2ECDE62
Computer Vision

Prof Bhupendra Fataniya

Assistant Professor,

EC,IT,NU

Outline

- Introduction to Computer Vision
- Why Computer Vision
- Applications of Computer Vision
- Specific of this Course
- Computer Vision Publications
  - Journals
  - Conferences

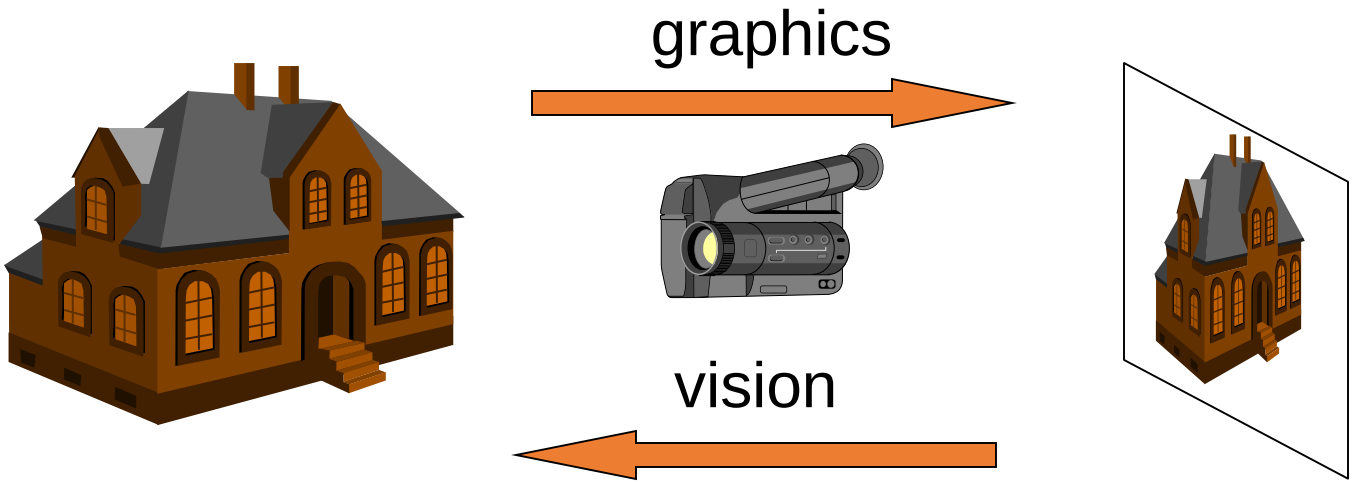
What is Computer Vision?

- Computer Graphics: Models to Images
- Comp. Photography: Images to Images
- Computer Vision: Images to Models

- Make computers understand images and video.
- The goal of computer vision is to develop algorithms that allow computer to “see”.

Computer Vision vs. Graphics

- 3D→2D implies information loss



- sensitivity to errors
- need for models

Computer Vision vs. Machine Learning

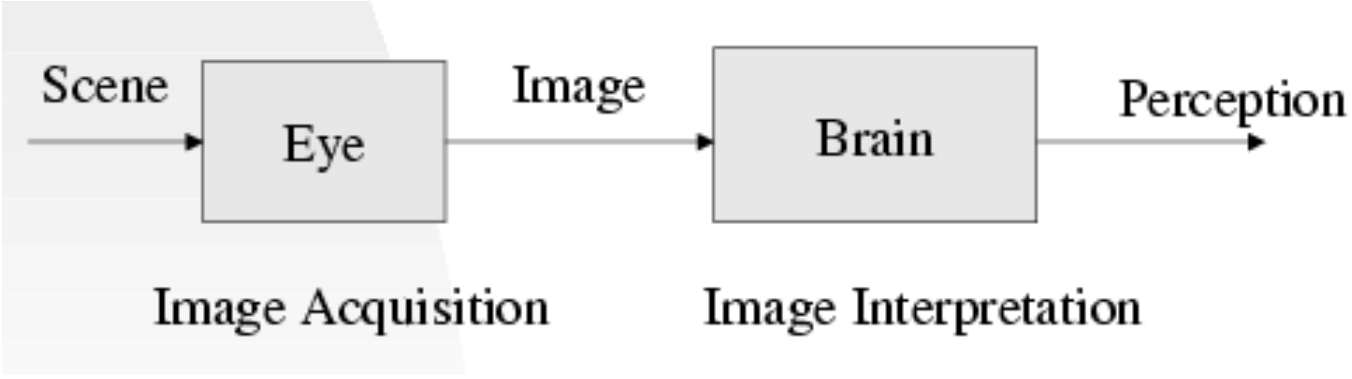
- **Machine learning** is a scientific discipline that is concerned with the design and development of algorithms that allow computers to change behavior based on data, such as from sensor data or databases (from Wikipedia)
- A major focus of machine learning research is to automatically learn to recognize complex patterns and make intelligent decisions based on data.

