PITT | SWANSON ENGINEERING
ELECTRICAL & COMPUTER

ECE 1390/2390
Image Processing and Computer Vision – Fall 2021

Introduction

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Personnel

- Instructor: Ahmed Dallal
- 1203 BEH, ahd12@pitt.edu
- Office hours (via zoom):
  - Tue, 9:30 pm – 10:30 pm
  - Wed, 6:00 pm – 7:00 pm

- TA: Shuda Zhong, shz116@pitt.edu
- Office hours: Thur, 3:30 – 5:00 pm

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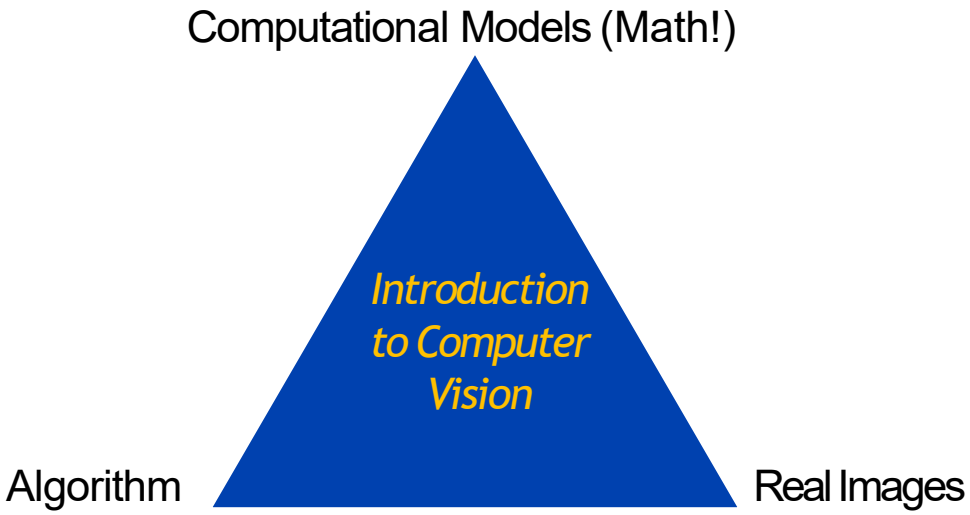
- Office hours: Fri, 12:00 – 1:30 pm

Outline

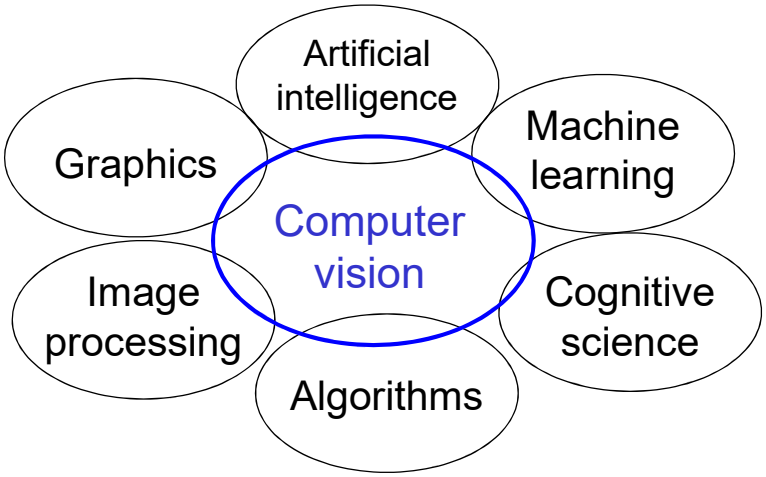
- Course overview
- What is computer vision?
- State of the art
- Why is this hard?

Course overview

A little bit of pedagogy…



Related disciplines



Kristen Grauman

Topicoutline

1. **INTRODUCTION**
2. **IMAGE PROCESSING FOR COMPUTER VISION**
3. **CAMERA MODELS AND VIEWS**
4. **FEATURES AND MATCHING**
5. **LIGHTNESS AND BRIGHTNESS**
6. **IMAGE MOTION**
7. **CLASSIFICATION AND RECOGNITION**
8. **Segmentation**
9. **MISCELLANEOUS OPERATIONS**

Problem sets and quizzes

- 6 – 8 problem sets; to be done individually
- Short quizzes will be administered at the beginning of some of the classes to assess your learning
  - Please refer to the syllabus for a complete schedule

With whom will you do homework?

