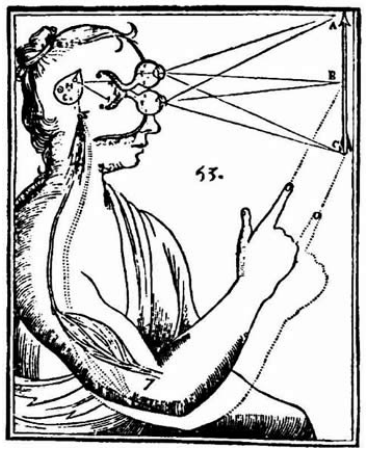
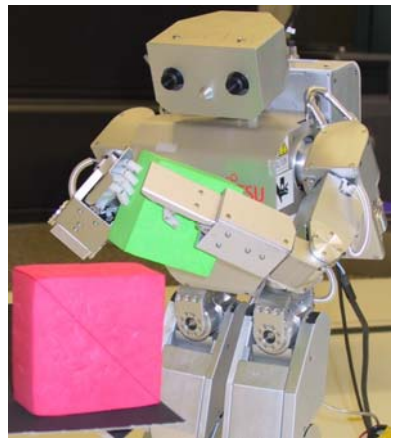


CSE 455
Computer Vision



Rajesh Rao (Instructor)
Jiun-Hung Chen (TA)

http://www.cs.washington.edu/455

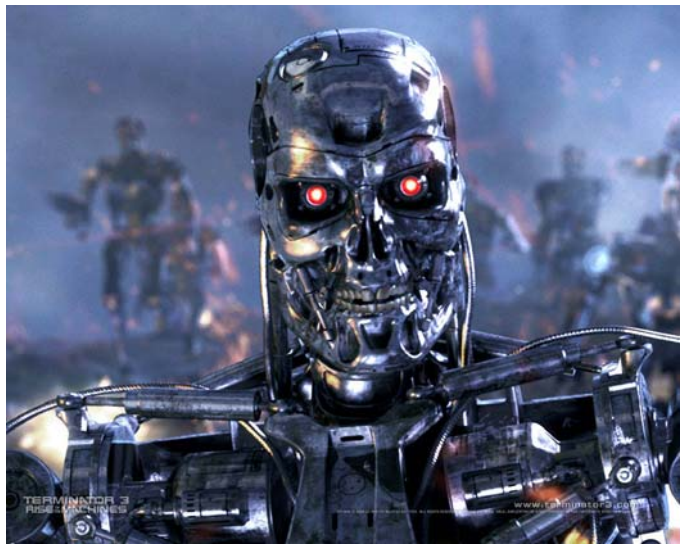
© UW CSE vision faculty

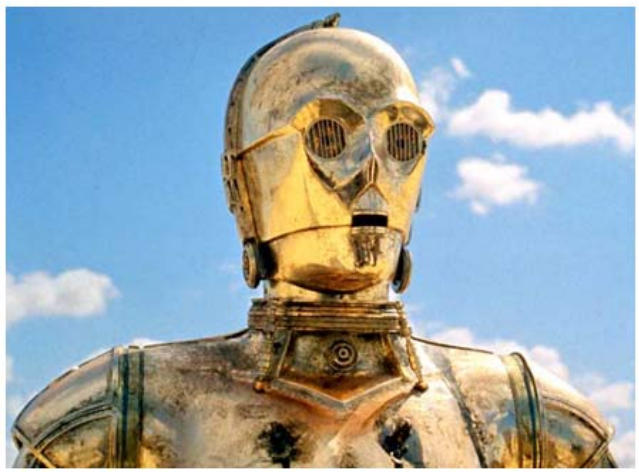
What’s on our plate today?

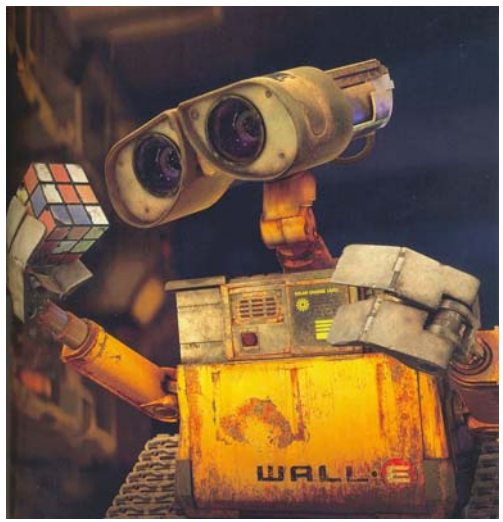
- What is computer vision?
- Examples of current state-of-the-art
- Goals of the course
- Logistics
- Intro to Images & Image Processing

What is computer vision?

Computer vision according to Hollywood







What is computer vision?

Making useful decisions about real physical objects and scenes based on images (Shapiro & Stockman, 2001)

Extracting descriptions of the world from pictures or sequences of pictures (Forsyth & Ponce, 2003)

Analyzing images and producing descriptions that can be used to interact with the environment (Horn, 1986)

Designing representations and algorithms for relating images to models of the world (Ballard & Brown, 1982)

A picture is worth a thousand words

Can a computer infer what happened from the image?

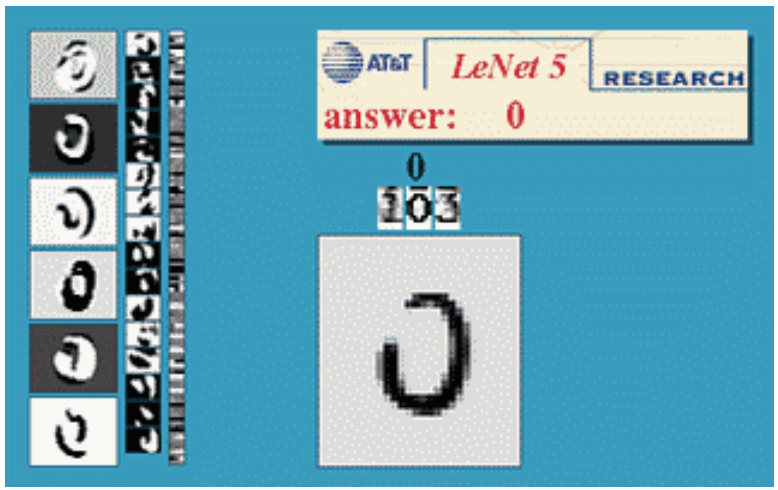
Computer Vision: Current State of the Art