Computer Vision vs. Machine Learning

- Machine Learning is very useful for Computer Vision (e.g., learning for vision)
- Computer Vision is more than just learning
  - Modeling
  - Example based learning
- In Machine Learning, it usually does not care about how to obtain the data or sensors
- In Computer Vision, we care how to obtain the visual data (sensor design, active vision), how to represent the visual data, and others

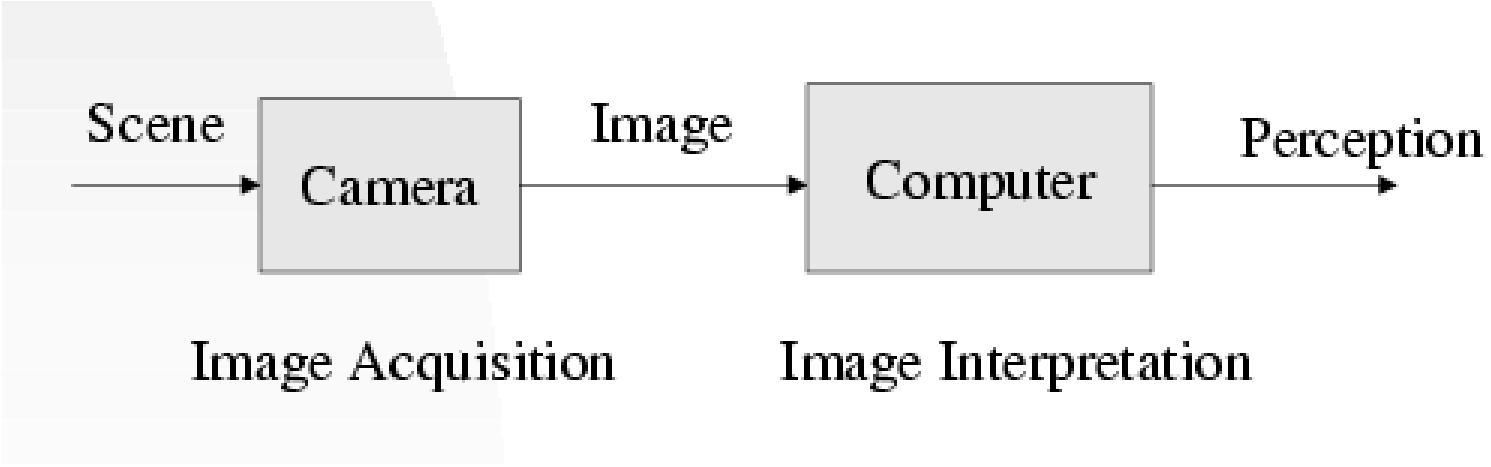
Vision

- Vision is the process of discovering what is present in the world and where it is by looking.



Computer Vision

- Computer Vision is the study of analysis of pictures and videos in order to achieve results similar to those as by people.

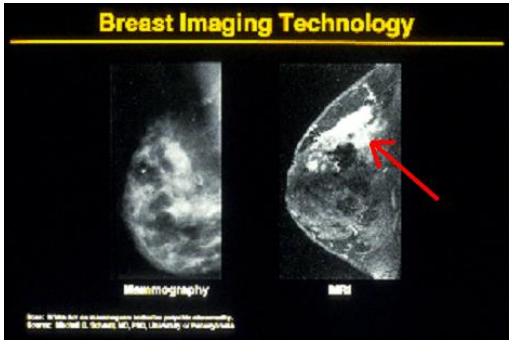


Why Computer Vision

- An image is worth 1000 words
- Many biological systems rely on vision
- The world is 3D and dynamic
- Cameras and computers are cheap
- …

Why computer vision matters

Safety



Health

Security

Comfort

Fun

Access

Computer Vision Examples

Finding People in images

Problem 1: Given an image I

Question: Does image I contain an image of a person?

