

Introduction to Computer Vision

CS / ECE 181B

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Today

→ Course introduction and overview
[thanks to Professor Matthew Turk, CS department
for the slides from S2003]

Web site

- <http://www.ece.ucsb.edu/~manj/ece181b>
- <http://www.ece.ucsb.edu/~manj/cs181b>
- Last Year (Prof. Turk)
 - <http://www.cs.ucsb.edu/~cs181b>
 - Has some useful information.

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Text Book

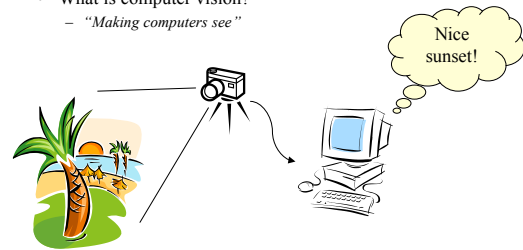
- NO Text Book
 - Follow the classroom discussions
 - Handouts and Lecture slides
- Reference Books (not required)
 - Forsyth and Ponce, "Computer Vision: A Modern Approach" (was the text used last year)
 - Nalwa, "A Guided Tour of Computer Vision"; a good introductory book for casual reading
 - Jain and Kasturi, "Machine Vision"; I used it in 1999.
 - Horn, "Robot Vision". A classic, but outdated.

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Computer Vision

- What is computer vision?
 - "Making computers see"



"Extracting descriptions of the world from pictures or sequences of pictures"

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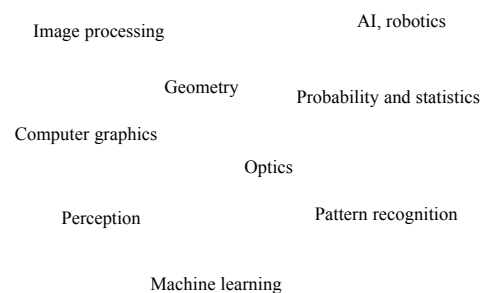
Computer Vision

- Also known as **image understanding**, **machine vision**, **computational vision**
- CV is about interpreting the *content* of images*
 - Field is 35-40 years old
 - Child of AI
- Vision is easy, right? Just open your eyes!
 - No, it's a hard problem!
 - Much of your very complex brain is devoted to doing vision
 - It involves cognition, navigation, manipulation and learning
 - ♦ Not just simple "match a feature vector to a database" tasks

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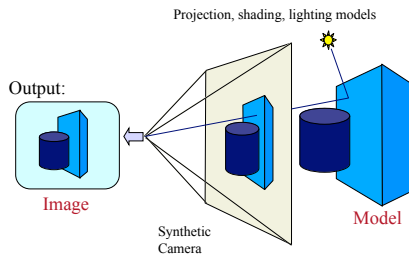
Relation to other fields



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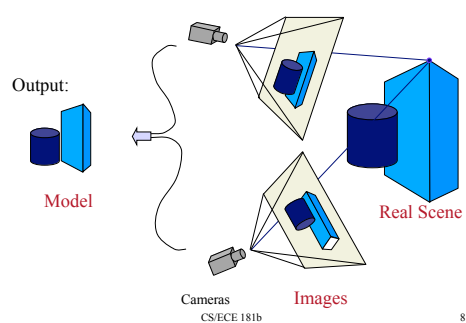
Computer Graphics



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Computer Vision



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Aims of Computer Vision

- Automate visual perception
- Construct scene descriptions from images
- Make useful decisions about real physical objects and scenes based on sensed images
- Produce symbolic (perhaps task-dependent) descriptions from images
- Produce from images of the external world a useful description that is not cluttered with irrelevant information
- Support tasks that require visual information

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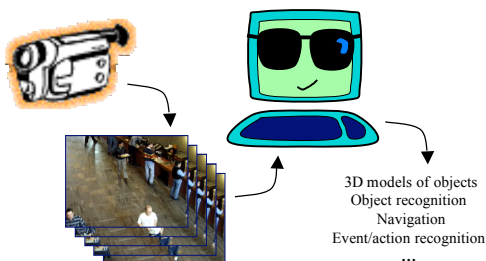
Some applications of computer vision

- Photogrammetry, GIS
 - Commercial, military, government
- Robotics
 - Industrial, military, medical, space, entertainment
- Inspection, measurement
- Medical imaging
 - Automatic detection, outlining, measurement
- Graphics and animation, special effects
- Surveillance and security
- Multimedia database indexing and retrieval, compression
- Human-computer interaction (VBI)

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What Does Computer Vision Do?