The next few slides show examples of what current computer vision systems can do…

Optical character recognition (OCR)

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software



Digit recognition, AT&T labs
http://www.research.att.com/~yann/

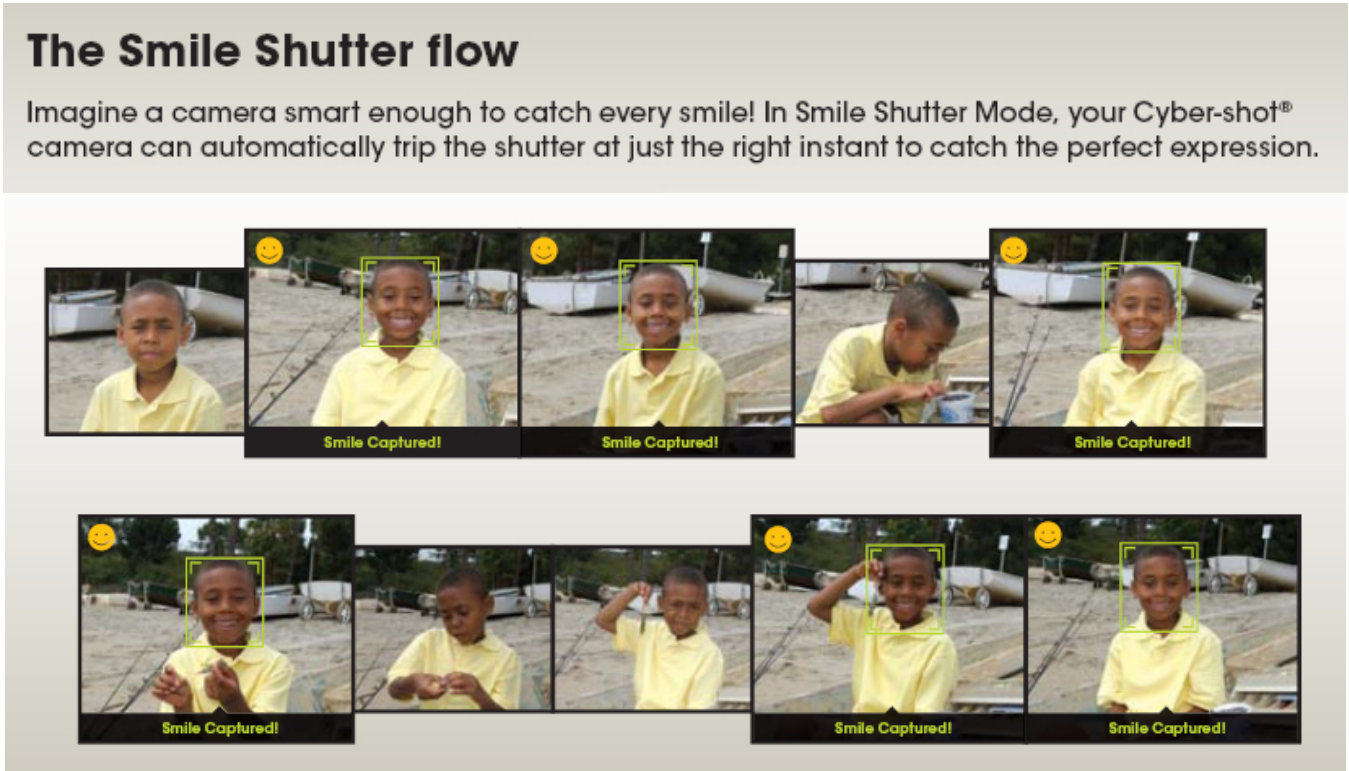
License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

Face Detection

Most new digital cameras now detect faces

(sometimes badly)

Smile Detection (automatically clicks when you smile!)



[Sony Cyber-shot® T70 Digital Still Camera]

Some unhappy customers

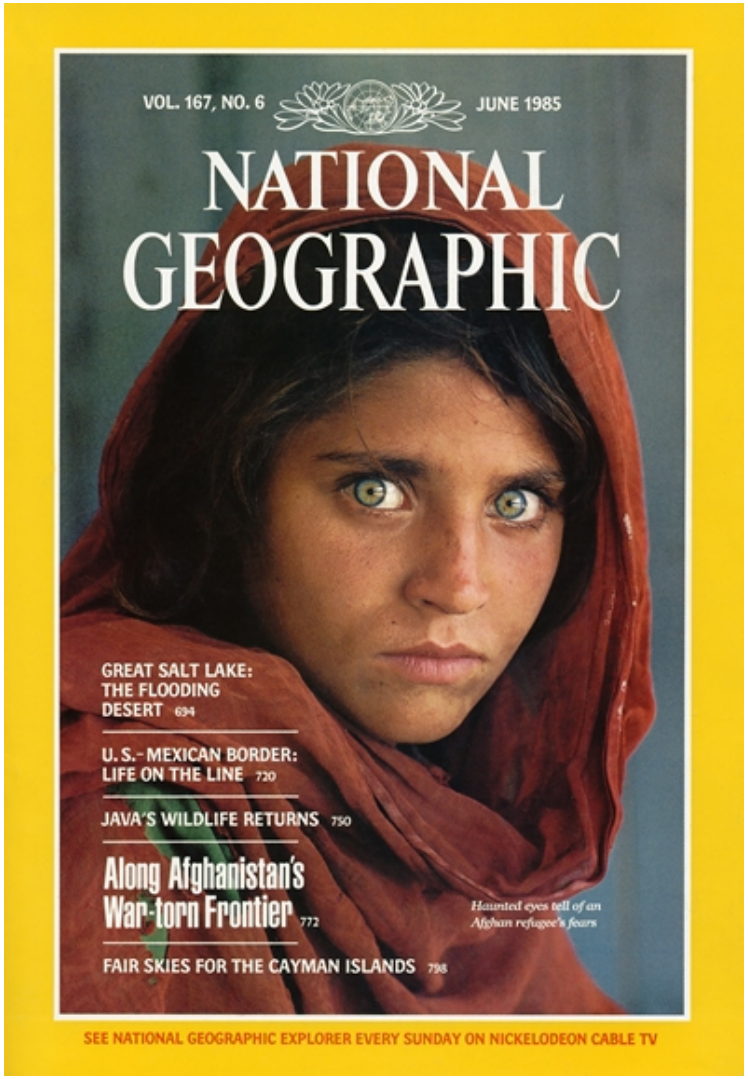
Object Recognition (in supermarkets)

