Computer Vision

Spring 2006 15-385,-685

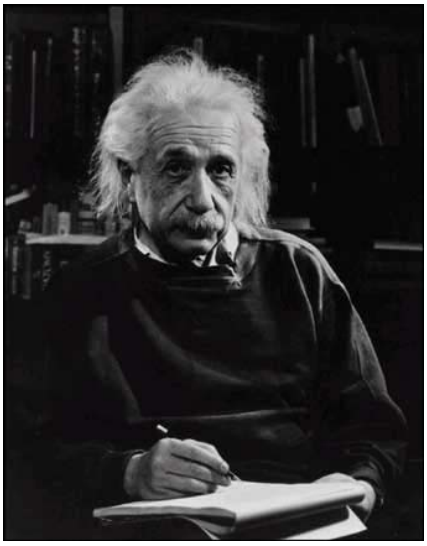
Instructor: S. Narasimhan

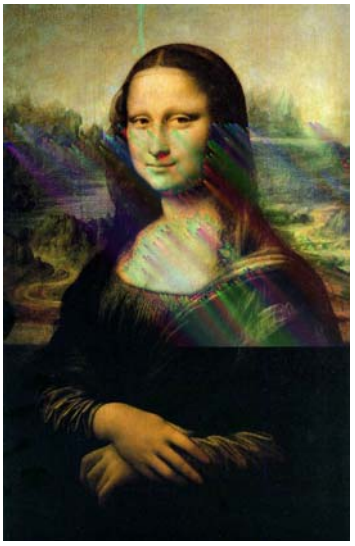
Wean 5403
T-R 3:00pm – 4:20pm

A Picture is Worth 1000 Words

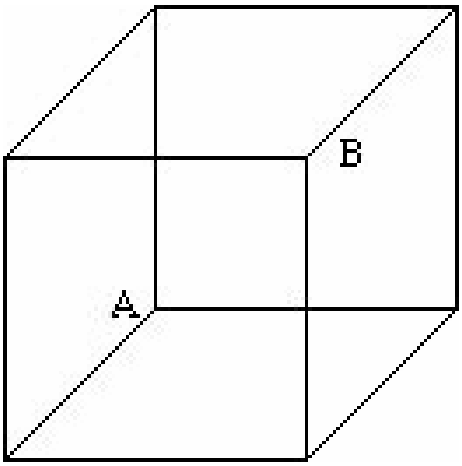
A Picture is Worth 100,000 Words

A Picture is Worth a Million Words



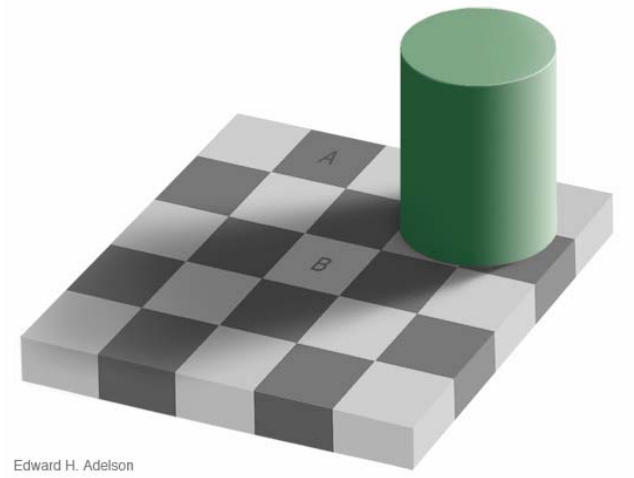


A Picture is Worth a ...?



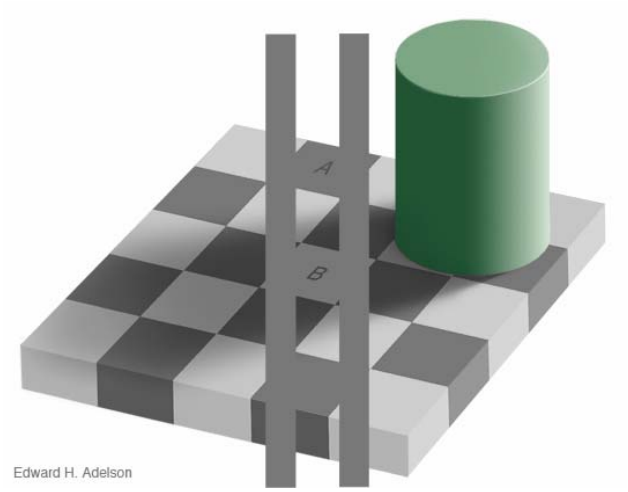
Necker's Cube Reversal

A Picture is Worth a ...?



Checker Shadow Illusion – [E. H. Adelson]

A Picture is Worth a ...?