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Vision Transforms From This...

[illegible]

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To this...

- Objects
 - Cat, chair, window, star, bush, water, a shoe, my mother...
- Properties
 - Big, bright, yellow, fast, graspable, moving...
- Relations
 - In front, behind, on top, next to, larger, closer, identical...
- Shapes
 - Round, rectangular, star-shaped, symmetric...
- Textures
 - Rough, smooth, irregular...
- Movement
 - Turning, looming, rolling...

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- “A harbor with many dozens of boats; water is calm and glassy; masts are all vertical; mountains in background, blue sky with a touch of clouds...”

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- “J548043”

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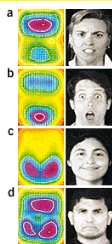
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- “Hallway straight ahead”

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- “Angry
Surprised
Happy
Disgusted”

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Why is Vision Difficult?

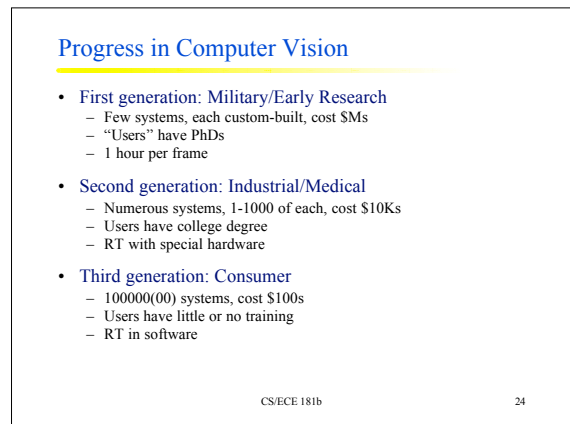
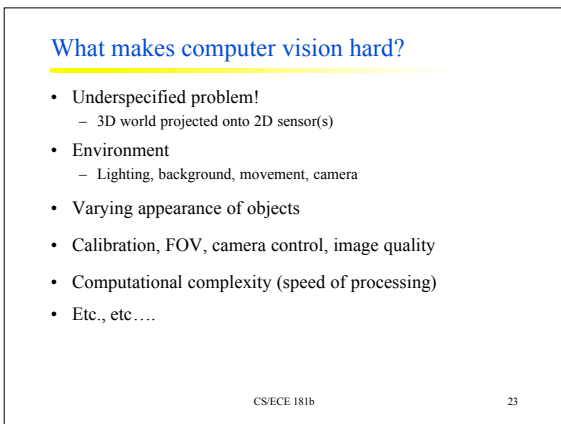
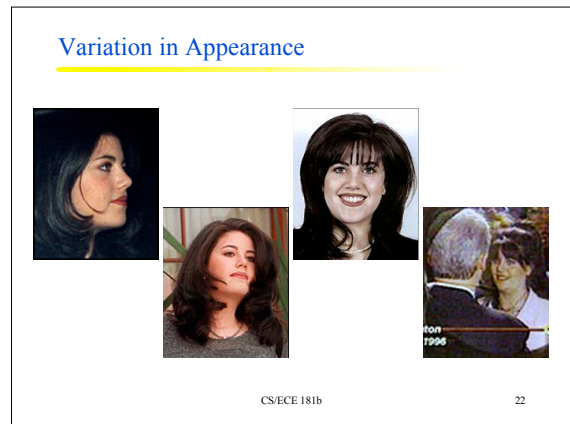
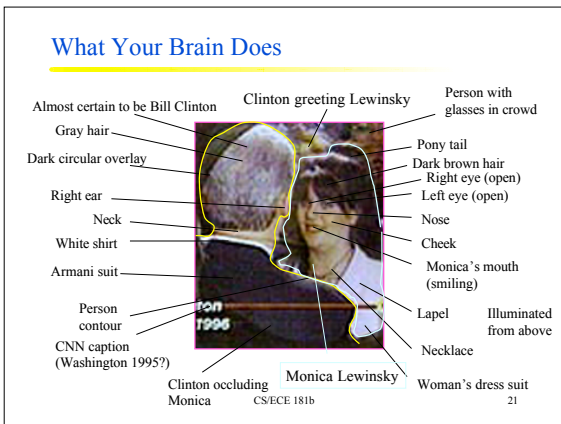
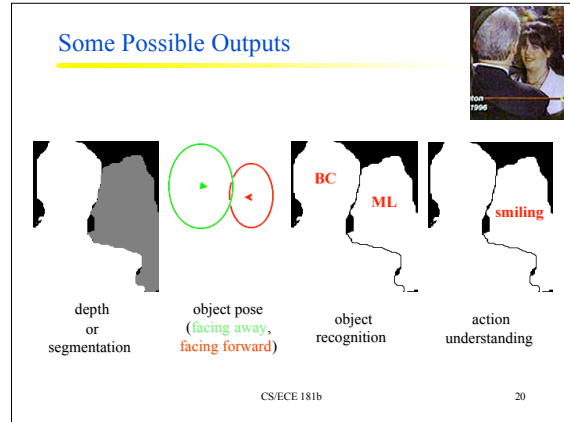
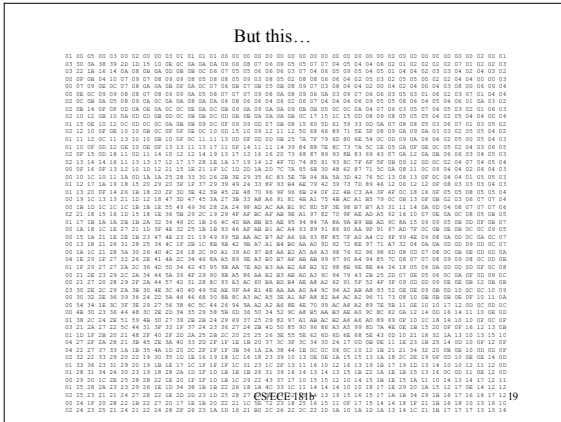
Consider the input...