“Yes” Instances

Phil Noble / AP


Mike Hewitt / Allsport


Patrick Gardin / AP


Andy Barron / Reno Gazette-Journal


Sydney Morning Herald

“No” Instances


Eric Miller / Reuters


Mark Garkfinkel / The Boston Herald

Jeff J. Mitchell / Reuters

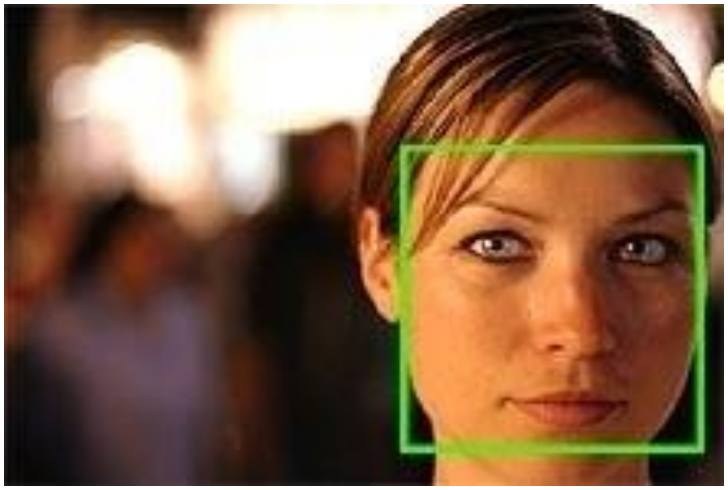

Monroe County Sheriffs Department / Newsmakers


Uno Andersson / AP


NASA via AFP

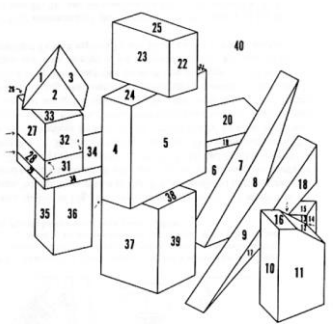
One Very Successful Example

- Face detection in a digital camera
  - The camera detects faces in a scene and then automatically focuses (AF) and optimizes exposure (AE) and, if needed, flash output.

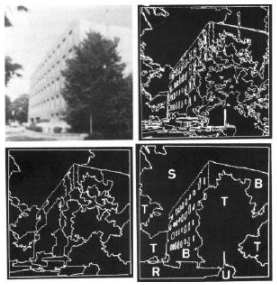


Ridiculously brief history of computer vision

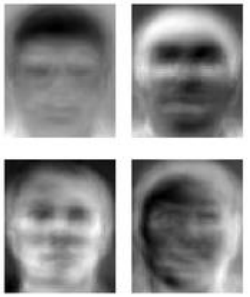
- 1966: Minsky assigns computer vision as an undergrad summer project
- 1960's: interpretation of synthetic worlds
- 1970's: some progress on interpreting selected images
- 1980's: ANNs come and go; shift toward geometry and increased mathematical rigor
- 1990's: face recognition; statistical analysis in vogue
- 2000's: broader recognition; large annotated datasets available; video processing starts
- 2010's: Deep learning with ConvNets
- 2030's: robot uprising?