- Honesty/Integrity policy (from web site):

  Problem sets are to be done individually but you may collaborate at the "white board level" helping each other with algorithms and general computation, BUT YOUR CODE MUST BE YOUR OWN.

- Do not hand in other people's code unless you (1) say you are, and (2) you want no credit for that section. We will be explicit about what previous or provided code you can use.

Software

- Matlab/Octave: Primary platform for exercises, problem sets
- Python + NumPy + OpenCV: You can submit your problem set solutions in Python, but there will be limited support

Course evaluation

- Homework 65%
- Quizzes 15%
- Final Exam 15%
- Class participation 5%

Course Goals

- To learn the basics of low-level image analysis
- To learn the modern approaches to classic high-level computer vision tasks
- To get experience with some computer vision techniques
- To get exposure to emerging topics and recent research
- To think critically about vision approaches, and to see connections between works and potential for improvement

Learning goals

What do you expect to learn from this course?

- Note down somewhere and track your progress.
- In the end, you may not have learnt everything you expected.
- At the same time, you may have learnt some things you did not know about at all ☺

Types of computer vision

- Lower-level vision
  - Analyzing textures, edges and gradients in images, without concern for the semantics (e.g. objects) of the image
- Higher-level vision
  - Making predictions about the semantics or higher-level functions of content in images (e.g. objects, attributes, styles, motion, etc.)
  - Involves machine learning

Every picture tells a story

- Goal of computer vision is to write computer programs that can interpret images

