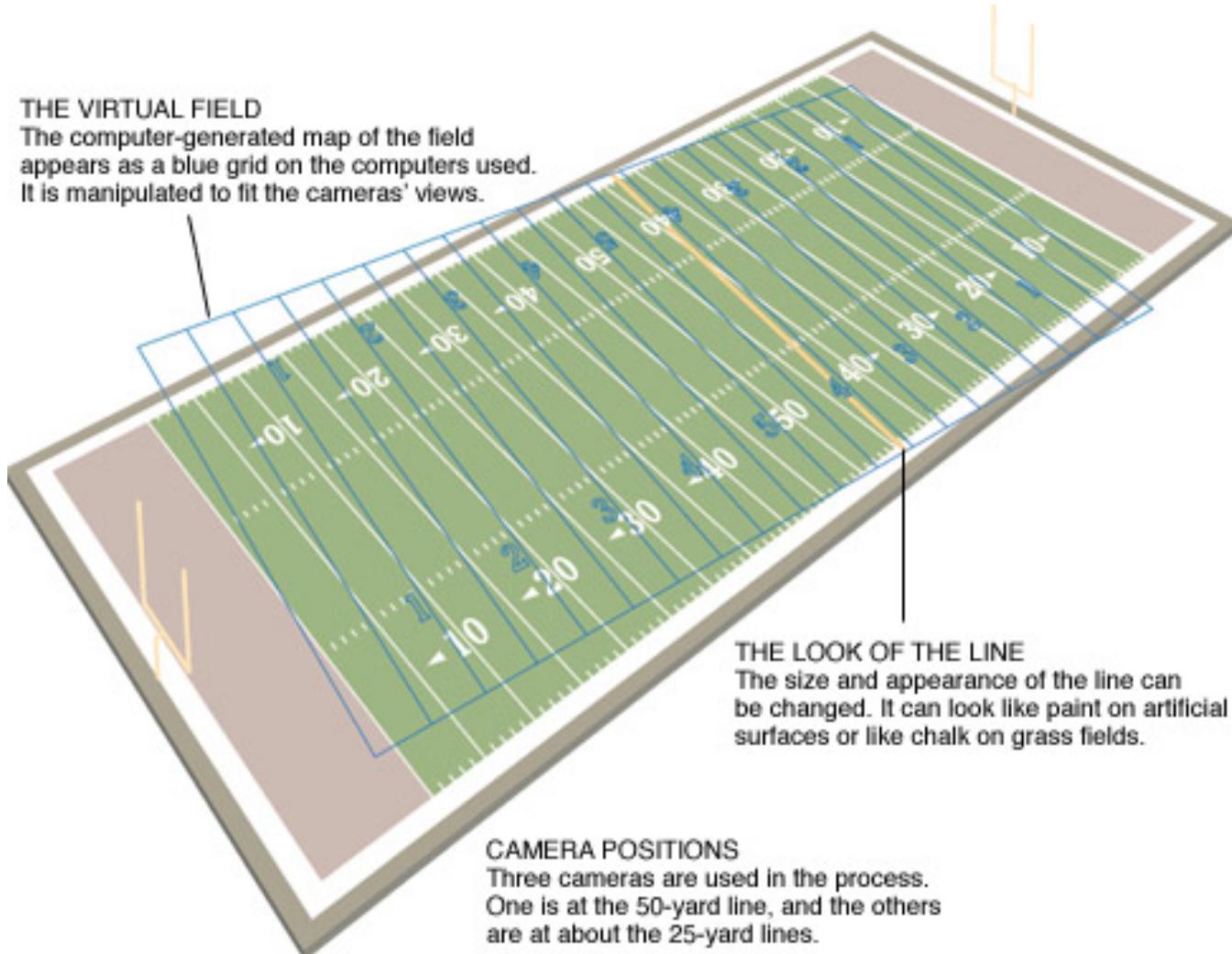


Entertainment



Medicine

The 'yellow line' in superbowls



The 'yellow line' in superbowls



Course overview

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

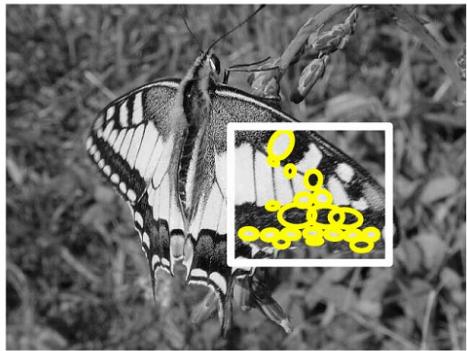
Mid-level vision:

- Extract useful building blocks
- Region segmentation
- Motion flows

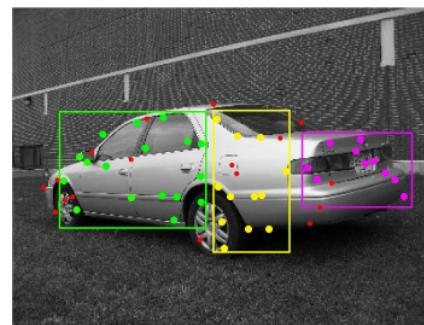
Extract useful building blocks



Extract useful building blocks



Alignment



Extract planar regions



Object segmentation

Image enhancement

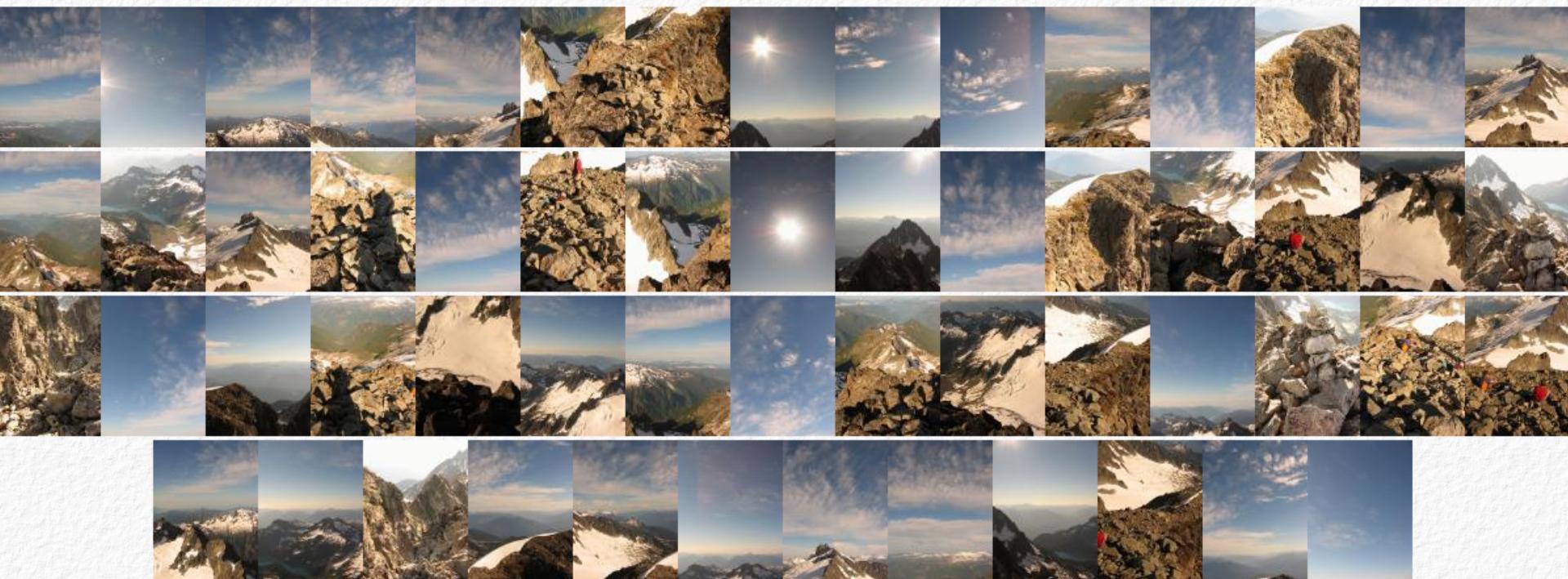


Image Inpainting, M. Bertalmio et al.
<http://www.iua.upf.es/~mbertalmio/restoration.html>