Guzman '68



Ohta Kanade '78



Turk and Pentland '91

How vision is used now

- Examples of real world applications

Some of the following slides by Steve Seitz

Industrial Application

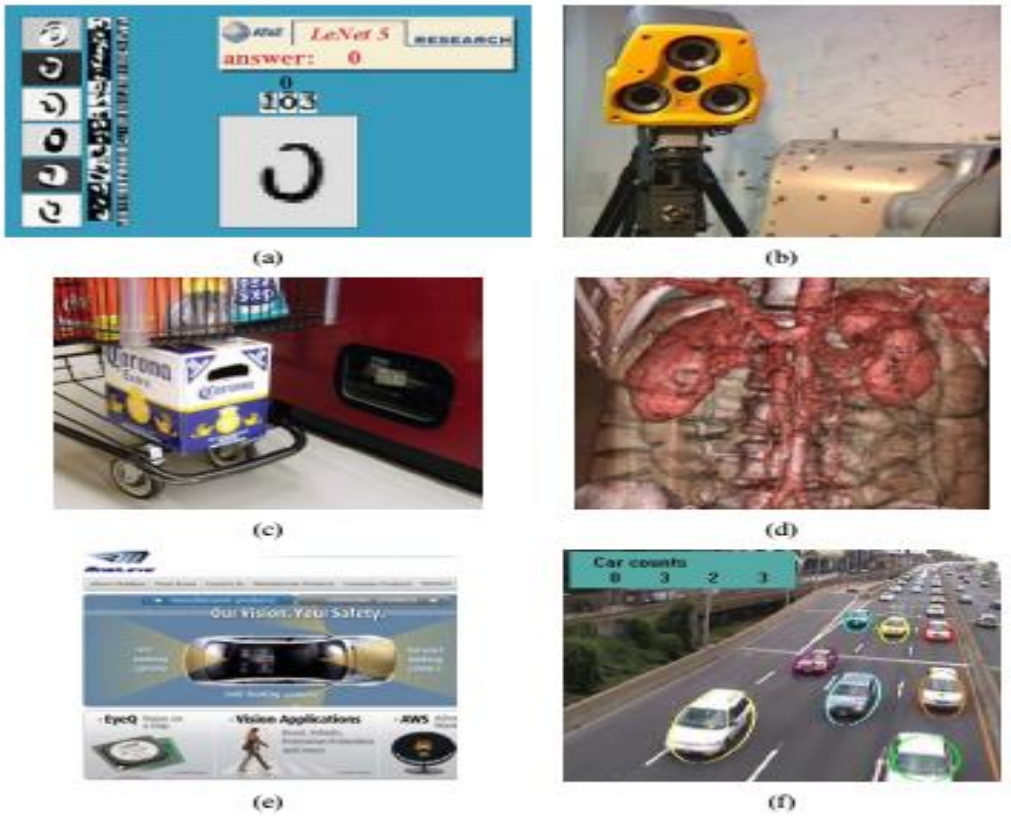


Figure 1.4 Some industrial applications of computer vision: (a) optical character recognition (OCR) http://yann.lecun.com/exdb/lenet/; (b) mechanical inspection http://www.cognitens.com/; (c) retail http://www.evoretail.com/; (d) medical imaging http://www.clarontech.com/; (e) automotive safety http://www.mobileye.com/; (f) surveillance and traffic monitoring http://www.honeywellvideo.com/, courtesy of Honeywell International Inc.