← Not this

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Examples



CMU NavLab



Cognex



MIT Media Lab

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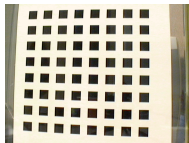
Computer Vision

- Areas of study
 - Camera (sensor) calibration and image formation
 - Binary image analysis
 - Edge detection and low-level filtering
 - Color representation and segmentation
 - Texture description and segmentation
 - Depth/shape from X
 - Stereopsis
 - Optical flow
 - Motion computation
 - Object matching, detection, and recognition
 - 3D sensing and shape description
 - Object and scene tracking

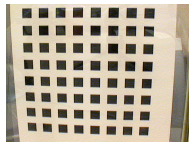
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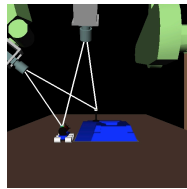
Camera calibration



Original planar pattern



Corrected for radial lens distortion



Two calibrated cameras

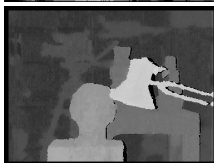
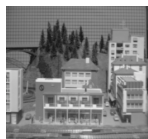
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Edge detection



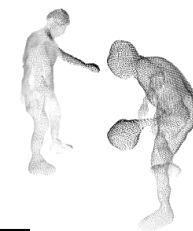
Stereopsis



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Multi-Camera Stereo



Images

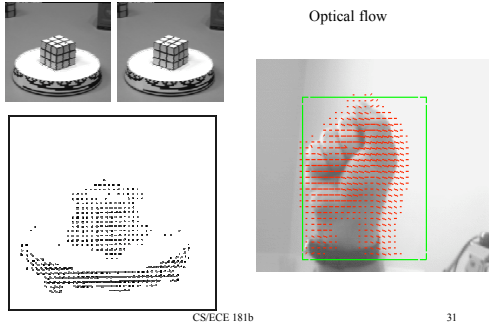


3D reconstruction

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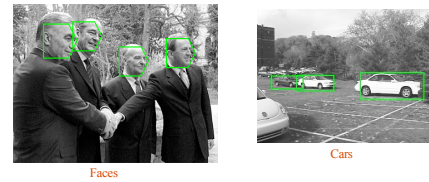
Motion computation