Image Inpainting, M. Bertalmio et al.
<http://www.iua.upf.es/~mbertalmio/restoration.html>

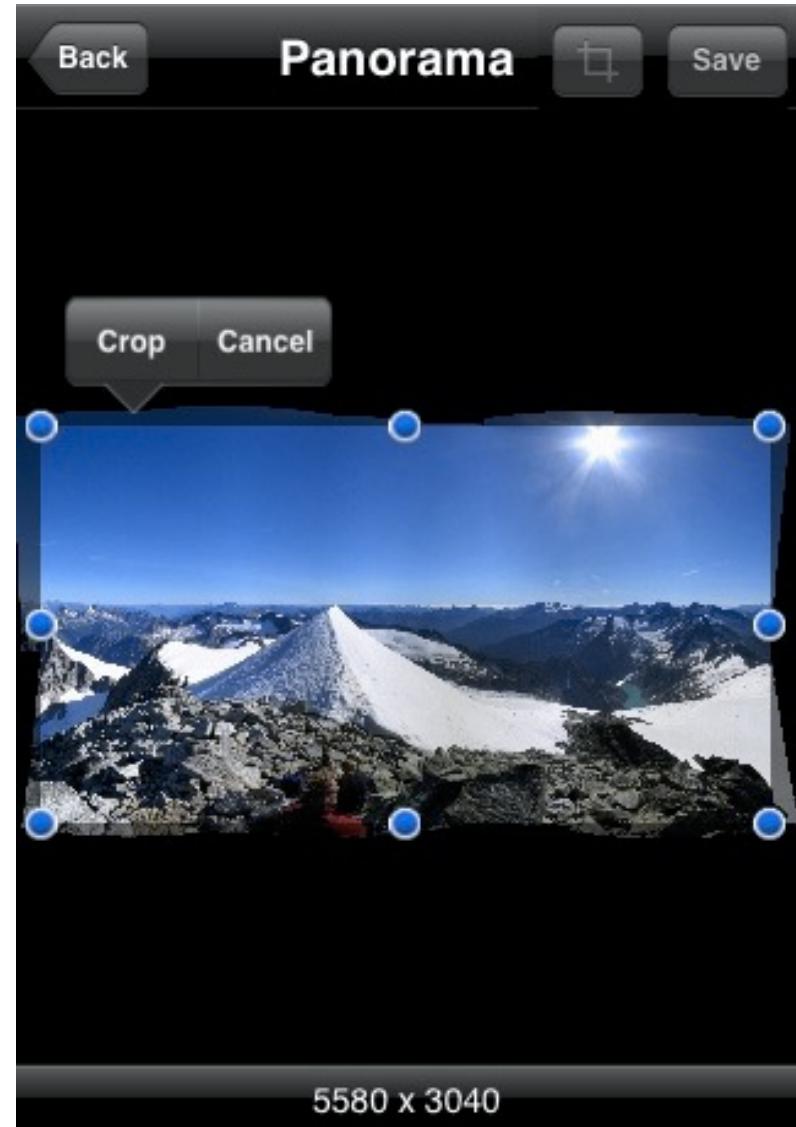
Automatic Panorama Stitching



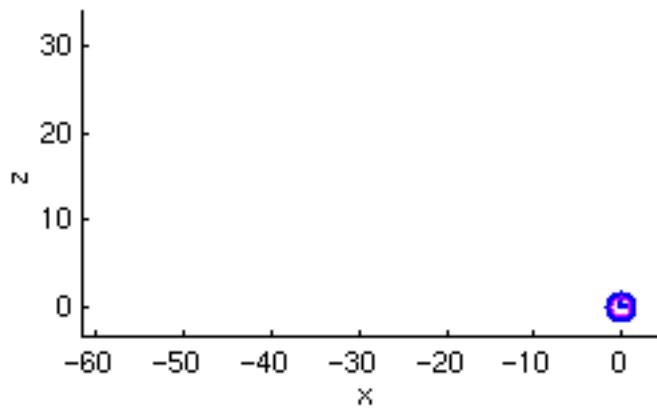
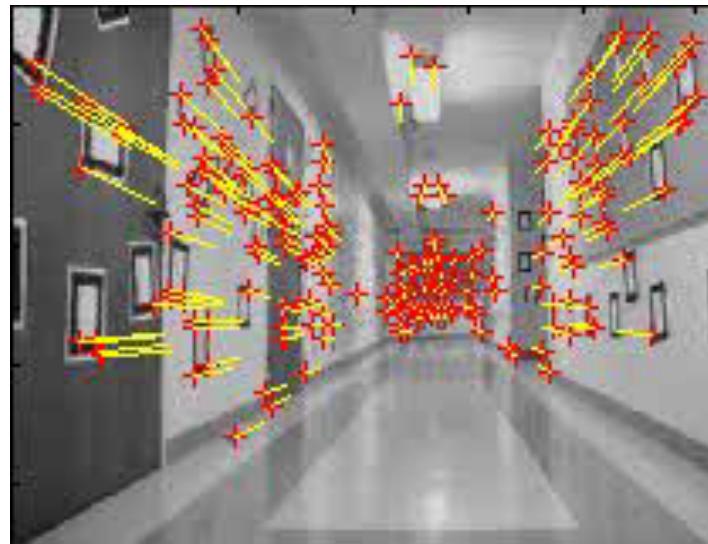
Automatic Panorama Stitching