Camera

LaneHawk by EvolutionRobotics

“A smart camera is flush-mounted in the checkout lane, continuously watching for items. When an item is detected and recognized, the cashier verifies the quantity of items that were found under the basket, and continues to close the transaction. The item can remain under the basket, and with LaneHawk, you are assured to get paid for it…”

Vision-Based Biometrics



Sharbat Gula at age 12 in an Afghan refugee camp in 1984

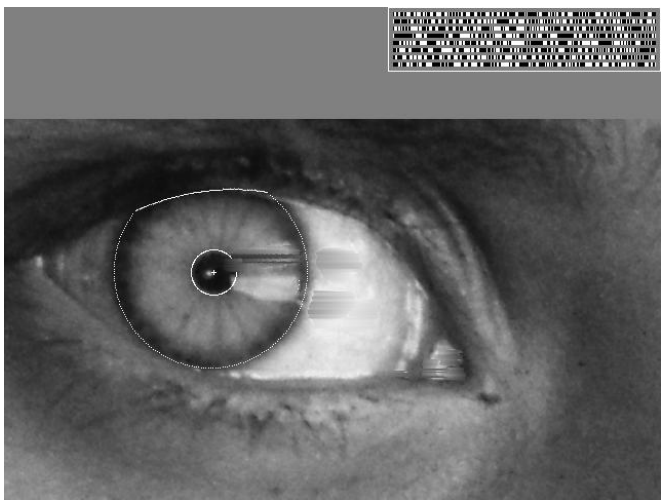
Traced in 2002 but is she the same person?

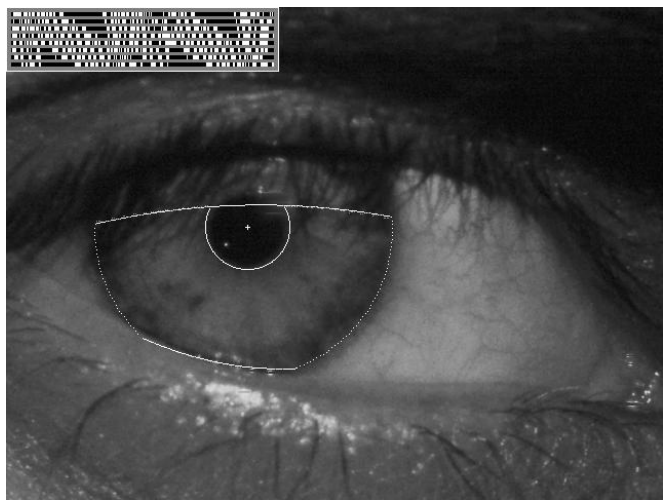
Identity verification through Iris code

1984

2002

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

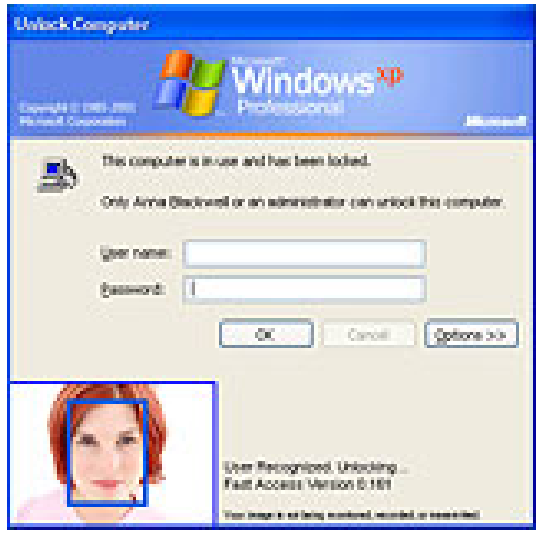




Login with your fingerprint or face

http://www.xmicro.com

Face identification systems now beginning to appear more widely
http://www.sensiblevision.com



Could be a problem if your face changes often

Object recognition (in mobile phones)

This is becoming real:

- Lincoln Microsoft Research: Mobile web search via pictures
- Nokia’s Point & Find