Source: Computer Vision Algorithms and Application by Richard Szeliski

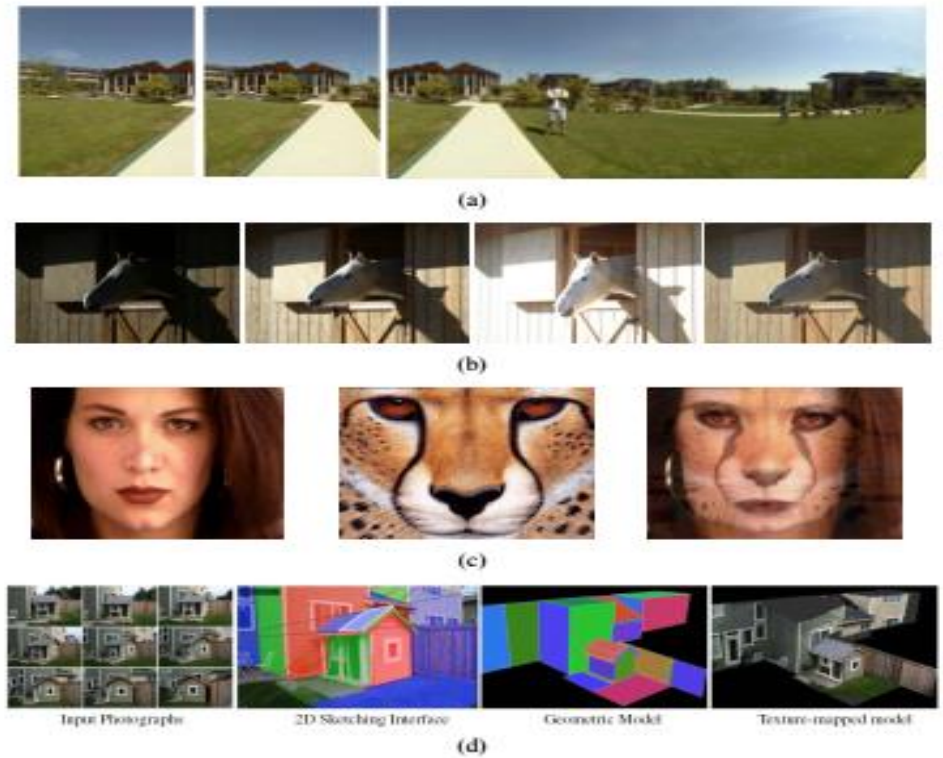


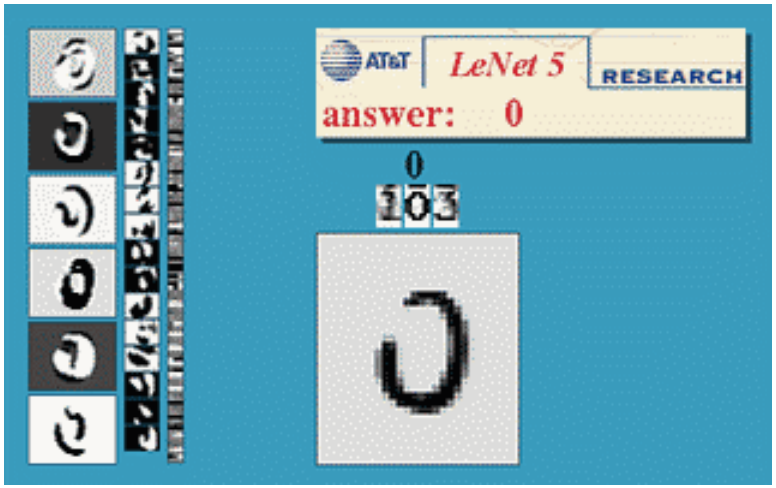
Figure 1.5 Some consumer applications of computer vision: (a) image stitching: merging different views (Szeliski and Shum 1997) © 1997 ACM; (b) exposure bracketing: merging different exposures; (c) morphing: blending between two photographs (Gomes, Darsa, Costa *et al.* 1999) © 1999 Morgan Kaufmann; (d) turning a collection of photographs into a 3D model (Sinha, Steedly, Szeliski *et al.* 2008) © 2008 ACM.

Source: Computer Vision Algorithms and Application by Richard Szeliski

Optical character recognition (OCR)