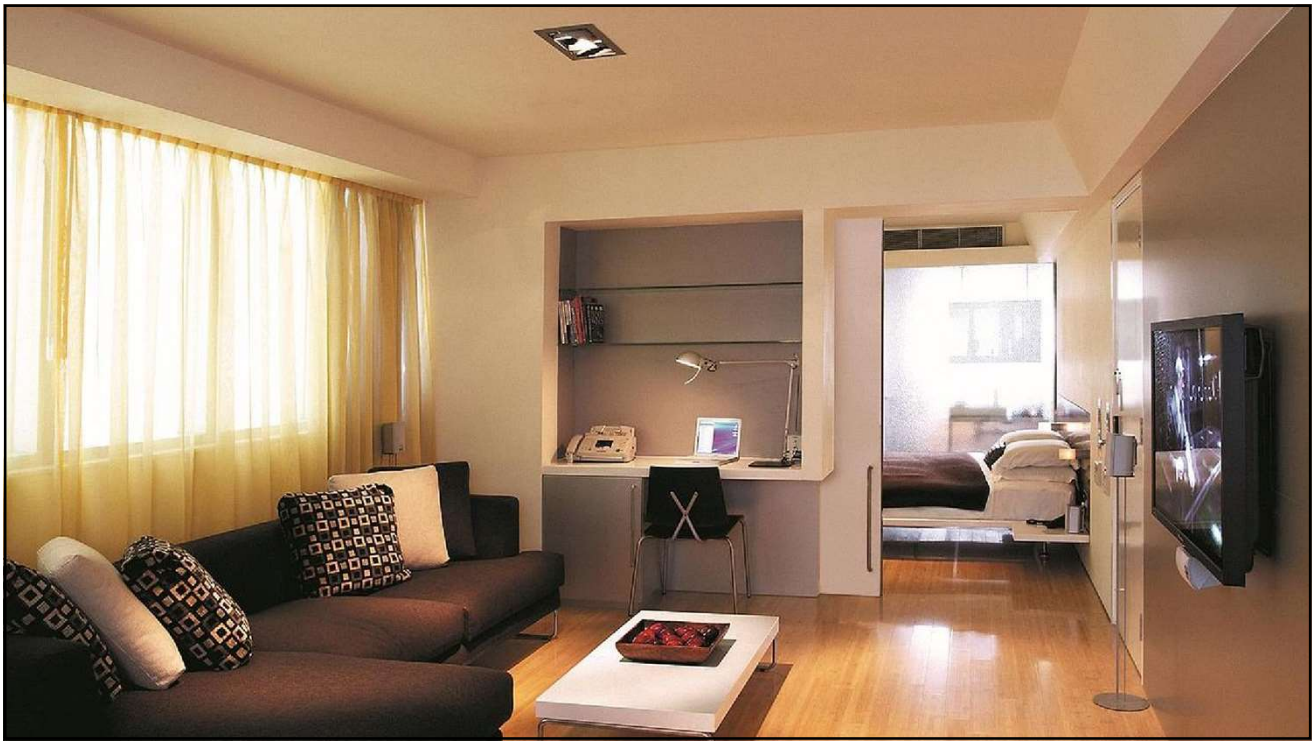
Steve Seitz

Making sense of a picture

- We want to extract meaning out of an image/sequence of images
- This is different from image processing, which is mainly concerned with transforming images
- Image processing operations such as blurring, thresholding etc. are often used as part of CV algorithms

Making sense of a picture

- Look at this scene carefully…



Making sense of a picture

- What items could you identify? How did you recognize them?
- What about other objects/spaces/time of day etc.?

Why study Computer Vision?

- Images (and movies) have become ubiquitous in both production and consumption.
- Therefore application to manipulate images (movies) are becoming core.
- As are systems that *extract information* from imagery
  - Surveillance
  - Building 3D representations
  - Motion capture assisted
- But most of all…

It is a really deep and cool set of problems!

Current state of the art

- Can computers match (or beat) human vision?
  - Yes and no (but mostly no!)
- Humans are much better at "hard" things
- Computers can be better at "easy" things
  - Though getting really good at labeling using machine learning techniques. Only a little on that in this course.

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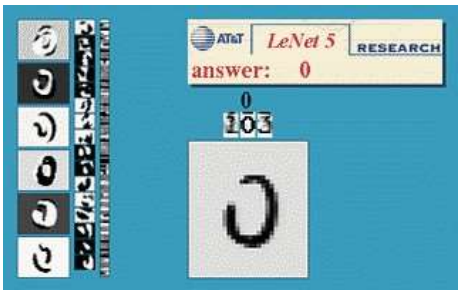
Current state of the art

- The next slides show some examples of what current vision systems can do

Optical character recognition (OCR)



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

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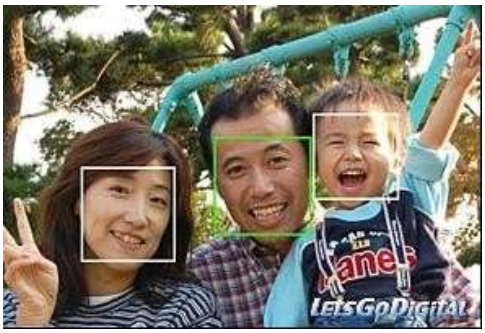
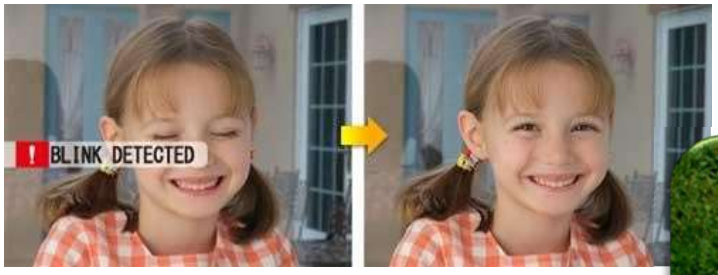
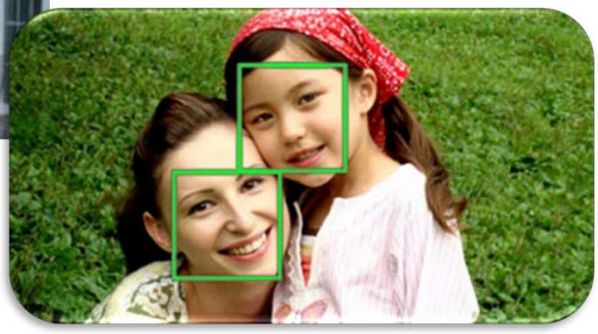
Face detection and more…