3D modeling: Earth viewers

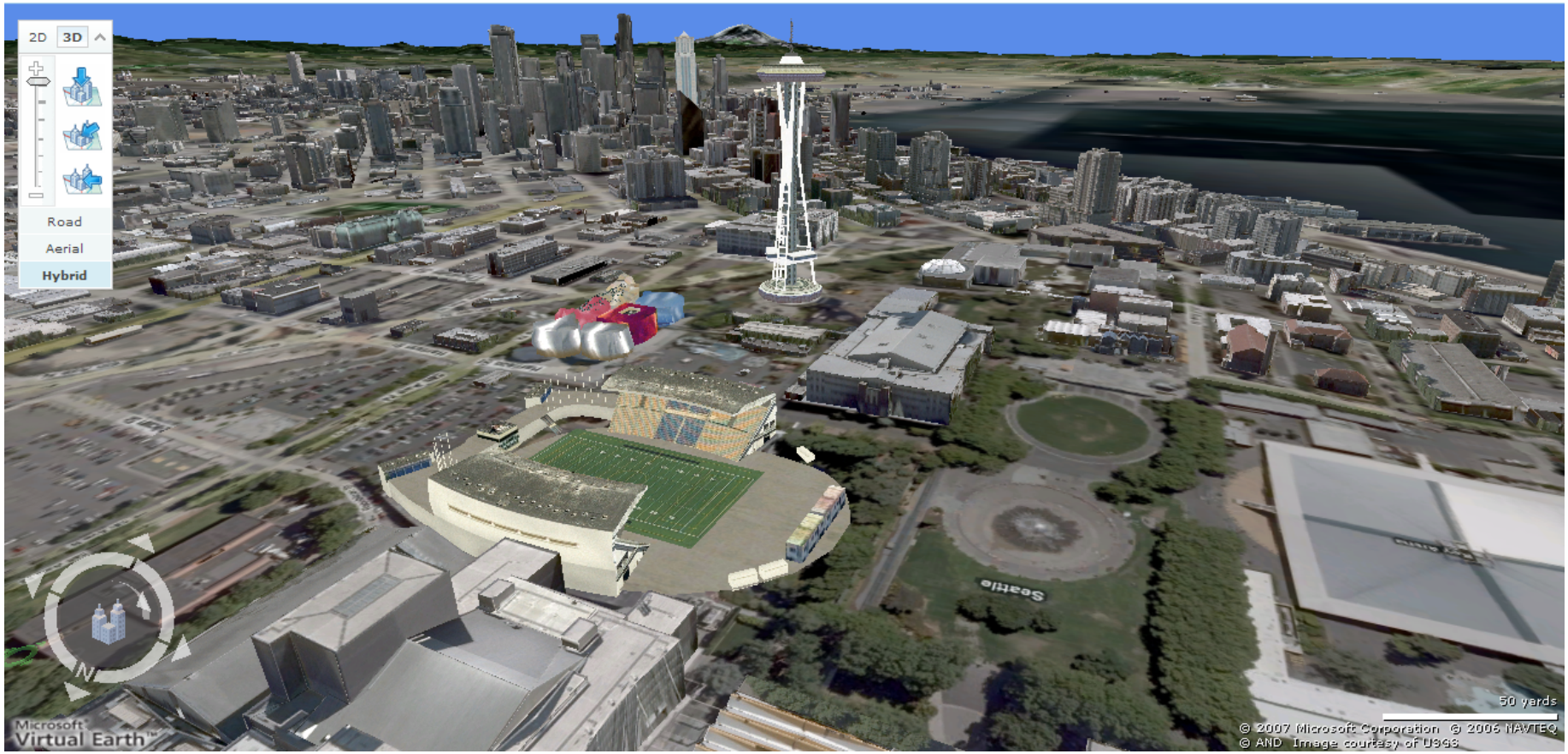
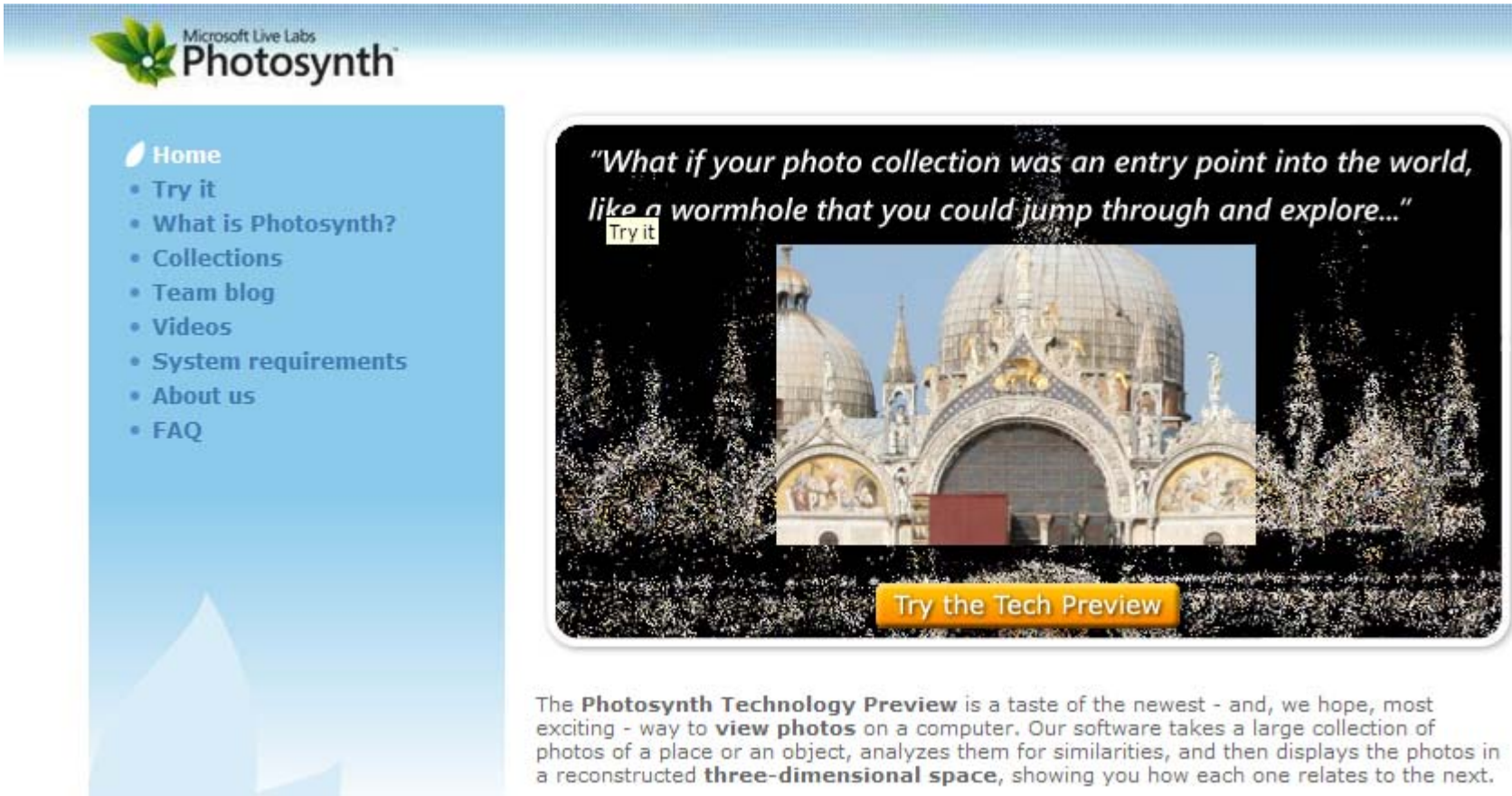


Image from Microsoft's Virtual Earth
(see also: Google Earth)



http://photosynth.net

Based on Photo Tourism technology developed here in CSE!
by Noah Snavely, Steve Seitz, and Rick Szeliski

Special effects: shape capture

The Burly Brawl scene in *The Matrix Reloaded*

Special effects: motion capture

Pirates of the Carribean, Industrial Light and Magic
Click here for interactive demo

Sports (http://www.sportvision.com)

Virtual first down line
(explanation on www.howstuffworks.com)

Real-time strike zone box

Ball tracking

Virtual Ads!