Image Modeling



Tracking and 3D modeling



Camera tracking and V.R. insertions



Courtesy of Exford **Visual Geometry Group**

Course overview

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

High level operations

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

Object recognition and categorization

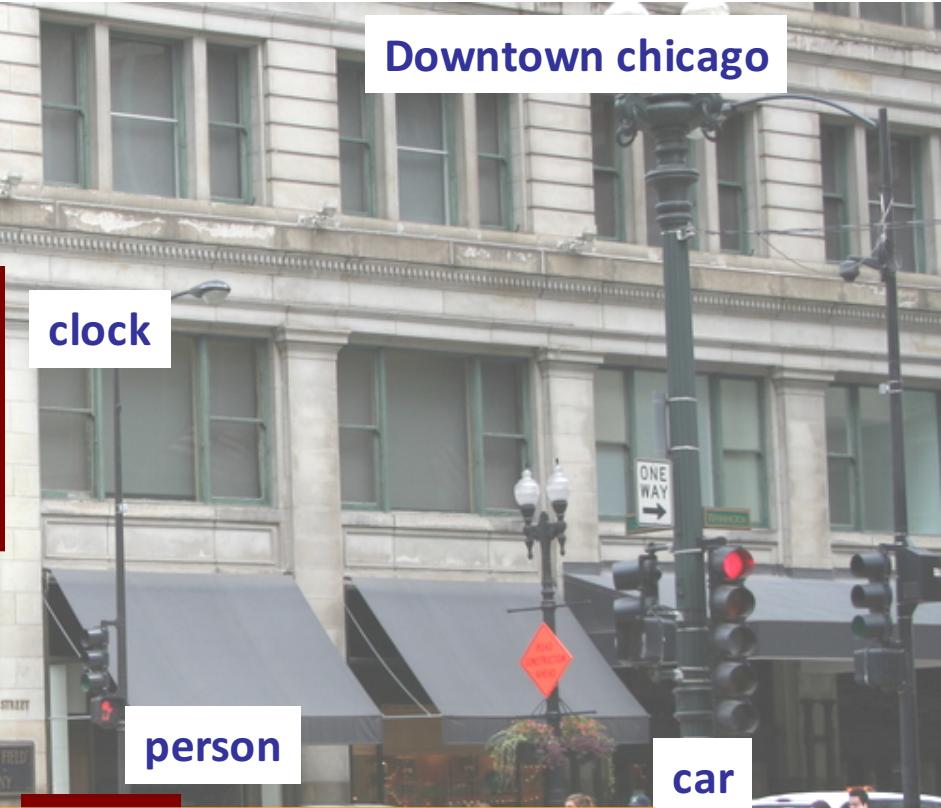
Building



clock



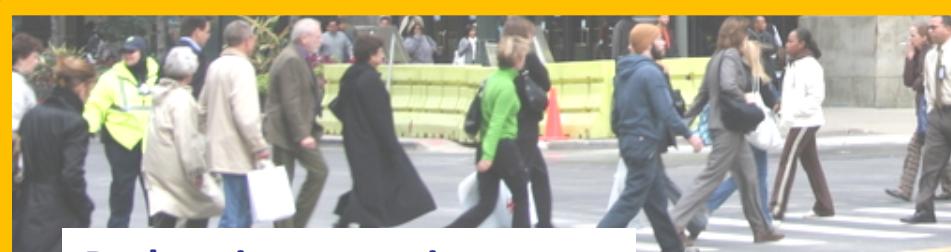
Downtown chicago



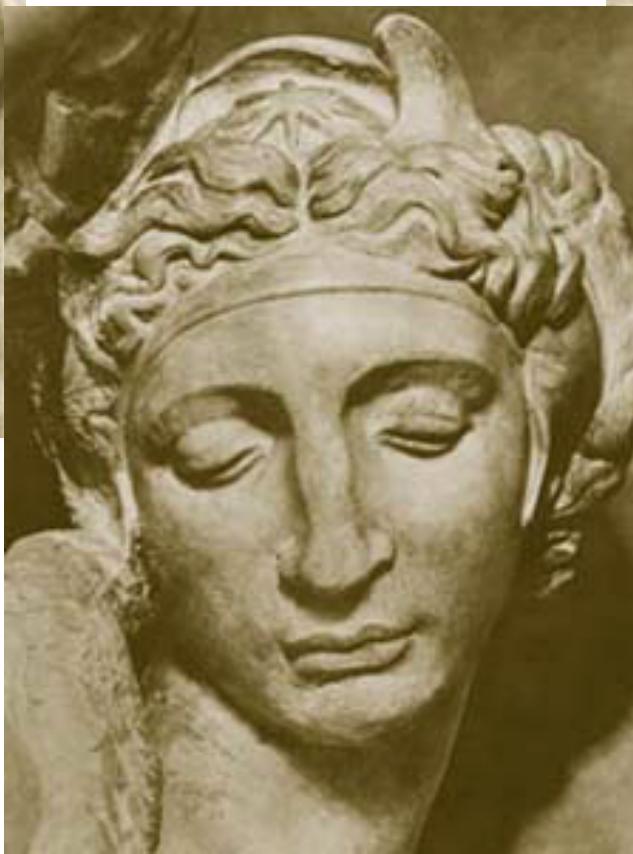
person

car

Pedestrians crossing street



Challenges: viewpoint variation



Challenges: illumination

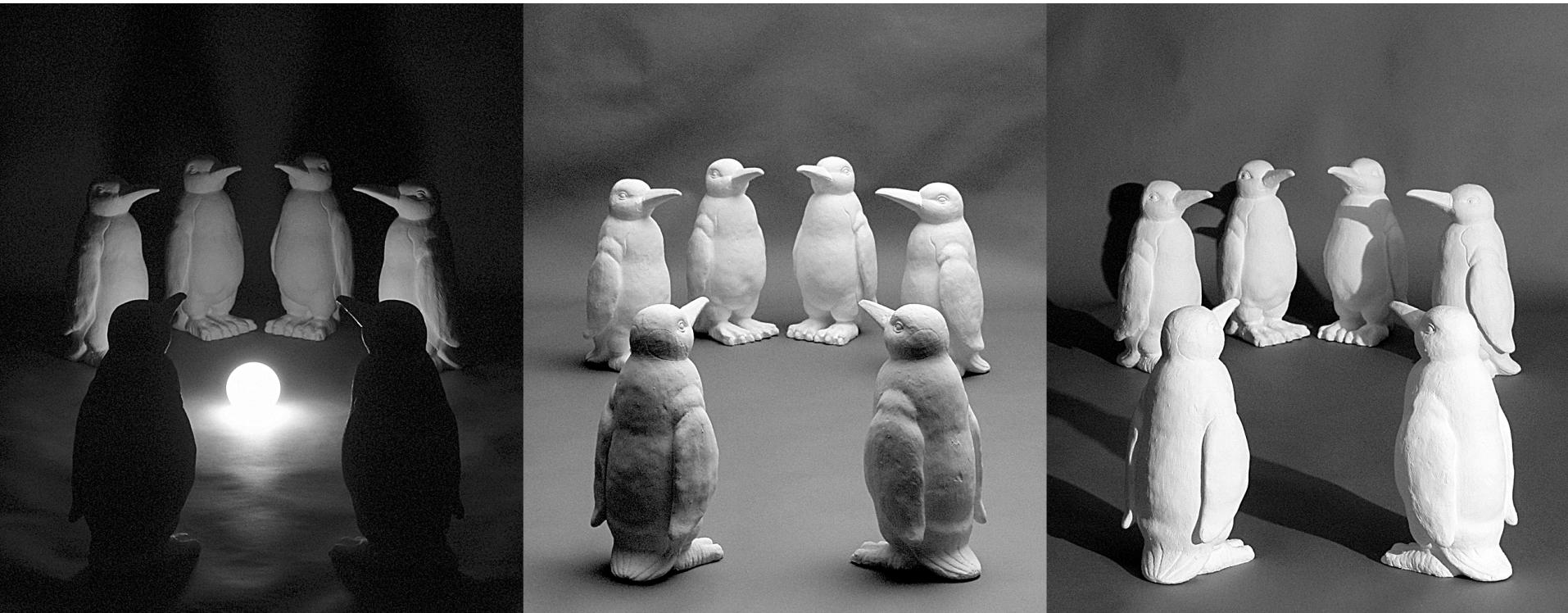