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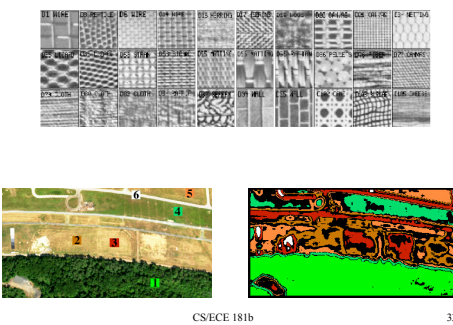
Object Detection and Recognition

- Model, detect, and recognize objects in images
- Main issues
 - Object representation, feature extraction, matching, learning from data



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Texture analysis



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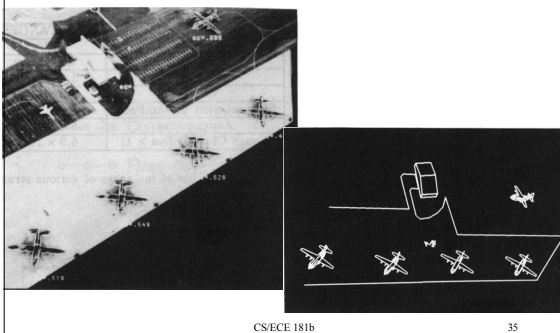
Some Computer Vision Examples

- Academic and industrial research
- Companies and products

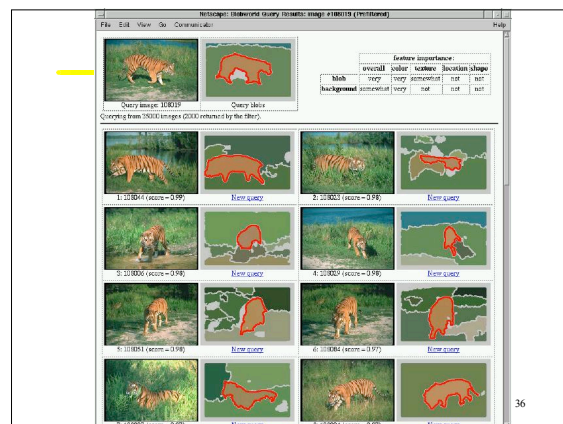
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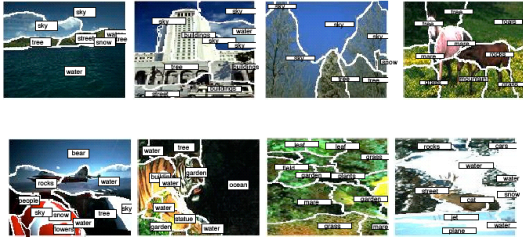
Early CV research



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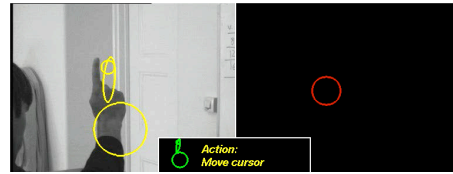
Labeling images



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Vision for HCI



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Vision and computer graphics



Eyematic Interfaces

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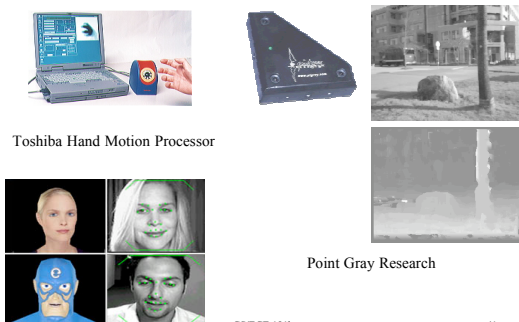
Vision for Biometrics



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Examples of Commercial Vision Systems



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Example application: Face recognition

- If we could reliably detect and recognize faces in images...
 - Digital libraries
 - ♦ Find me the picture of my brother and Ted
 - ♦ Show all the scenes with more than four people
 - Surveillance
 - ♦ Alert the operator when a known suspect enters the area
 - HCI
 - ♦ Automatically log in as I walk up to the computer
 - ♦ Refuse to open my files when someone else is at my machine
 - Military
 - ♦ Friend or foe?
 - Personal/entertainment robots
 - ♦ Follow the master, look the customer in the eyes

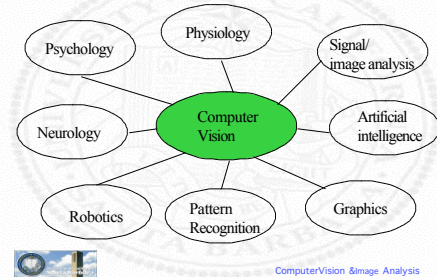
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So... why study computer vision?