Smart cars

Slide content courtesy of Amnon Shashua

Mobileye

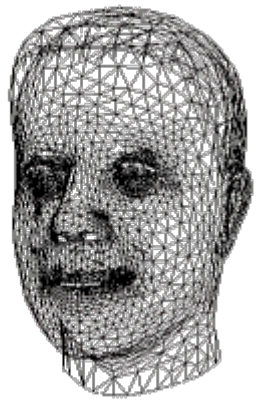
- Vision systems currently in high-end BMW, GM, Volvo models
- By 2010: 70% of car manufacturers

Vision-based interaction and games

Nintendo Wii has camera-based IR tracking built in. See Lee's work at CMU on clever tricks on using it to create a multi-touch display!

"Game turns moviegoers into Human Joysticks", CNET
Camera tracking a crowd, based on this work.

Digimask: put your face on a 3D avatar



Computer 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.

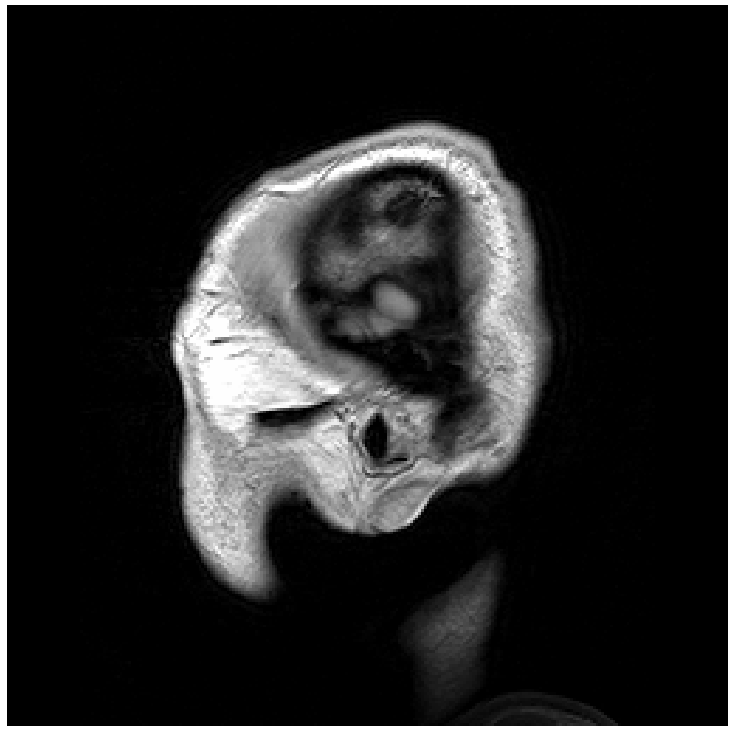
Vision systems (JPL) used for several tasks

- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read "Computer Vision on Mars" by Matthies et al.