- Most digital cameras can detect faces…

Facedetection andmore…



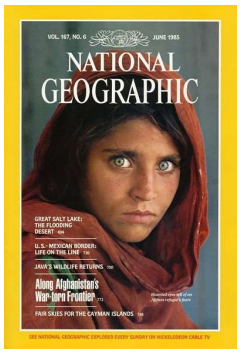


- Some can detect blinking or smiling…

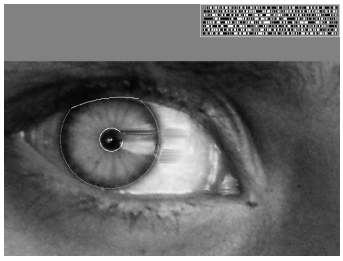
Facedetection andmore…

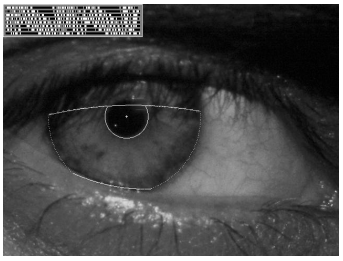
- And some can even recognize you!

Vision-based biometrics



"*How the Afghan Girl was Identified by Her Iris Patterns*" Read the story

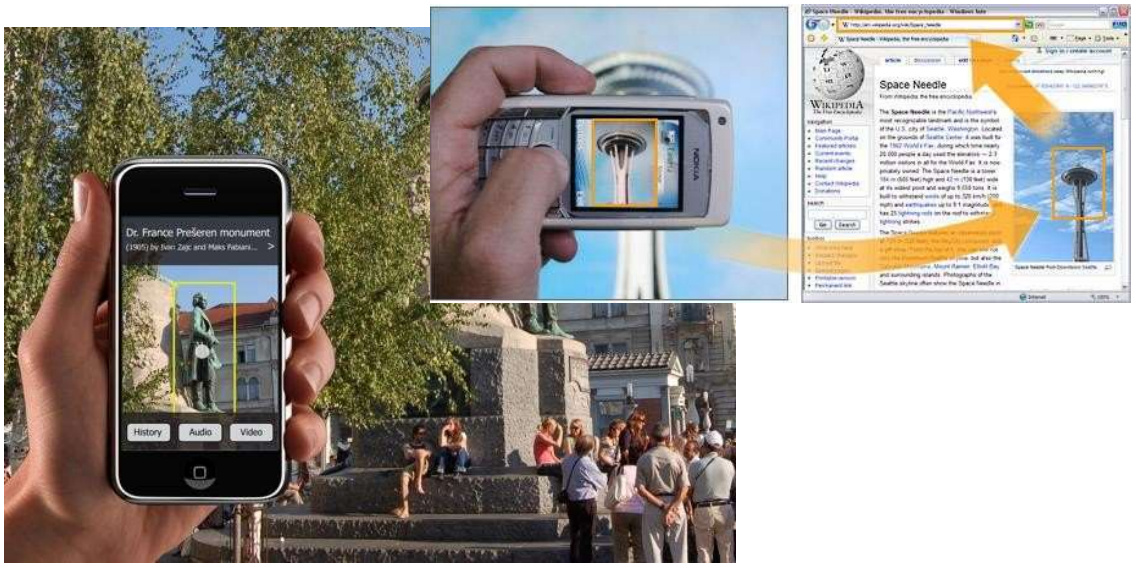




Object recognition (in supermarkets)

- Evolution Robotics Retail developed LaneHawk™, a retail loss-prevention solution that helps turn bottom-of-basket (BOB) losses and in-cart losses into profits in realtime.
- The company was acquired by Datalogic 5 years later!