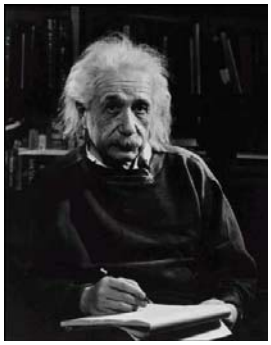


Checker Shadow Illusion – [E. H. Adelson]

Human Vision

- Can do amazing things like:
  - Recognize people and objects
  - Navigate through obstacles
  - Understand mood in the scene
  - Imagine stories
- But still is not perfect:
  - Suffers from Illusions
  - Ignores many details
  - Ambiguous description of the world
  - Doesn't care about accuracy of world

Computer Vision

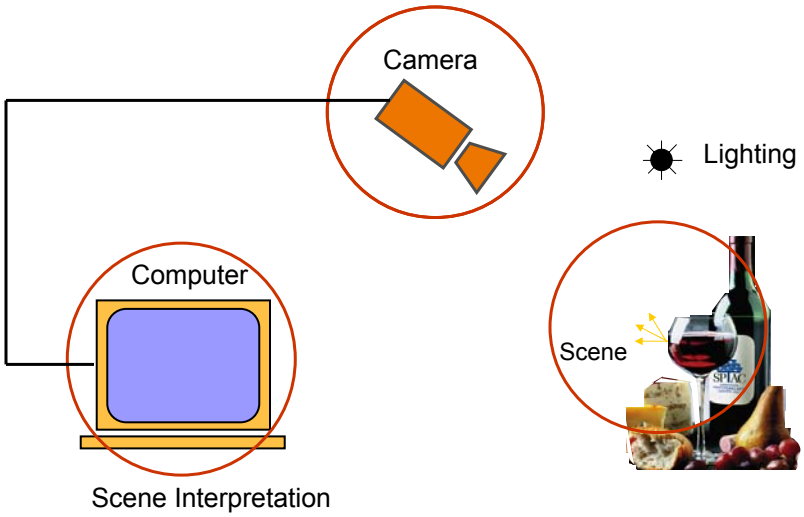


What we see

0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What a computer sees

Components of a Computer Vision System



What is Computer Vision?

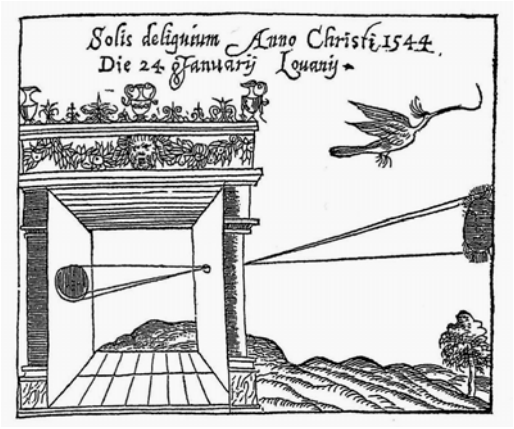
- Inverse Optics
- Intelligent interpretation of Imagery
- Building a Visual Cortex

- No matter what your definition is…
  - Vision is hard.
  - But is fun...