Medical imaging

Image guided surgery

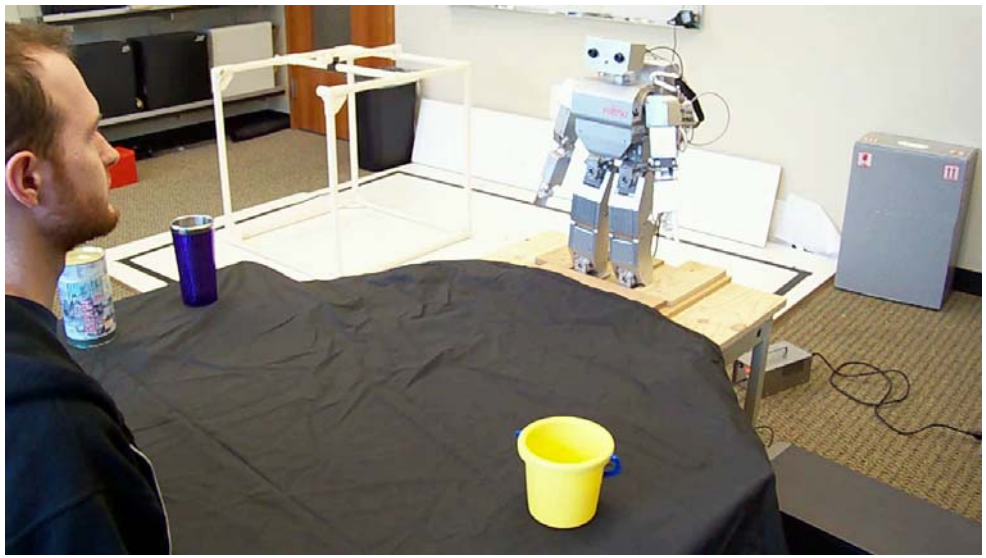
Grimson et al., MIT



3D imaging
MRI

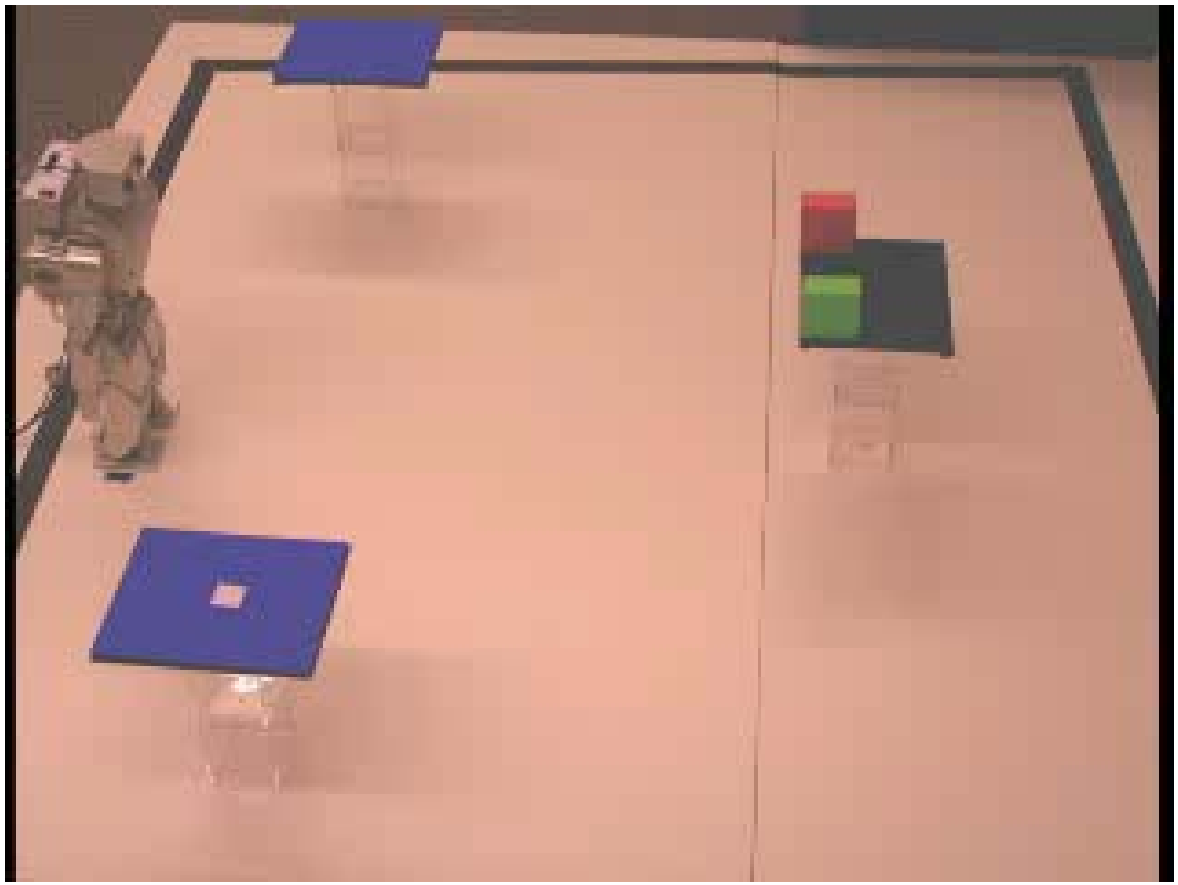
Vision-Based Robotic Learning of Language

Robot learns names for new objects through gaze following



Research done by UW CSE student Aaron Shon

Vision-Guided Brain-Robot Interfaces



CBS News Article

Current state of the art

You just saw examples of current systems.

- Many of these are less than 5 years old

This is a very active research area, and rapidly changing

- Many new apps in the next 5 years

To learn more about vision applications and companies

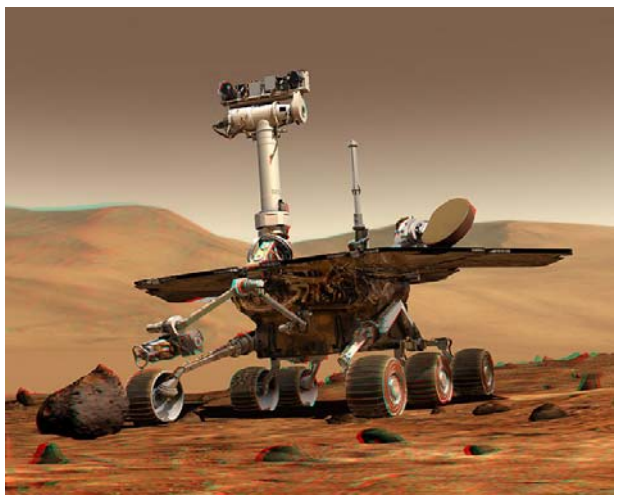
- David Lowe maintains an excellent overview of vision companies
  - http://www.cs.ubc.ca/spider/lowe/vision.html

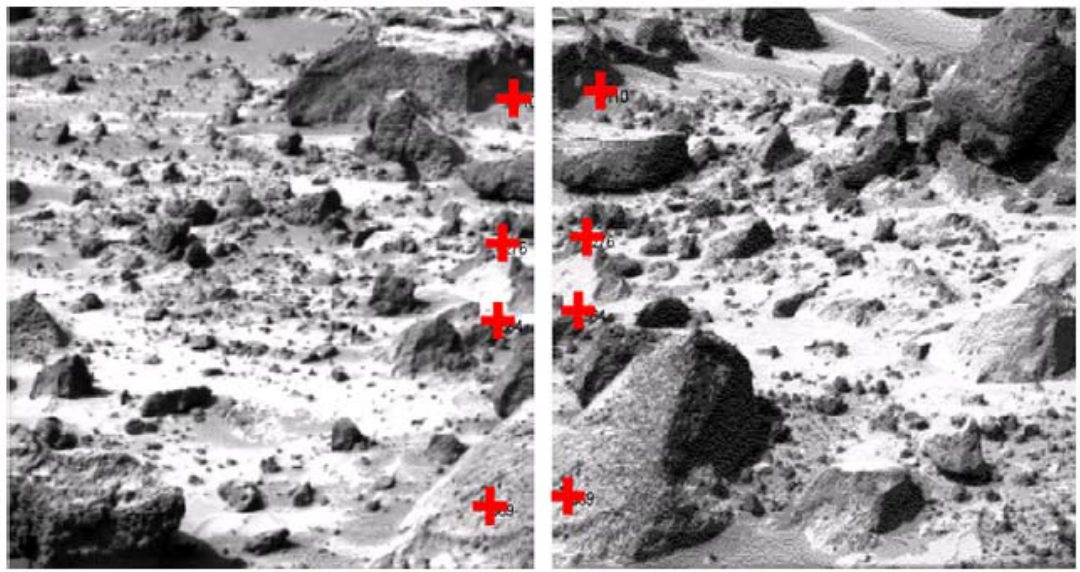
Goals of the course

- Provide an introduction to computer vision
- Topics to be covered:
  - Image processing and feature detection
  - Image stitching and mosaicing
  - Human vision
  - Pattern recognition & visual learning
  - Object recognition & Image segmentation
  - Motion estimation, color & texture
  - Stereo & 3D vision
  - Applications: content-based image retrieval, tactile graphics, computer vision for Mars exploration

Invited guest lectures

- Jan 29: Prof. Clark Olson (UW Bothell) on "Computer vision for Mars exploration"