image credit: J. Koenderink

Challenges: scale



slide credit: Fei-Fei, Fergus & Torralba

Challenges: deformation



Challenges: occlusion



Magritte, 1957

slide credit: Fei-Fei, Fergus & Torralba

Challenges: background clutter



Kilmenny Niland. 1995

Challenges: object intra-class variation



slide credit: Fei-Fei, Fergus & Torralba



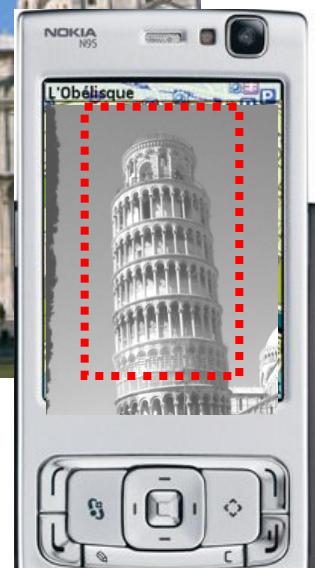
~10,000 to 30,000



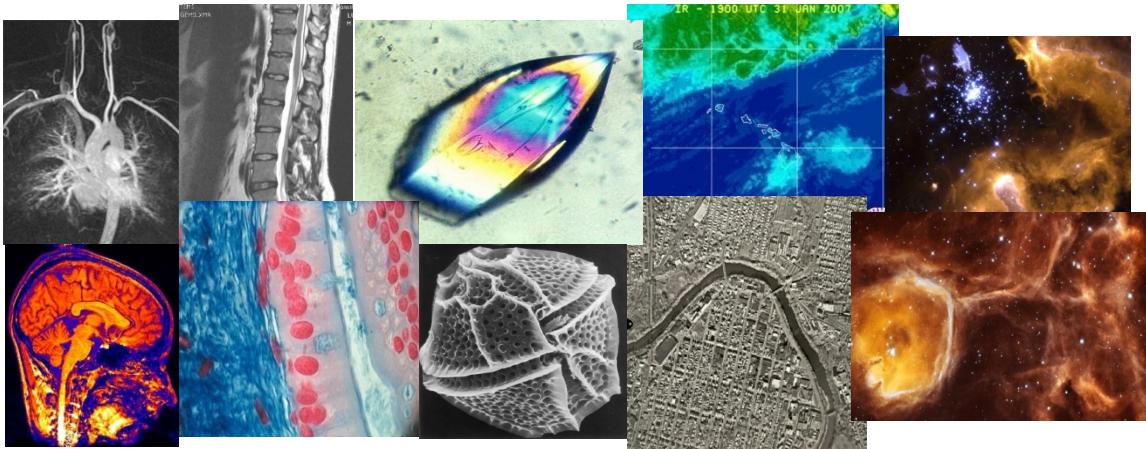
Face recognition

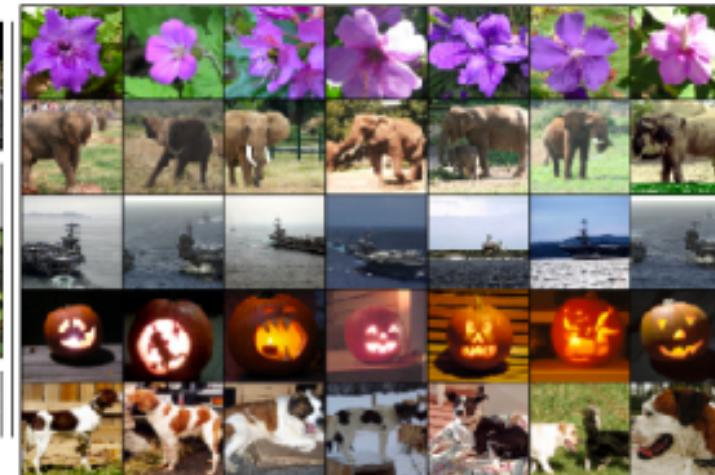
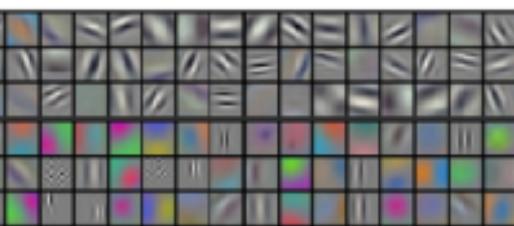
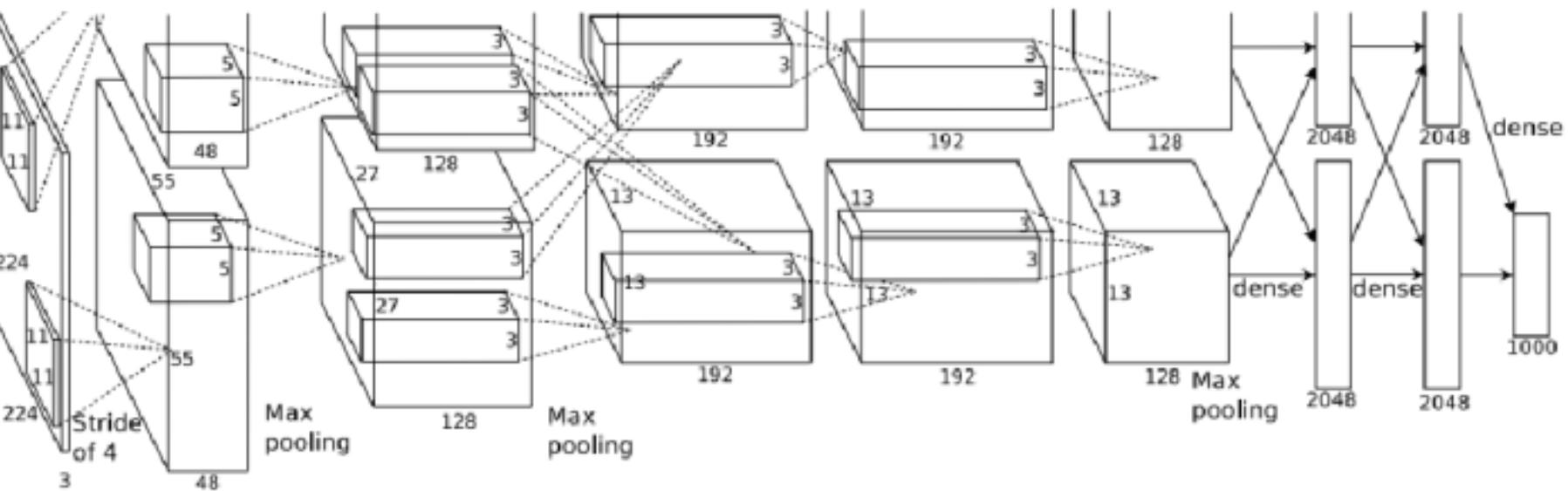