Technology to convert scanned docs to text

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



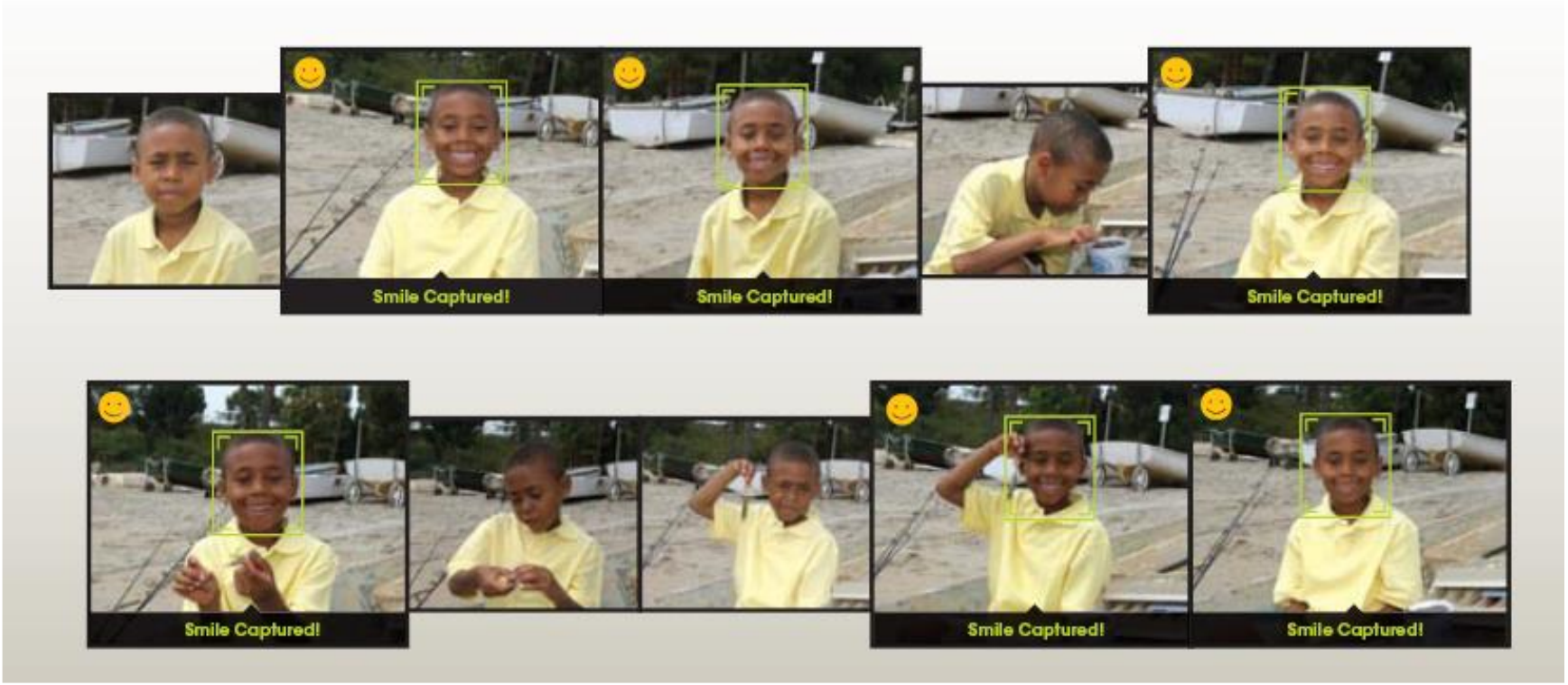
Digit recognition, AT&T labs
http://www.research.att.com/~yann/

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

Face detection

- Digital cameras detect faces

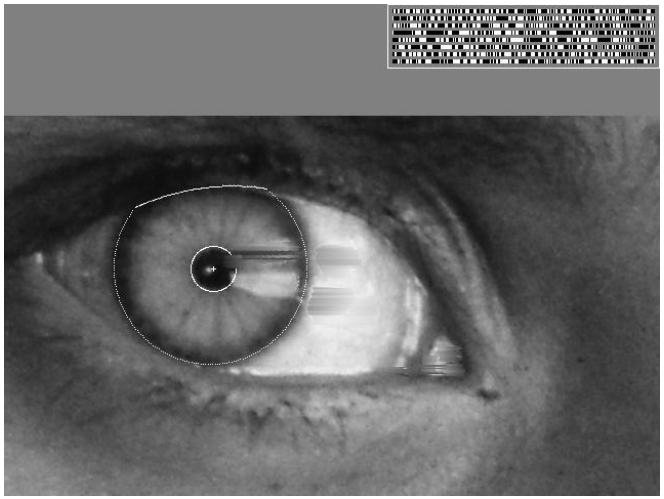
Smile detection

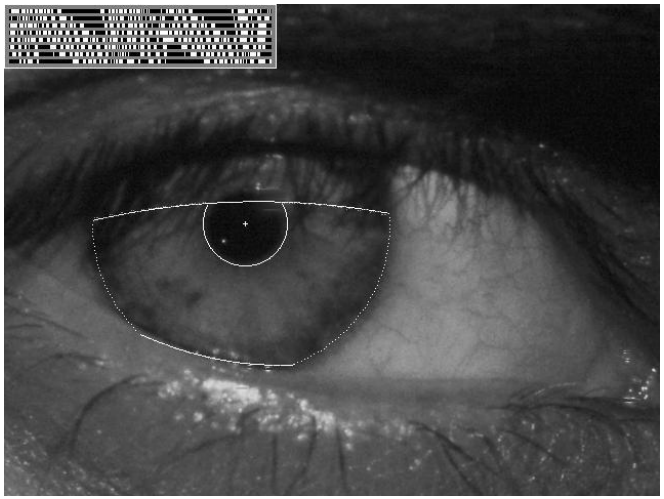


Sony Cyber-shot® T70 Digital Still Camera

Vision-based biometrics

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





Login without a password…

Fingerprint scanners on many new laptops, other devices

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

Object recognition (in mobile phones)