Invited guest lectures

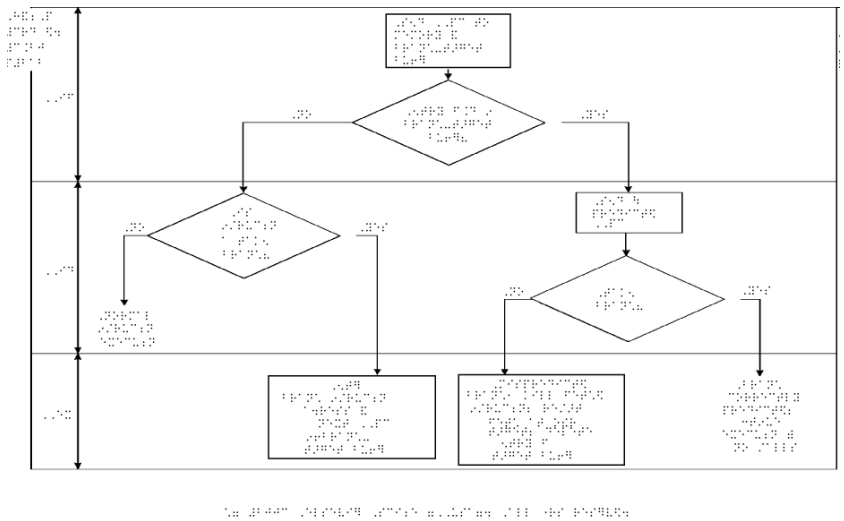
- Feb 19: Prof. Linda Shapiro (UW Seattle) on

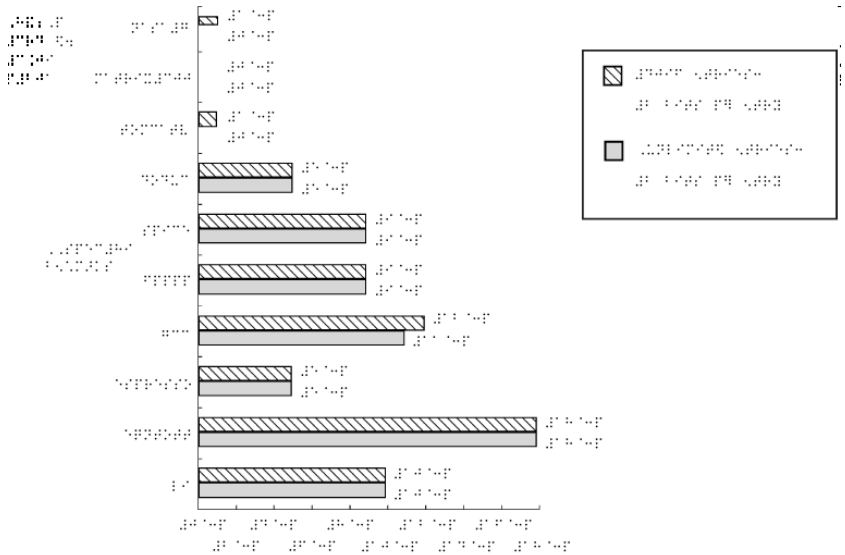
  “Content-Based Image Retrieval”

Invited guest lectures

- Mar 5: Prof. Richard Ladner (UW Seattle) on

  “Tactile Graphics”





Tactile versions (with Braille) of graphical images in *Computer Architecture: A Quantitative Approach* by Hennessy and Patterson.

Projects

1. Image scissors

2. Image stitching

3. Content-based image retrieval

4. Face recognition & detection

Project 1: intelligent scissors

David Dewey, 455 02wi

Project 2: panorama stitching

Oscar Danielsson, 455 06wi

Project 3: Content-Based Image Retrieval

Project 4: Face Recognition & Face Detection

Eigenfaces

Recognition

Detection

Grading

Programming Projects (80%)

- Image scissors (20%)
- Panoramas (20%)
- Content-based image retrieval (20%)
- Face recognition & detection (20%)

Final (20%)

Prerequisites

The following are essential!

- Data structures
- A good working knowledge of C and C++ programming
  - (or willingness/time to pick it up quickly!)
- Linear algebra
- Vector calculus

Course does ***not*** assume prior imaging experience

- computer vision, image processing, graphics, etc.

Okay, let’s begin

What is an image?

What is an image?

Think of an **image** as a function, *f*, from R^2 to R:

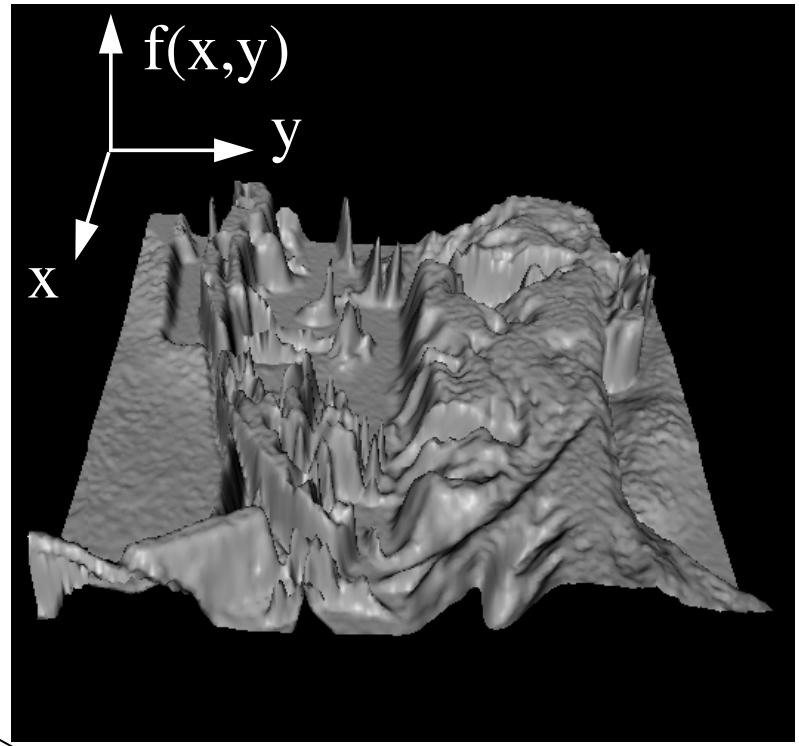
- $f(x, y)$ gives the **intensity** at position (x, y)
- Realistically, images defined over a rectangle:

  $f: [a,b]\mathrm{x}[c,d] \rightarrow [0,1]$

Color image = three functions pasted together

$$f(x,y) = \begin{bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{bmatrix}$$