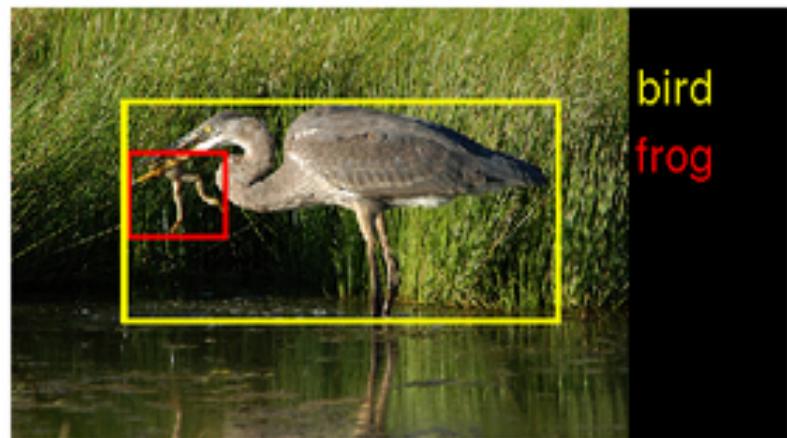
Recognizing scenes



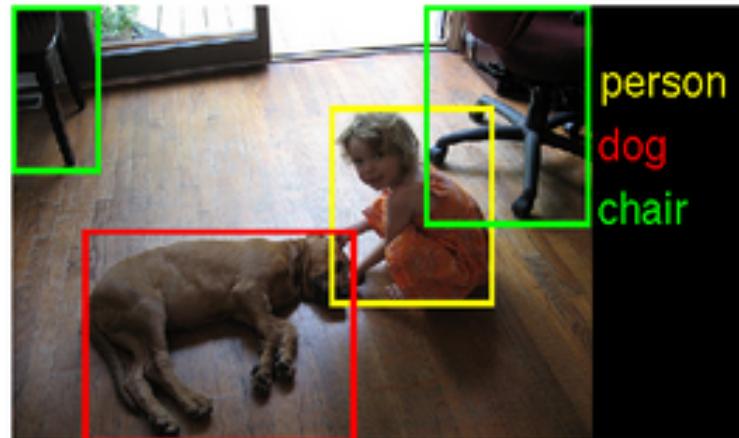
Sorting out millions of images/videos







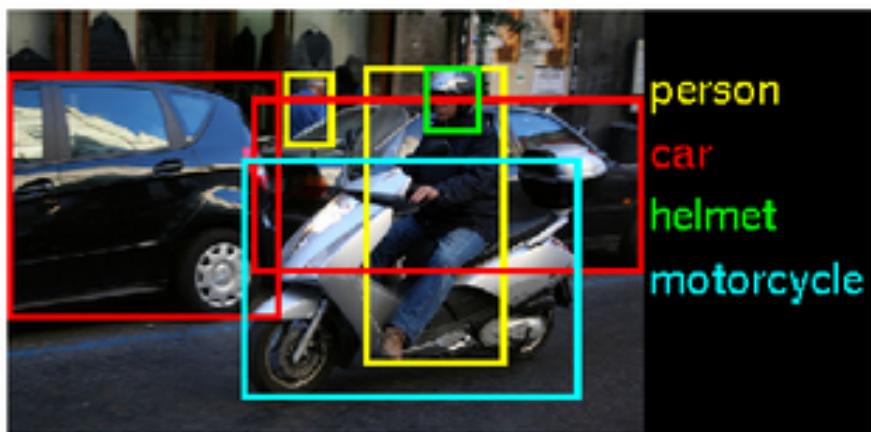
bird
frog



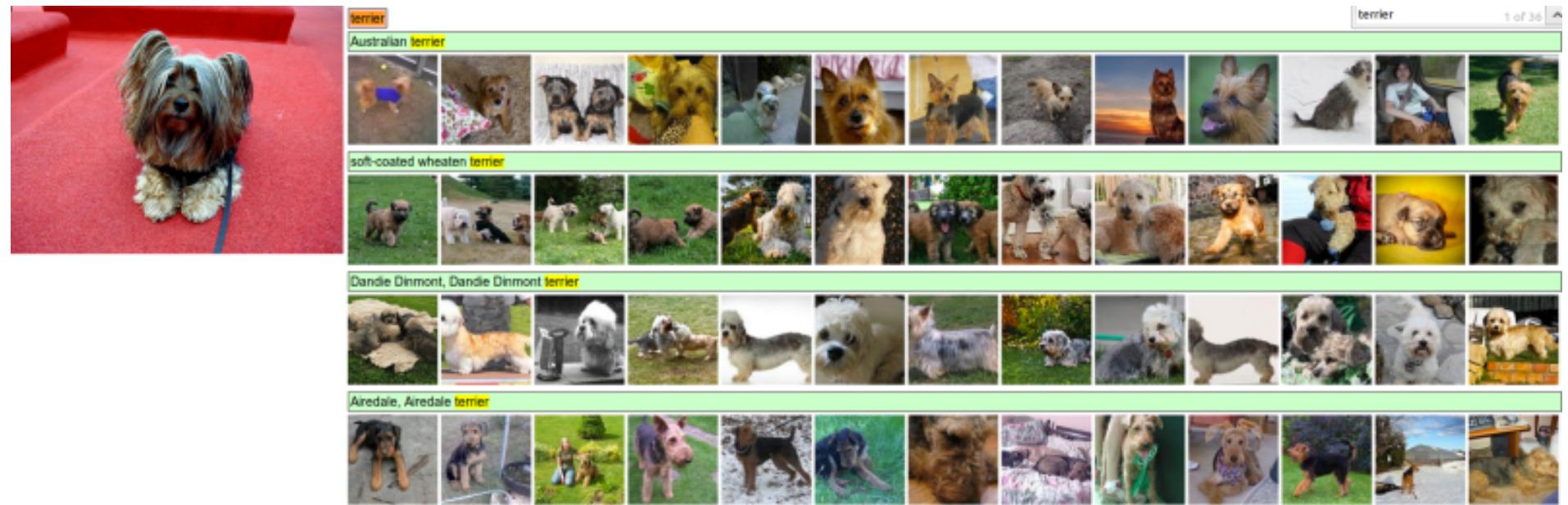
person
dog
chair



person
hammer
flower pot
power drill



person
car
helmet
motorcycle



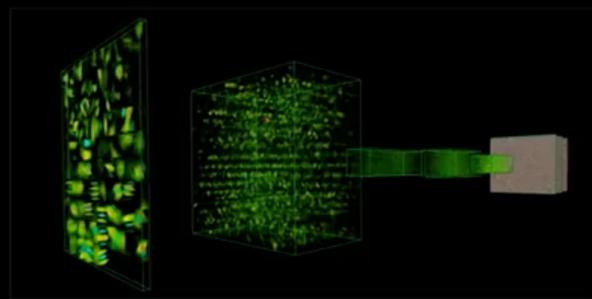
terrier

Australian terrier

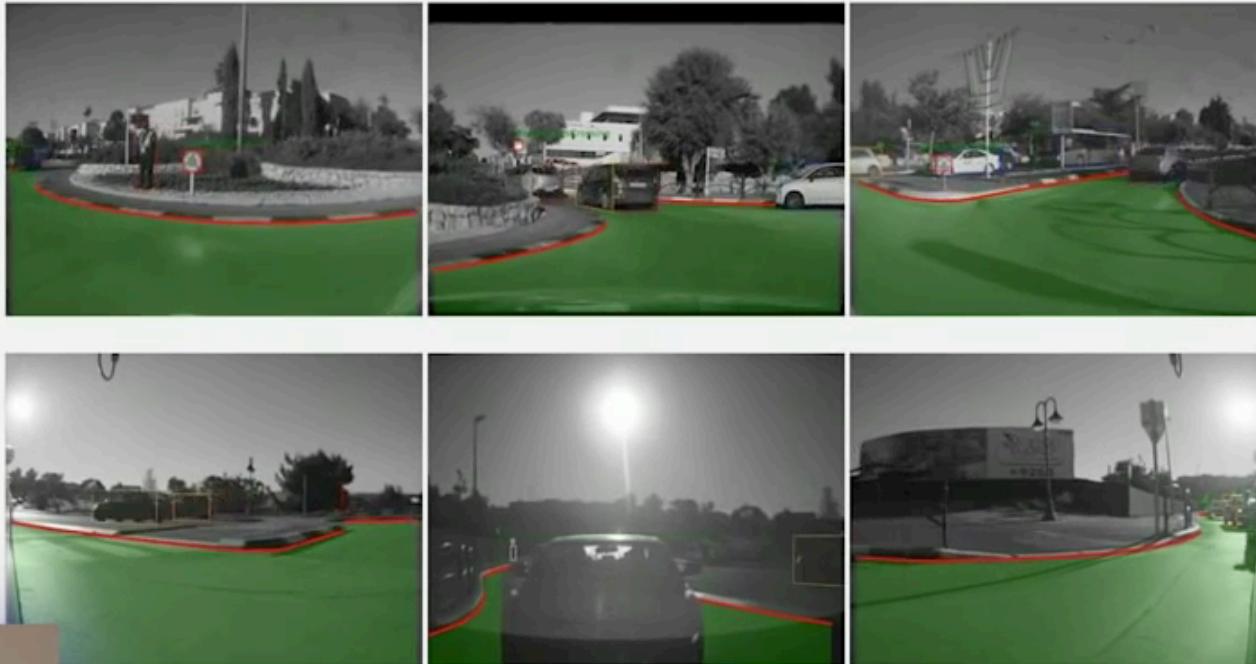
terrier

1 of 36

THE BIG BANG

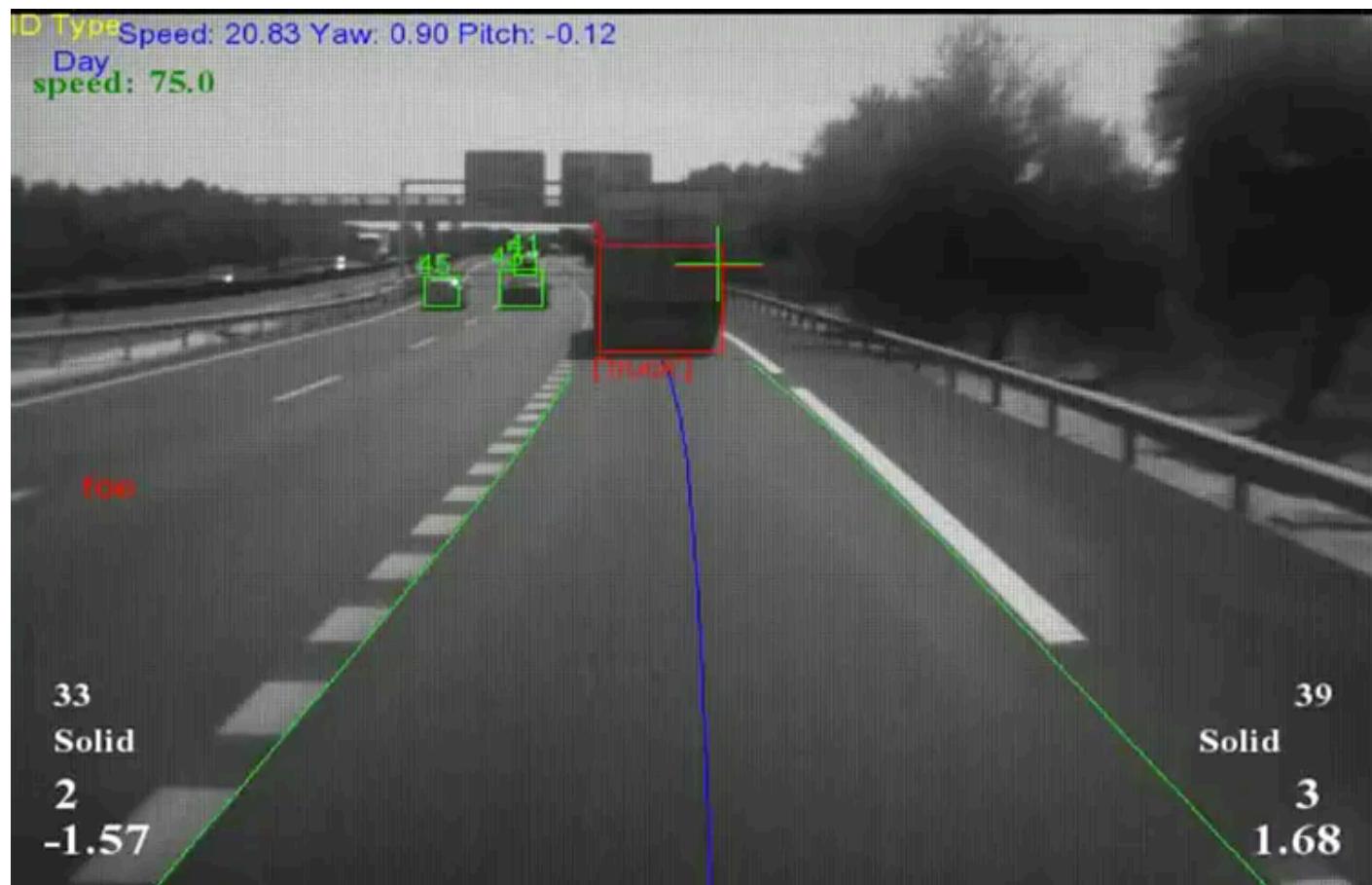


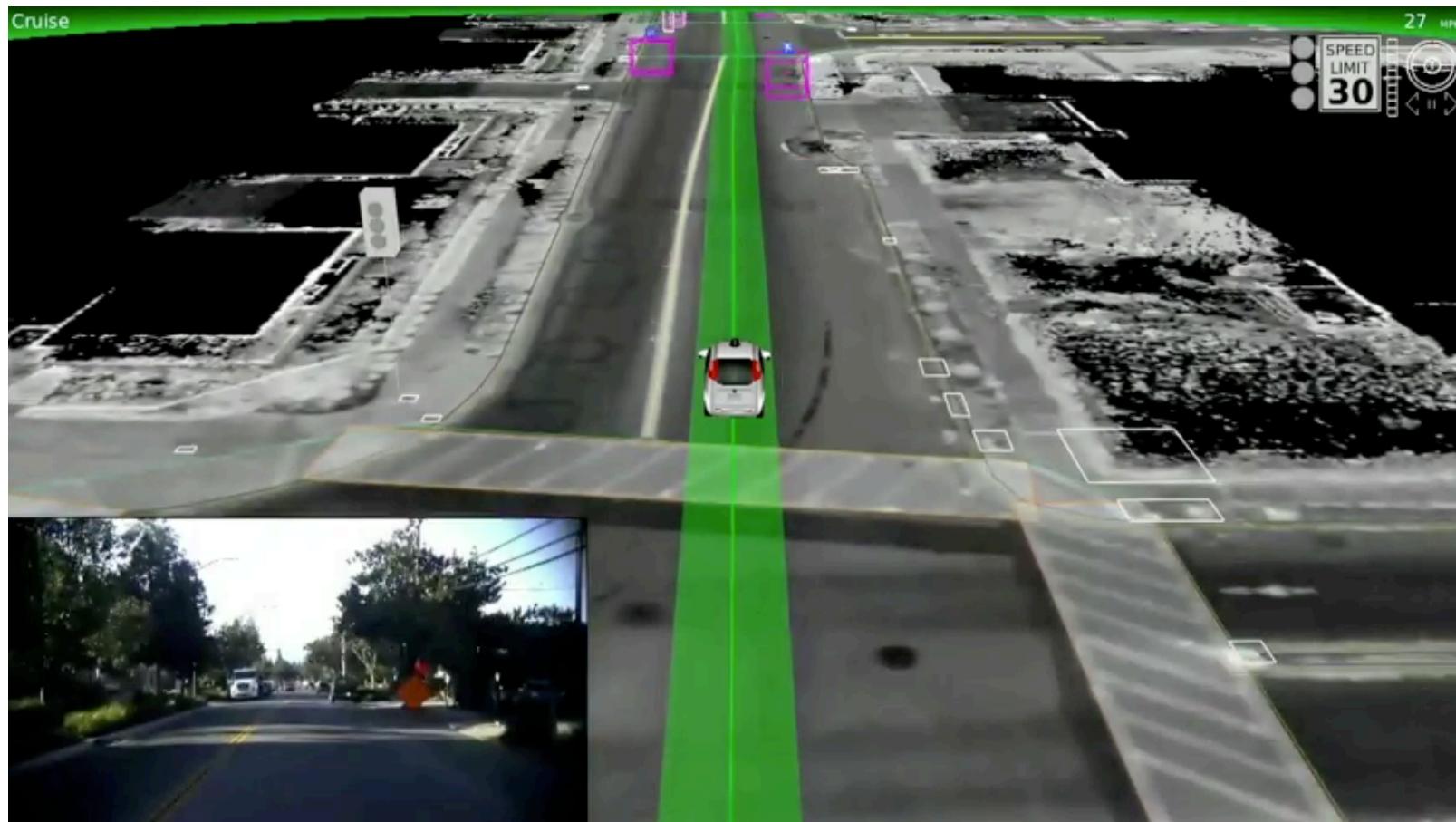