Topics covered

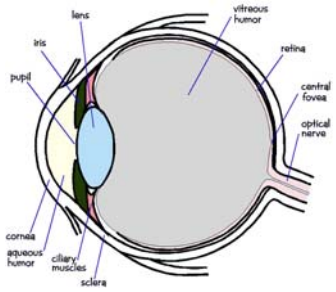
Cameras and their Optics

Today's Digital Cameras

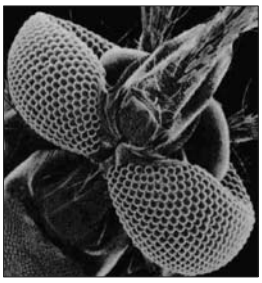


The *Camera Obscura*

Biological Cameras

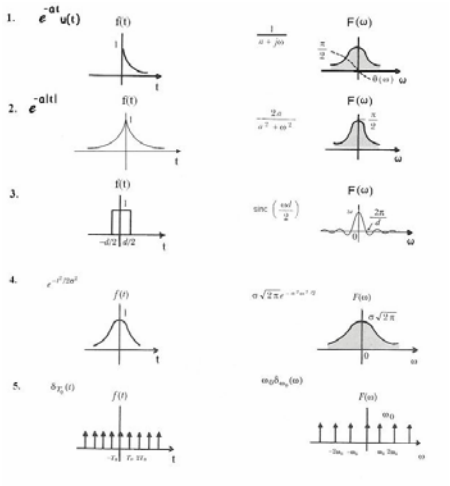


Human Eye



Mosquito Eye

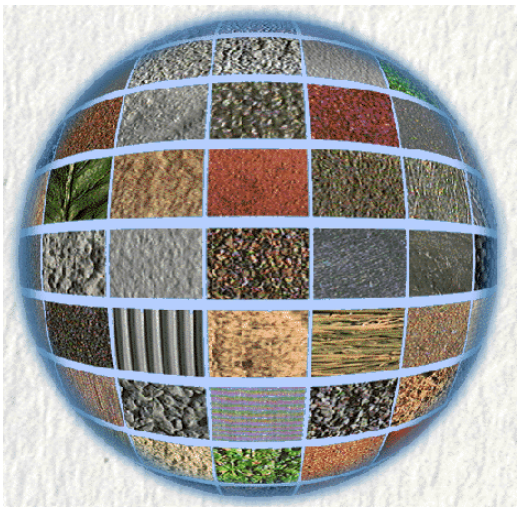
Image Processing



Fourier Transform
Sampling, Convolution

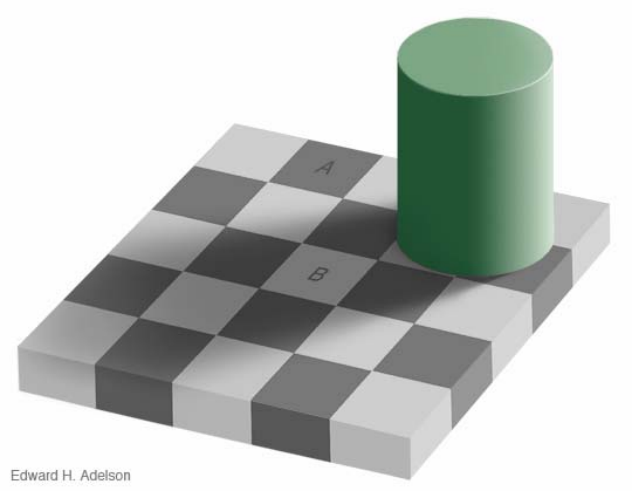
Image enhancement
Feature detection

Surface Reflectance



[CURET]

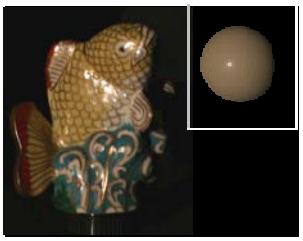
Lightness and Perception



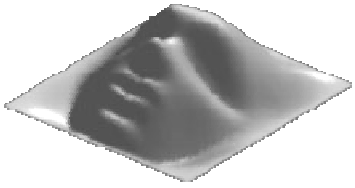
Checker Shadow Illusion – [E. H. Adelson]