An image as a function

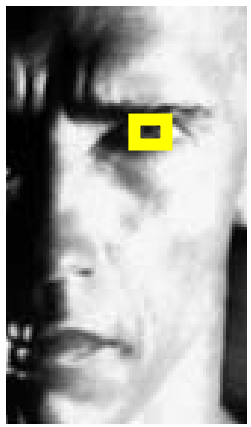


Bright regions are high, dark regions are low

Digital images

In computer vision we usually operate on **digital** (**discrete**) images:

- **Sample** the 2D space on a regular grid
- **Quantize** each sample (round to nearest integer)
- Each sample is a "**pixel**" (picture element)
- If 1 byte for each pixel, values range from 0 to 255



y

x

62	79	23	119	120	105	4	0
10	10	9	62	12	78	34	0
10	58	197	46	46	0	0	48
176	135	5	188	191	68	0	49
2	1	1	29	26	37	0	77
0	89	144	147	187	102	62	208
255	252	0	166	123	62	0	31
166	63	127	17	1	0	99	30

Image processing

An **image processing** operation converts an existing image f to a new image g

Can transform either the domain or range of f

Image processing

Range transformation: $g(x, y) = t(f(x, y))$

(What is an example?)

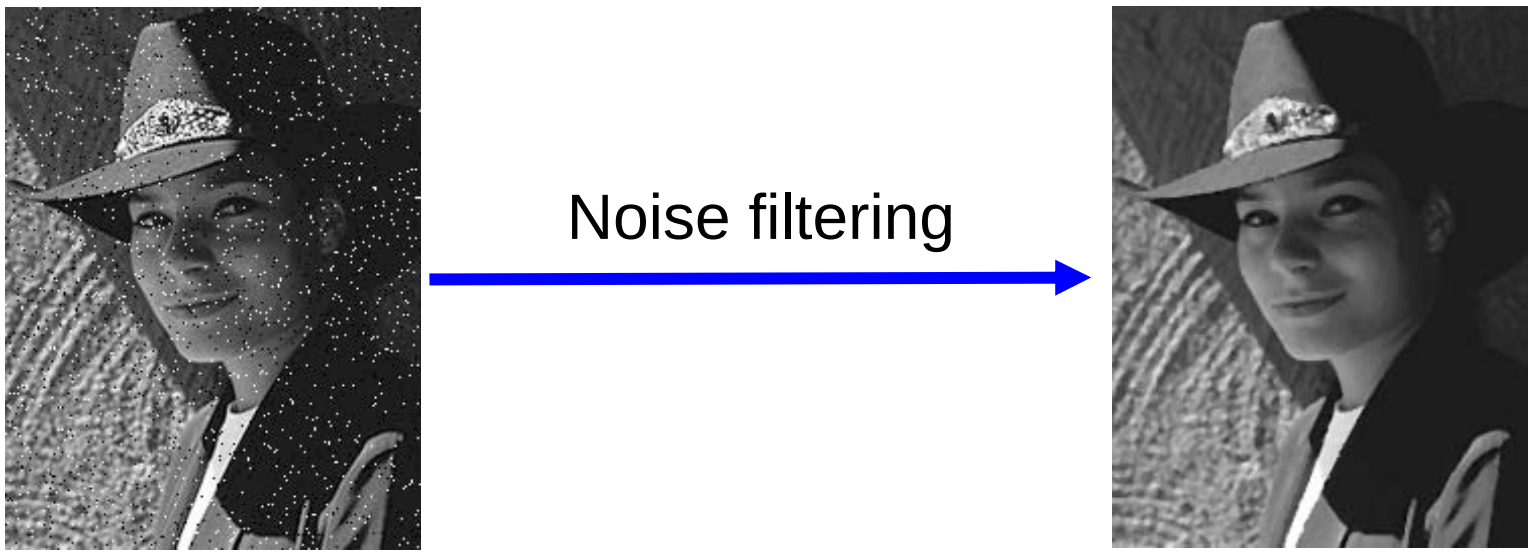
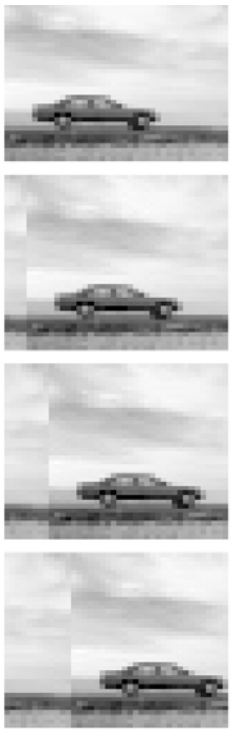


Image Processing

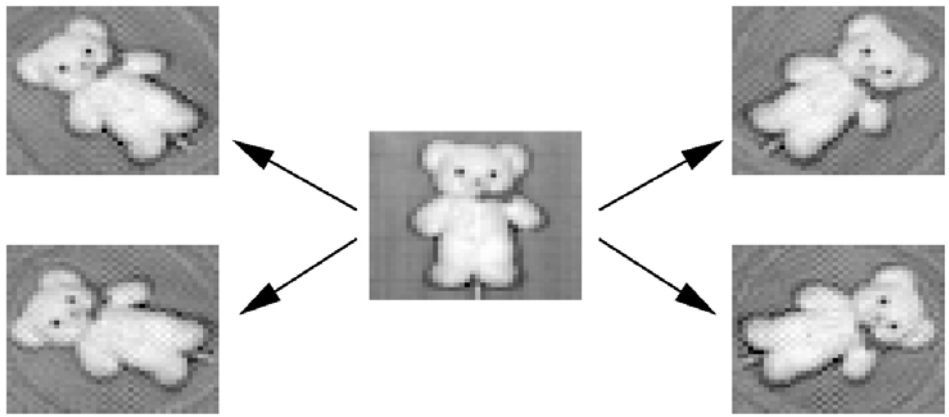
Domain transformation: $g(x, y) = f(t_x(x, y), t_y(x, y))$

(What is an example?)

Translation



Rotation



Next Time: Image Processing and Filtering

- Things to do:
  - Read Chap 2 & Chap 5: Sec. 5.1-5.5, 5.10
  - Browse class website
  - Mailing list: cse455@cs.washington.edu
    - Did you receive the welcome message? Otherwise, sign up
  - Brush up on C/C++ programming skills
  - Visit Vision and Graphics Lab (Sieg 327)
    - Your ID card should open Sieg 327
    - Check to make sure ASAP