Free Space through Pixel Labeling



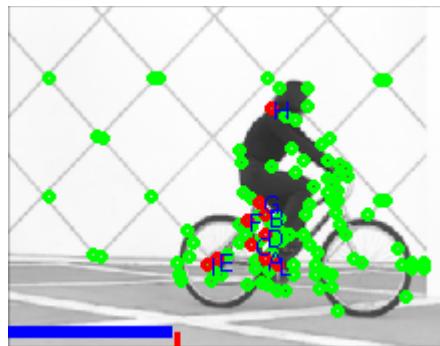
Our Vision. Your Safety.™


MOBILEYE®
Our Vision. Your Safety.™

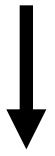
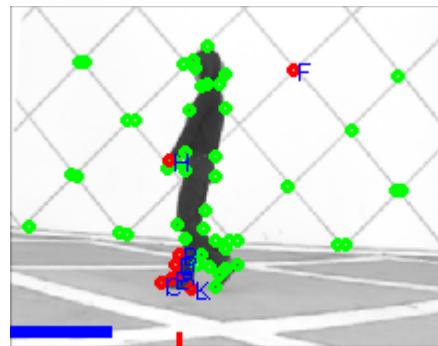




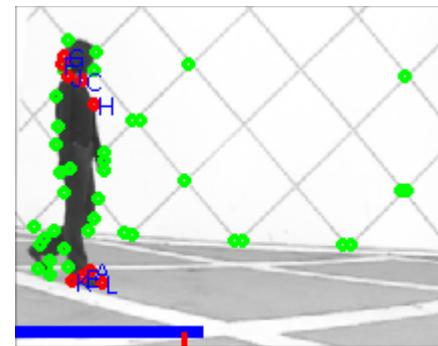
Recognizing human activities



Biking



Walking



Walking

Credit slide: Song & Perona

Integrating Recognition and Reconstruction

- Perception is an inherently ambiguous problem
 - Many different 3D scenes could have given rise to a particular 2D picture