- “Engineering” reasons
 - Images are become more and more ubiquitous
 - Plenty of useful applications
 - Great mixture of applied mathematics, signal processing, computer science, etc.
 - Solving interesting, underconstrained (“ill-posed”) problems
 - Etc.
- “Science” reasons
 - How does the brain do it?
 - Understanding biological vision
 - Deep computational issues
 - Etc.

- Fusion of several old and new research fields

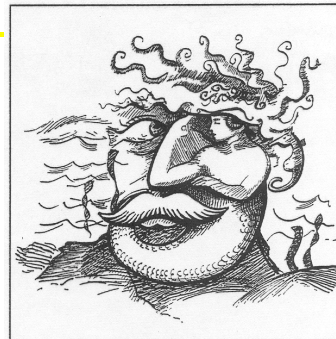
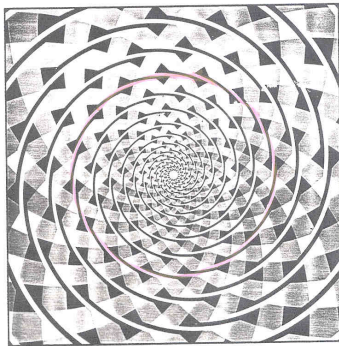


Psychology, Neurology, and Physiology

- Understand human (biological) perception
 - Study the structure of the eye, and the neural-networks for visual information processing
 - Design computational algorithms to evaluate biological visual perception functions

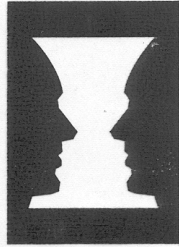
Human vision—not perfect..

- Check out the illusions...and ambiguities..

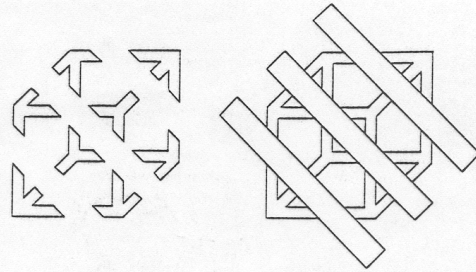




Young Girl/Old Woman

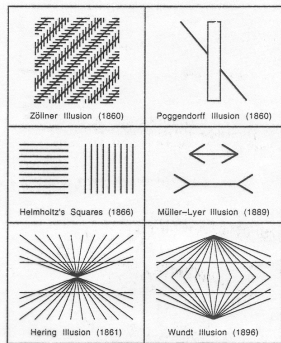


Vase / Faces



(a)

(b)



This Quarter...

- Vision is unlike *any other* course you may have taken in engineering/science.
- There are MANY questions, very few answers! Remember this as we go through this subject.
- *We are so familiar with seeing, that it takes a leap of imagination to realize that there are problems to be solved* --- Richard Gregory
- *Vision is a bag of tricks* --- Ramachandran

(tentative) Grading

- Homeworks & Programming Assignments (25%)
- Midterm (15%)
- Project on Face Recognition (20%)
- Final Examination (40%)

Project

- Topic: Face recognition
- More details soon.
- Individual or groups of no more than 4 students.

What will we study?

- **Part I: The physics of imaging**
 - Camera models and calibration
 - Radiometry
 - Color
- **Part II: “Early” vision**
 - Filtering and edge detection
 - Stereo, optical flow
- **Part III: “Mid-level” vision**
 - Segmentation
 - Classification
 - Tracking
- **Part IV: “High-level” vision and applications**
 - Model-based vision
 - Various applications of computer vision

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Course web site

- <http://www.ece.ucsb.edu/~manj/ece181b>
- <http://www.ece.ucsb.edu/~manj/cs181b>
- <http://www.cs.ucsb.edu/~cs181b>: this is last year’s web site that you might find very useful.
- Visit it often!

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