Object recognition *(in mobile devices!)*



Object recognition *(in mobile devices!)*

Special effects: shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

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Special effects: motion capture

Pirates of the Caribbean
Industrial Light and Magic
www.ilm.com

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Earth viewers (3Dmodeling)

Image from Microsoft's Virtual Earth
(see also: Google Earth)

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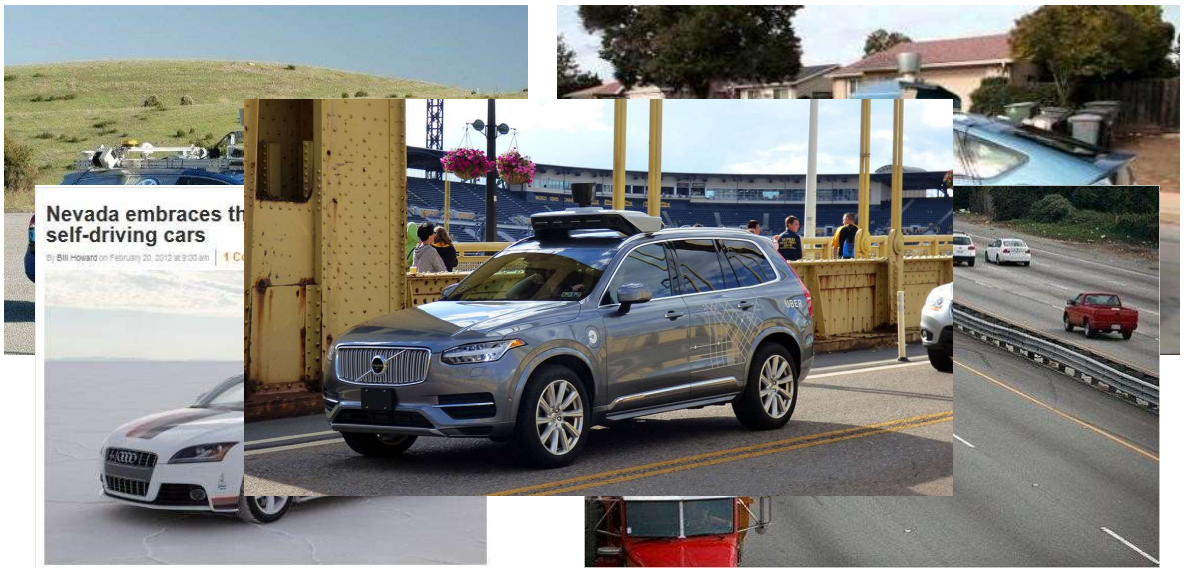
Smartcars

Mobileye

Slide content courtesy of Amnon Shashua

Smart cars *are here!*



Sports

Sportvision first down line
Nice explanation on www.howstuffworks.com

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Vision-based interaction (andgames)

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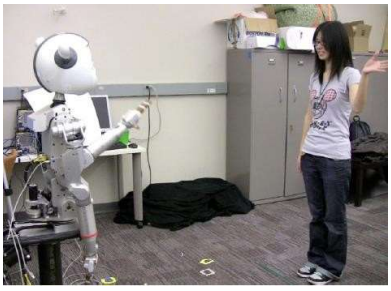
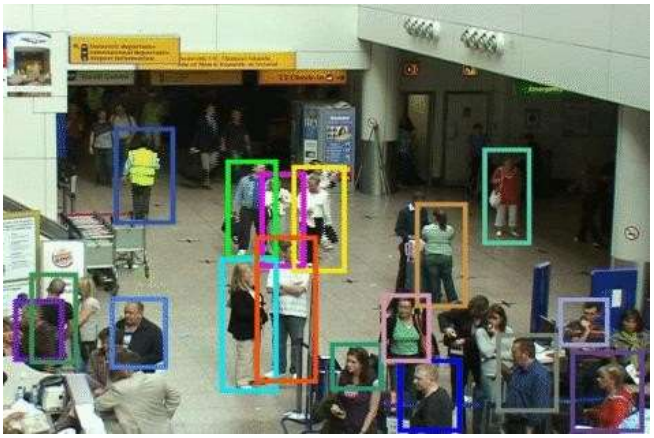
But thegame changer:

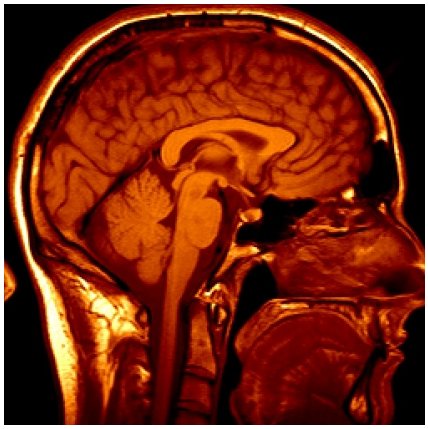
KINECT for Windows



Security and surveillance



Medical imaging



3D imaging
MRI, CT

Grimson et al., MIT

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Vision in space

NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

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.