Possible solutions

- Bring in more constraints (more images)
- Use prior knowledge about the structure of the world
- Need a combination of different methods



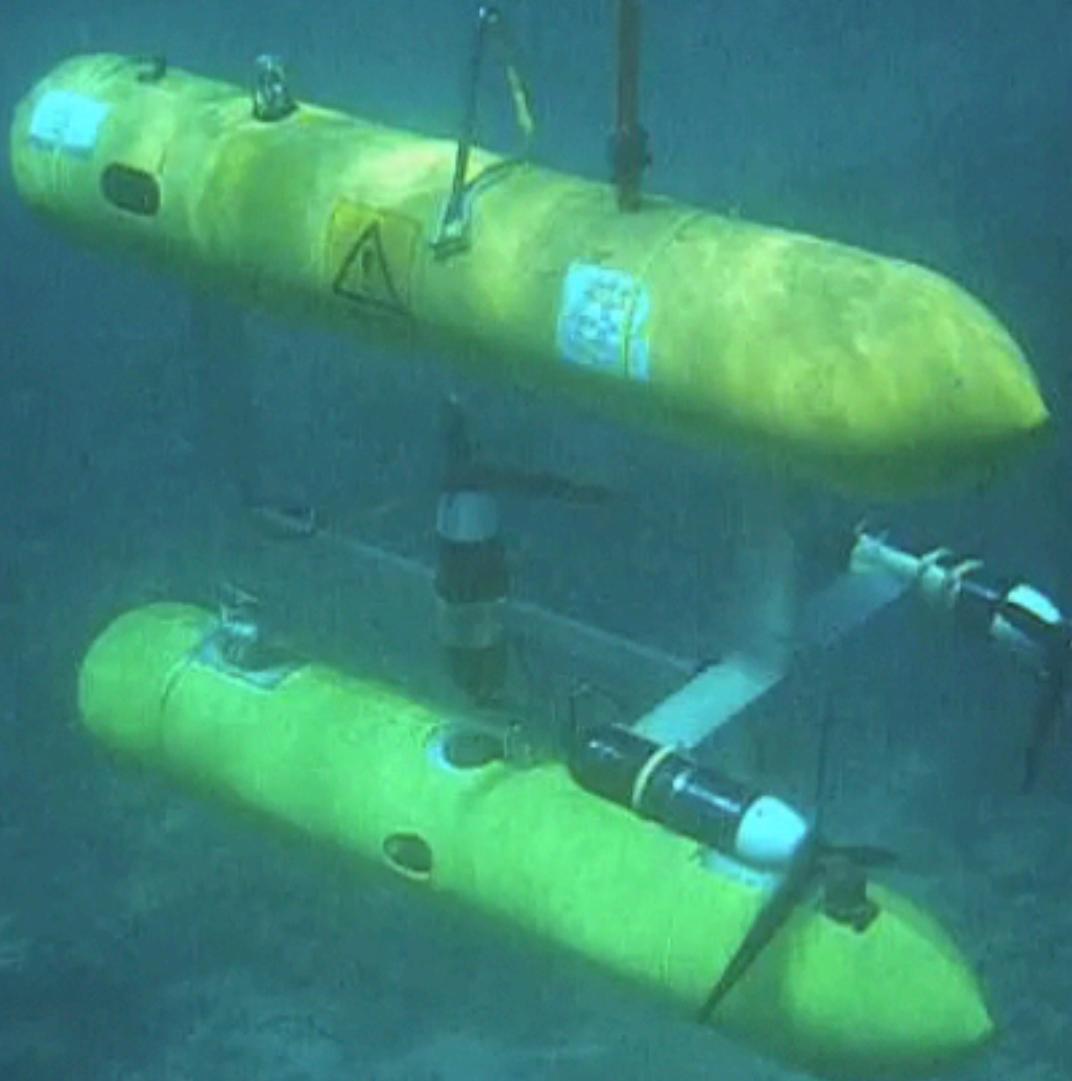
"There was a table set out under a tree in front of the house, and the March Hare and the Hatter were having tea at it."

"The table was a large one, but the three were all crowded together at one corner of it ..."

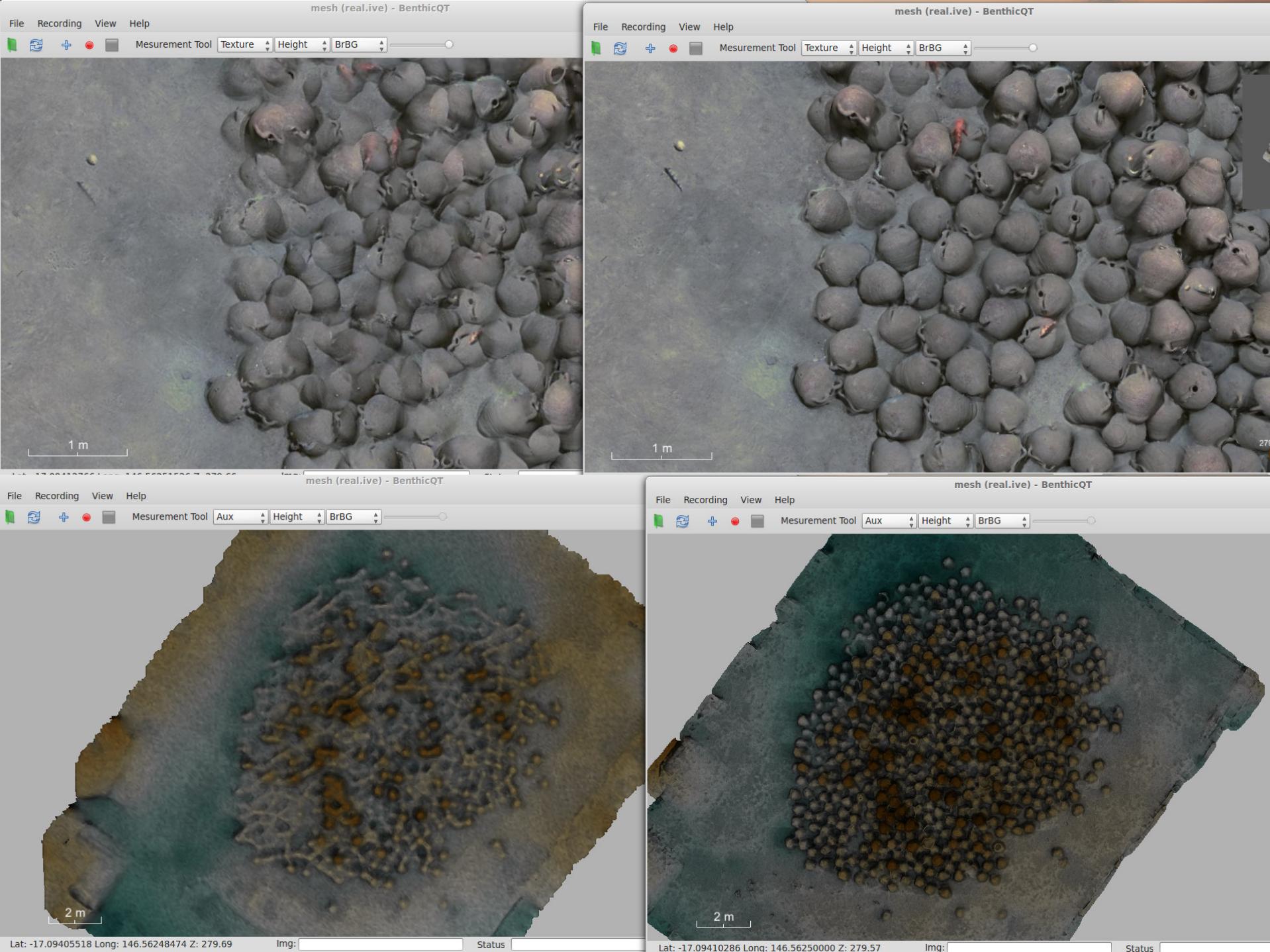
**From "A Mad Tea-Party"
Alice's Adventures in Wonderland
by
Lewis Carroll**