[Point & Find](), [Nokia]()

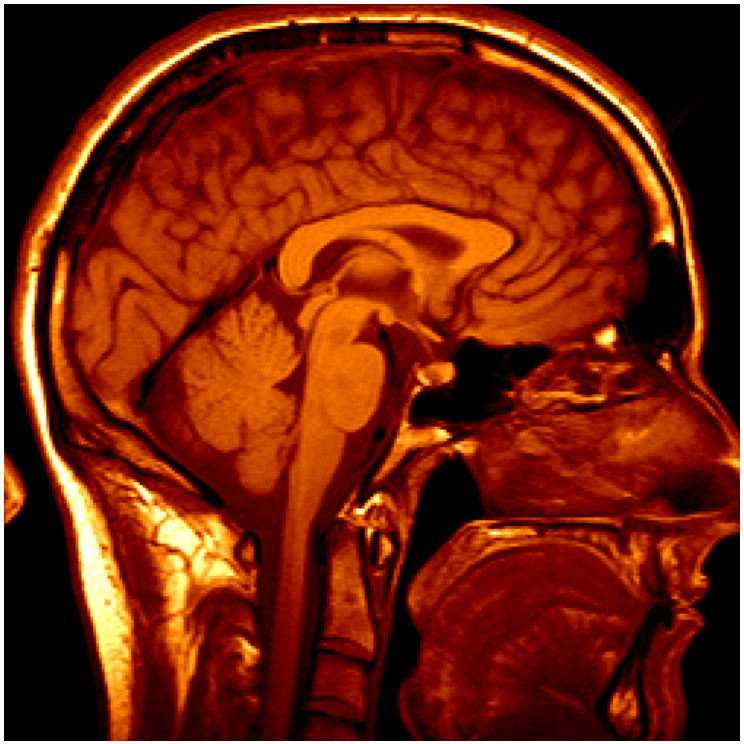
[Google Goggles]()

Sports

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

http://www.sportvision.com/video.html

Medical imaging



3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Smart cars

Slide content courtesy of Amnon Shashua

- Mobileye
  - Market Capitalization: 11 Billion dollars

Google cars

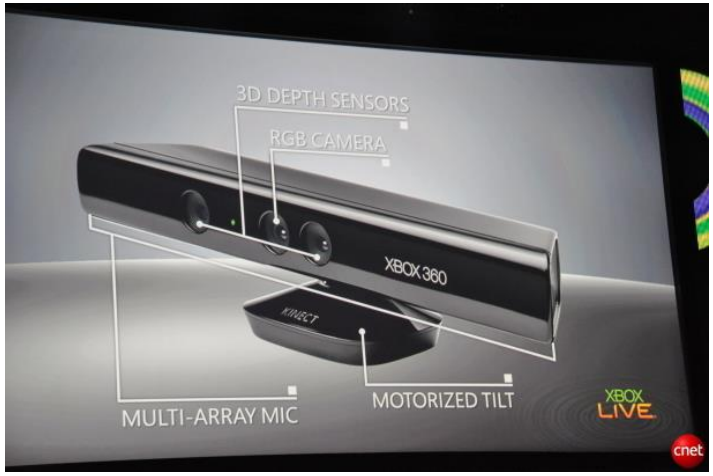
Oct 9, 2010. "Google Cars Drive Themselves, in Traffic". *The New York Times*. John Markoff

June 24, 2011. "Nevada state law paves the way for driverless cars". *Financial Post*. Christine Dobby

Aug 9, 2011, "Human error blamed after Google's driverless car sparks five-vehicle crash". *The Star* (Toronto)

Interactive Games: Kinect

- Object Recognition: http://www.youtube.com/watch?feature=iv&v=fQ59dXOo63o
- Mario: http://www.youtube.com/watch?v=8CTJL5lUjHg
- 3D: http://www.youtube.com/watch?v=7QrnwoO1-8A
- Robot: http://www.youtube.com/watch?v=w8BmgtMKFbY



Industrial robots

Vision-guided robots position nut runners on wheels

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.