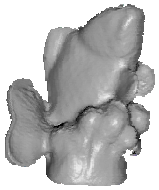
3D from Shading

Shape from Shading

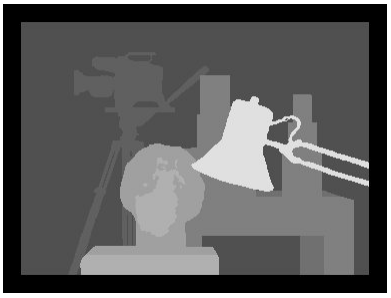


Photometric Stereo

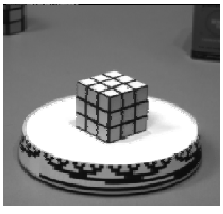


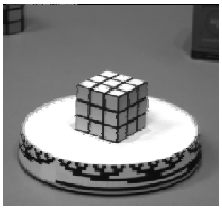


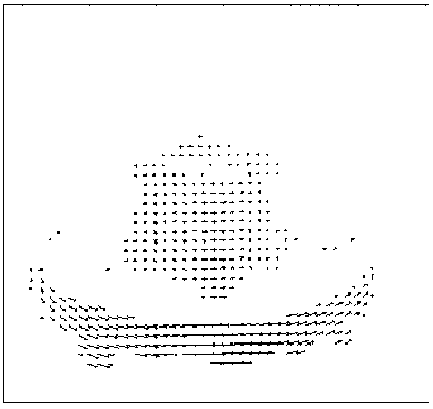
Binocular Stereo



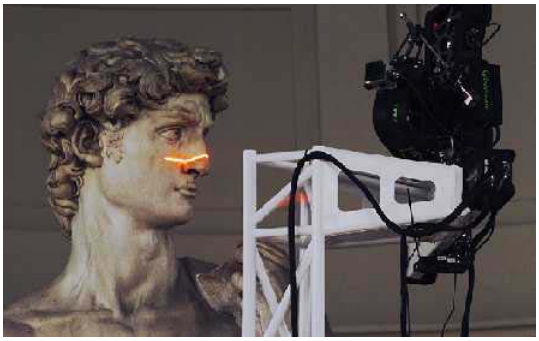
Optical Flow



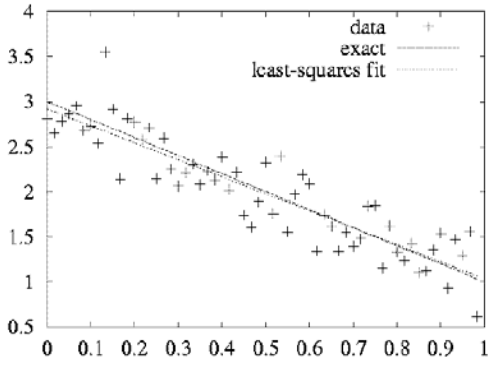




Range Scanning and Structured Light



Statistical Techniques



Least Squares Fitting

Statistical Techniques

- Principle Components Analysis (PCA)
- Face Recognition

Some Recent Trends in Vision

Novel Cameras and Displays

*** Topics change every year

Advanced Related Courses at CMU

- Graduate Level Computer Vision (Hebert, Fall)
- Advanced Perception (Efros, Spring)
- Appearance Modeling (Narasimhan, Fall)
- Advanced Mobile Robotics (Whittaker, Spring/Summer)
- Many other special topics courses offered irregularly.

Course Logistics

Text, Readings

- Class Notes (required)
- Text, Robot Vision, B.K.P.Horn, MIT Press (recommended)
- Supplementary Material (papers, tutorials)

Course Schedule

1/17/2006:	Introduction and Course Fundamentals	
PART 1 : Cameras and Imaging		
1/19/2006:	Image Formation and Projection	
1/24/2006:	Matlab Review	
1/26/2006:	Image Sensing	[Homework 1 OUT]
PART 2 : Signal and Image Processing		
1/31/2006:	Binary Image Processing	
2/2/2006:	1D Signal Processing	[Homework 1 DUE; Homework 2 OUT]
2/7/2006:	2D Image Processing	
2/9/2006:	Edge Detection	
2/14/2006:	Image Pyramids	
2/16/2006:	Hough Transform	[Homework 2 DUE; Homework 3 OUT]
PART 3: Physics of the World		
2/21/2006:	Basic Principles of Radiometry	
2/23/2006:	Retinex Theory	
2/28/2006:	Surface Reflectance and BRDF	
3/2/2006:	Photometric Stereo	[Homework 3 DUE]
3/7/2006:	**Midterm Review**	
3/9/2006:	**Midterm Exam**	
3/13/2006:	**Midterm Grades Due**	
3/21/2006:	Shape from Shading	[Homework 4 OUT]

Course Schedule

PART 4 : 3D Geometry

3/23/2006:	Binocular Stereo 1	
3/28/2006:	Binocular Stereo 2	
3/30/2006:	Motion and Optical Flow	
4/4/2006:	Line Drawing	[Homework 4 DUE; Homework 5 OUT]
4/6/2006:	Structured Light	

PART 5 : Statistical Techniques

4/11/2006:	Linear Least Squares	
4/13/2006:	Principle Components Analysis	
4/18/2006:	Applications of PCA	[Homework 5 DUE; Homework 6 OUT]

PART 6: Current Trends and Challenges in Vision Research

4/27/2006:	Novel Cameras and Displays	
5/2/2006:	Open challenges in vision research	
5/4/2006:	Review Class	[Homework 6 DUE]
5/9/2006:	**Final Exam**	
5/18/2006:	**Final Grades Due**	

*** Use as a guide…changes possible

Prerequisites

- Basic Linear Algebra, Probability, Calculus Required
- Basic Data structures/Programming knowledge
- No Prior knowledge of Computer Vision Required

Grading

- FIVE Assignments – 60 %
- ONE Midterm – 15 %
- ONE Final – 25 %
- ONE Extra Assignment for Graduate Students
  - Most assignments include analytic and programming parts.
  - All assignments must be done individually.
  - Programming Environment – Matlab.
  - Assignments due BEFORE class submitted using Blackboard.
  - Late Assignments – **ZERO** Credit.

Office Hours

Narasimhan: NSH 4117, Tuesdays 4:30pm – 5:30pm
Email: srinivas@cs.cmu.edu

Yan Ke: Location??, Mondays 1:00pm – 2:00pm
Email: yke@cmu.edu

Nik Melchior: NSH 1612E, Wednesdays 1:00pm – 2:00pm
Email: melchior@cmu.edu

- Technical Questions: Post on bboard, we will answer.
- 5% Extra Credit for students answering bboard questions regularly.

Next Class

- Image Formation
- Horn, Chapter 2