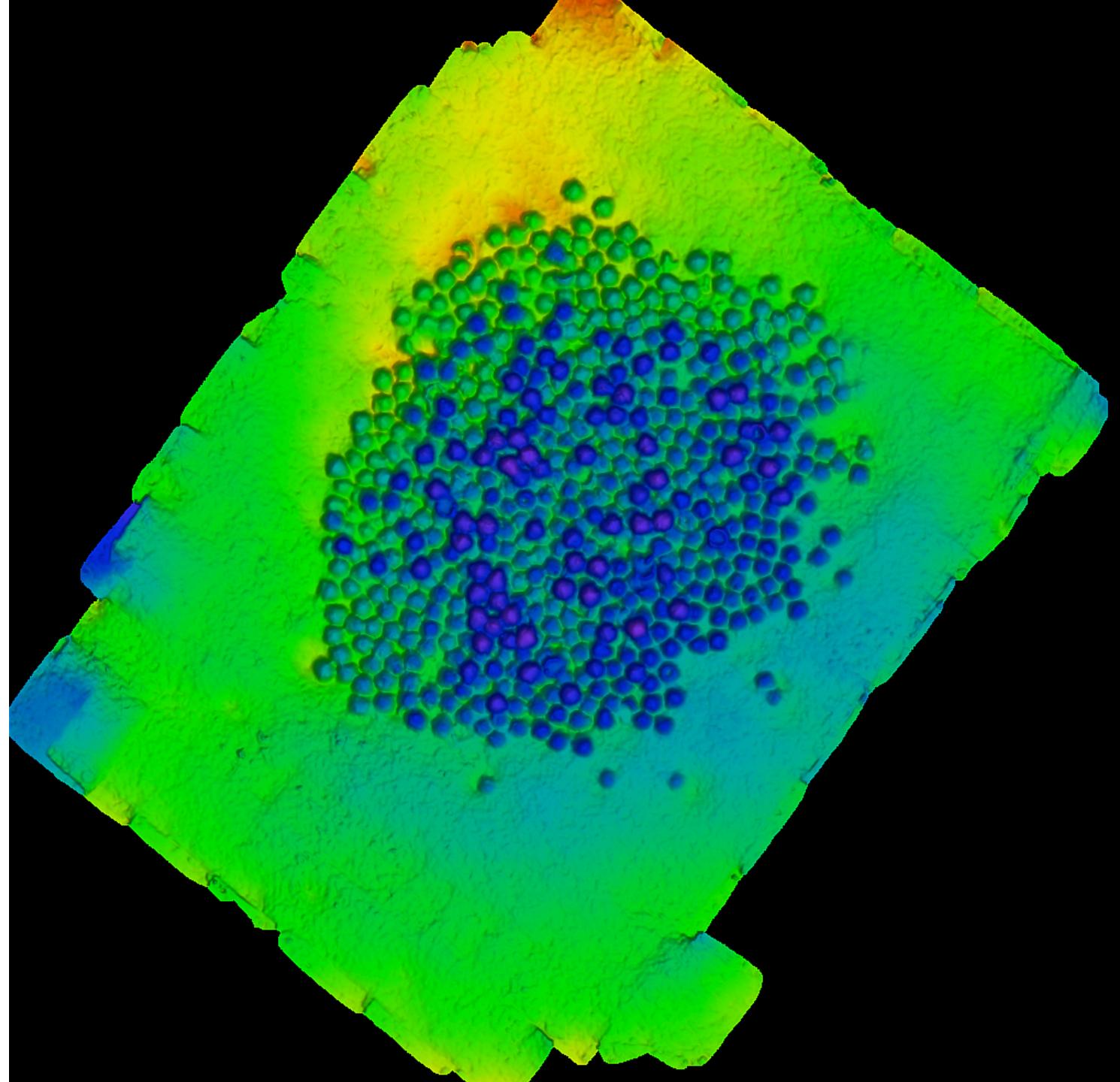
Syllabus

See ctools webpage



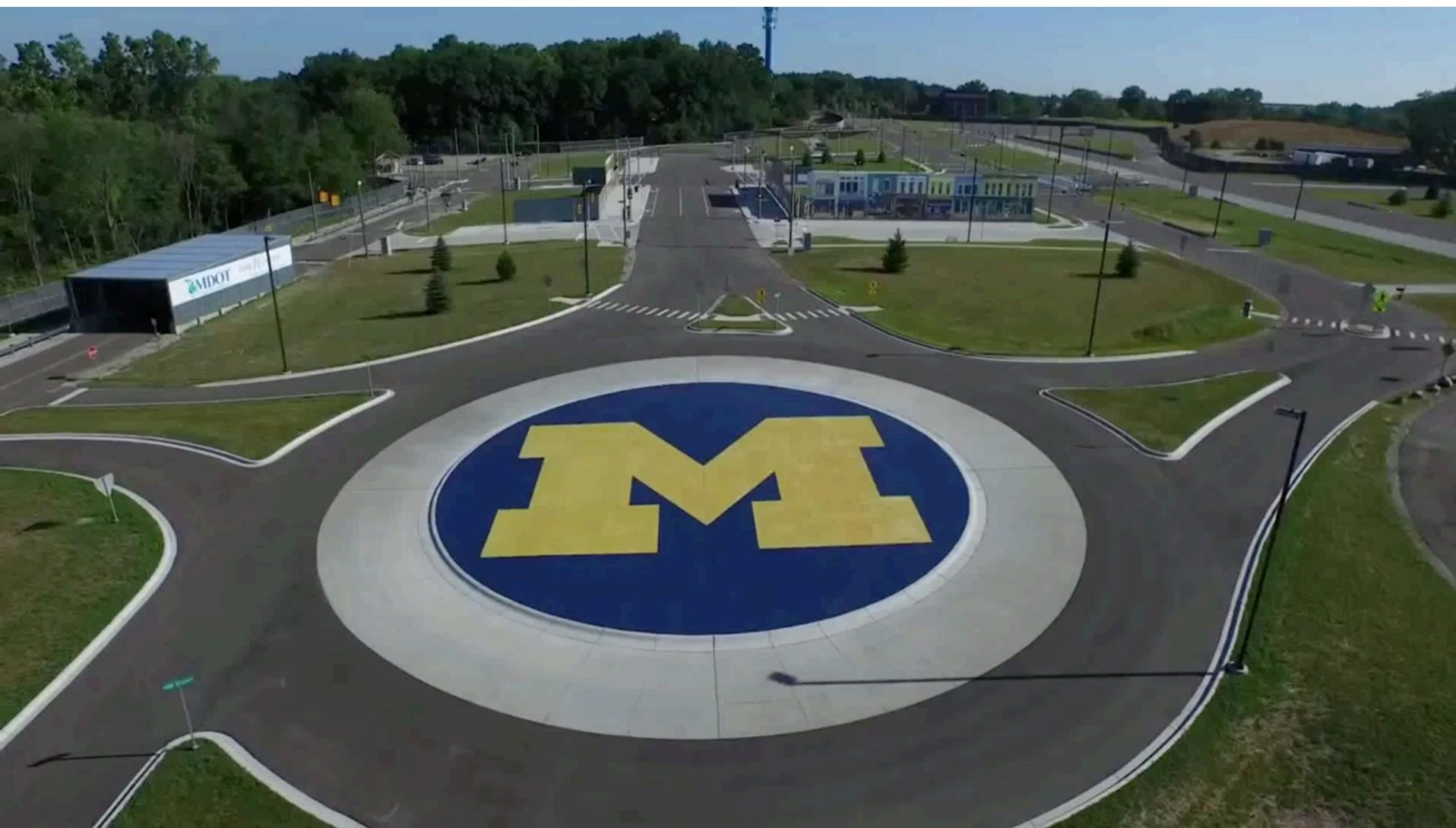














Next lecture

- Review of linear algebra for multi-view geometry
- Basic image transformations