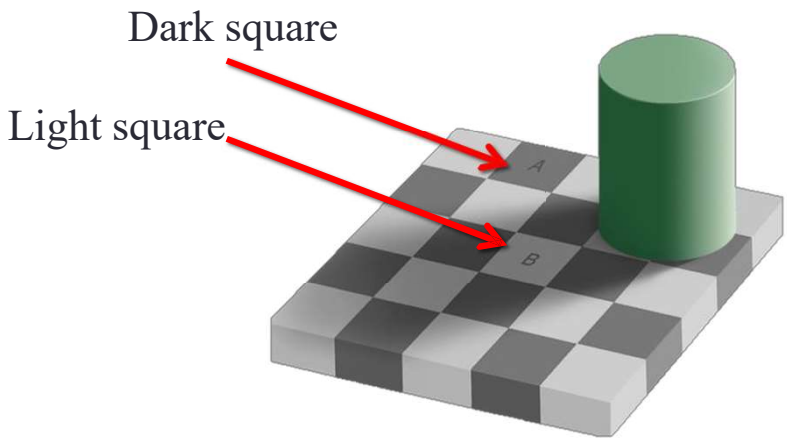
Steve Seitz

Current state of the art

- This is just a taste of the state of the art.
- Most of these applications are less than 10 yrs old
- This is a very active research area, and rapidly changing
- Many new apps in the next 5 years

Why is this hard?

Simple scene right?



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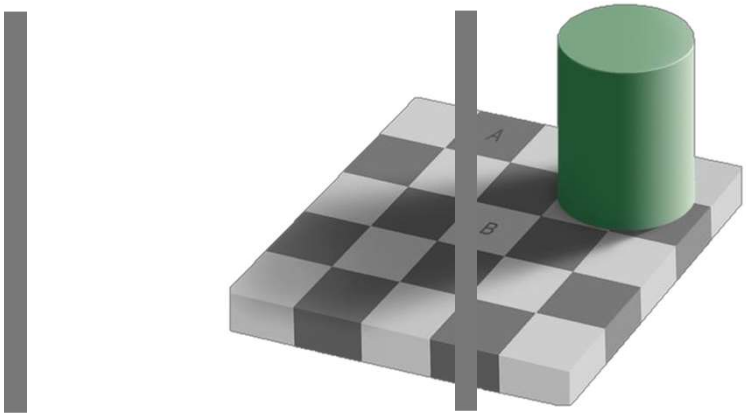
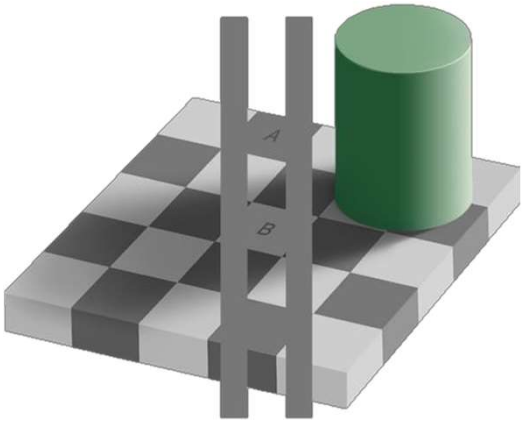
Really?



Edward Adelson

Really!



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Vision is NOT Image Processing

- In the previous example, the two squares have exactly the same *measurement* of intensity.
- So, seeing is not the same as measuring properties in the image.
- Rather, "seeing" is building a *percept* of what is in the world based upon the measurements made by an imaging sensor.

Building models from change (1)

http://vision.psych.umn.edu/users/kersten/kersten-lab/shadows.html

Building models from change (2)

http://vision.psych.umn.edu/users/kersten/kersten-lab/shadows.html

Interpreting images

- The previous example is one where the human system is again "wrong" – nothing is moving upwards. But feels like the best interpretation.
- Our goal is to develop your understanding of some of what it takes to go from image to interpretation.