**Introduction**

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**Why is vision hard?**

- A typical image includes many objects organized in many different configurations.
- Vision requires solving ill-posed problems.
- Images are both complicated and highly ambiguous.
- Same object can generate very different images.
- Different objects can generate similar images.

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**The purpose of Vision**

- What does it mean, to see? The plain man's answer (and Aristotle's too) would be, to know what is where by looking. In other words, vision is the process of discovering from images what is present in the world, and where it is. [Marr, 1982]

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**Challenges: Illumination**

Figure: J. Koenderink

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Figure: Steven Pinker, How the Mind Works, 1997
Challenges: viewpoint variation

Michelangelo 1475-1564

Slide credit: L. Fei-Fei, R. Fergus and A. Torralba

Challenges: Scale

Michelangelo 1475-1564

Slide credit: L. Fei-Fei, R. Fergus and A. Torralba

Challenges: Deformations

Xu, Beihong 1943

Slide credit: L. Fei-Fei, R. Fergus and A. Torralba

Challenges: Occlusion

The Blank Check, by René Magritte

Slide credit: L. Fei-Fei, R. Fergus and A. Torralba
Challenges: background clutter

Challenges: Motion

Challenges: Some things have strong variations in appearance

Challenges: local ambiguity
Why does vision appear easy to humans?

- Our brains are specialized to do vision.
- ~50% of the cortex in a human brain is devoted for visual processing (cf. motor control ~20-30%, language ~10-20%)

Visual Pathways

Challenges or opportunities?

- Images are confusing, but they also reveal the structure of the world through numerous cues
- Our job is to interpret the cues!

Measuring light vs. measuring scene properties

We perceive two squares, one on top of each other.
Depth processing is automatic, and we can not shut it down...

(c) 2006 Walt Anthony
Measuring light vs. measuring scene properties

Figure: Richard L. Gregory, Phil. Trans. R. Soc. B, 2005

Illusory contours

• Continuity of discontinuities

Figures: Steven Pinker, How the Mind Works, 1999

Assumptions can be wrong!

Ames room

Some things know that you have eyes


Slide credit: B. Freeman and A. Torralba
Computer Vision

What we see

What a computer sees

Related Disciplines

Origins of computer vision

Vision as an information processing task, David Marr

“Vision is a process that produces from images of the external world a description that is useful to the viewer and not cluttered with irrelevant information”

- 3 levels of understanding:
  1. Computational theory
     - What is computed? Why it is computed?
  2. Representation and Algorithm
     - How it is computed?
     - Input, Output, Transformation
  3. Physical Realization
     - Hardware

Marr’s observation: Studying vision at 3 levels

Reading Assignment

- David Marr. Vision. Chapter 1
  - Prepare a short (about ~2, 3 pages) summary.
  - Be careful to use your own words!
  - Due next week (Feb 26). Print out and bring to the class.

- Some other additional readings are also available on the course webpage!
Course Information

• Instructor: Aykut ERDEM
  aykut@cs.hacettepe.edu.tr
  Office: 111
  Tel: 297 7500, 146
• Lectures: Wednesdays 13:00-15:45_D7
• Office Hour: By appointment
• Prerequisites: Good math background (Calculus, Linear Algebra, Statistical Methods) and programming skills (MATLAB, C/C++)
• Course Website: http://web.cs.hacettepe.edu.tr/~aykut/classes/spring2014/bil719/

Communication

• We will be using Piazza for course related discussions and announcements.
• Please enroll it by following the link https://piazza.com/hacettepe.edu.tr/spring2014/bil719

Reference Books


Supplemental Reading Material

• Lecture notes and handouts
• Papers and journal articles
Related Conferences

• IEEE International Conference on Computer Vision (ICCV)
• European Conference on Computer Vision (ECCV)
• IEEE Conference on Computer Vision and Pattern Recognition (CVPR)
• British Machine Vision Conference (BMVC)
• Asian Conference of Computer Vision (ACCV)
• IEEE International Conference on Pattern Recognition (ICPR)
• Advances in Neural Information Processing Systems (NIPS)

Related Journals

• International Journal of Computer Vision (IJCV)
• IEEE Transactions on Pattern Analysis and Machine Intelligence (IEEE TPAMI)
• Computer Vision and Image Understanding (CVIU)
• Pattern Recognition (PR) Journal of
• Mathematical Imaging and Vision (JMIV)
• Image and Vision Computing (IMAVIS)

Grading Policy

• 20% Programming Assignments
• 20% Quizzes
• 20% Paper Presentations/Class participation
• 40% Project and final term paper

Programming Assignments

• A total of 4 programming assignments
• Related to the topics covered in the class.
• Each one will involve
  – implementing an algorithm (usually in Matlab),
  – carrying out a set of experiments, and
  – writing up a report

• All assignments have to be done individually, unless stated otherwise.
Paper presentations and Quizzes

- The students will be required to present at least one research paper either of their choice or from the suggested reading list.
- These papers should be read by every student as the quizzes about the presented papers will be given on the weeks of the presentations.

Project

- The students taking the course will be required to do a project in computer vision, which should be done individually.
- This project may be
  - An original implementation of a new or published study
  - A detailed empirical evaluation of two or more related methods not covered in the class

- March 12: Project proposals
- April 23: Project progress reports
- June 04: Project final reports

Course Overview

- (1 week) Introduction, image formation
- (2 weeks) Filtering and texture
- (3 weeks) Grouping and fitting
- (3 weeks) Multiple geometry and stereo
- (3 weeks) Recognition
- (1 week) Motion

Image formation

- Color
- Pinhole cameras
- Lenses

Filtering and texture

Grouping and fitting

Multiple geometry and stereo

Recognition

45
Slide credit: K. Grauman

46
Slide credit: S. Narasimhan

47
Slide credit: S. Narasimhan

48
Slide credit: S. Narasimhan, D. Lowe, L. Fei-Fei