Augmented Reality and Virtual Reality

Magic Leap, Oculus, Hololens, etc.

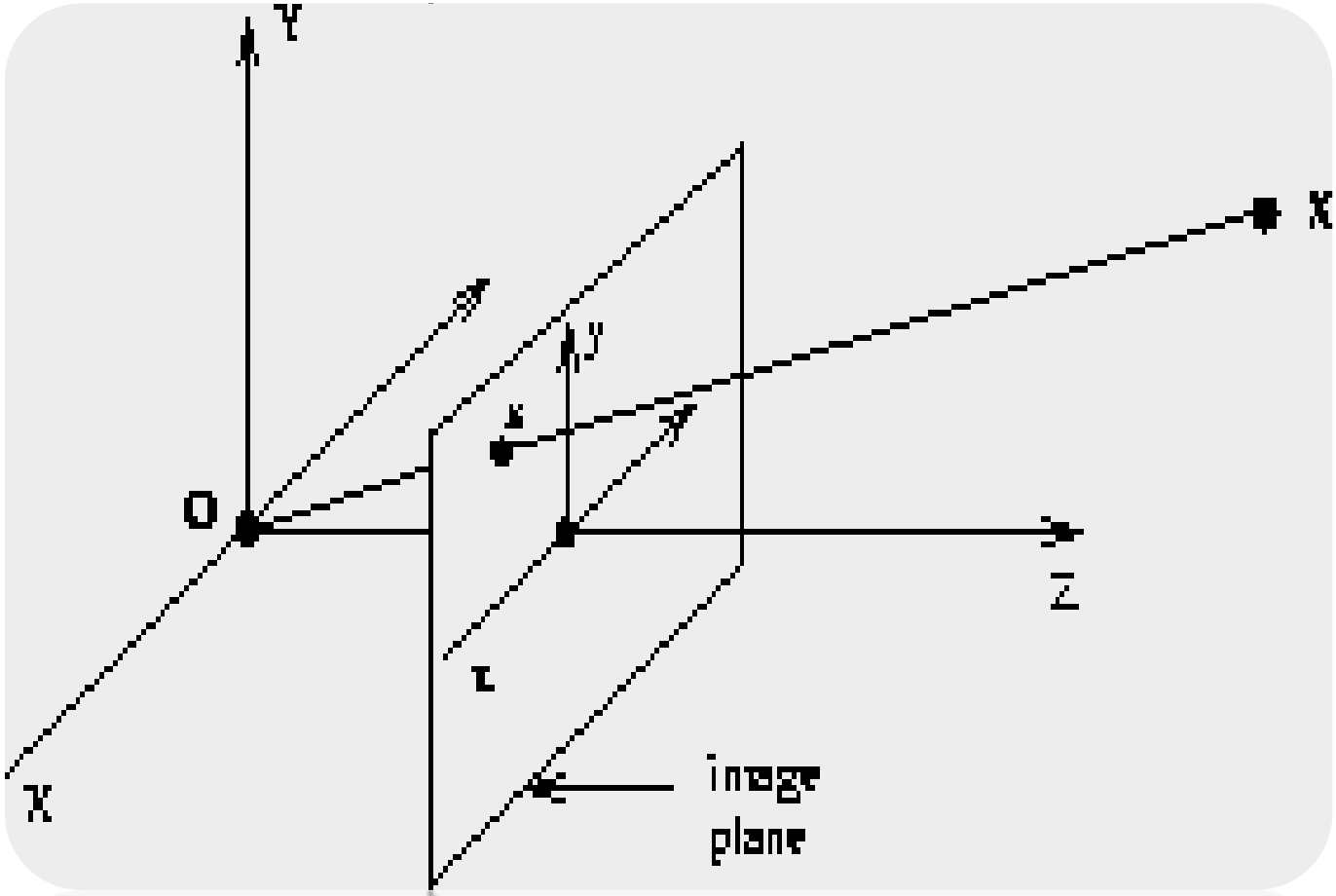
State of the art today?

With enough training data, computer vision nearly matches human vision at most recognition tasks

Deep learning has been an enormous disruption to the field. More and more techniques are being “deepified”.

Some Computer Vision Topics

Imaging Geometry



Camera Modeling

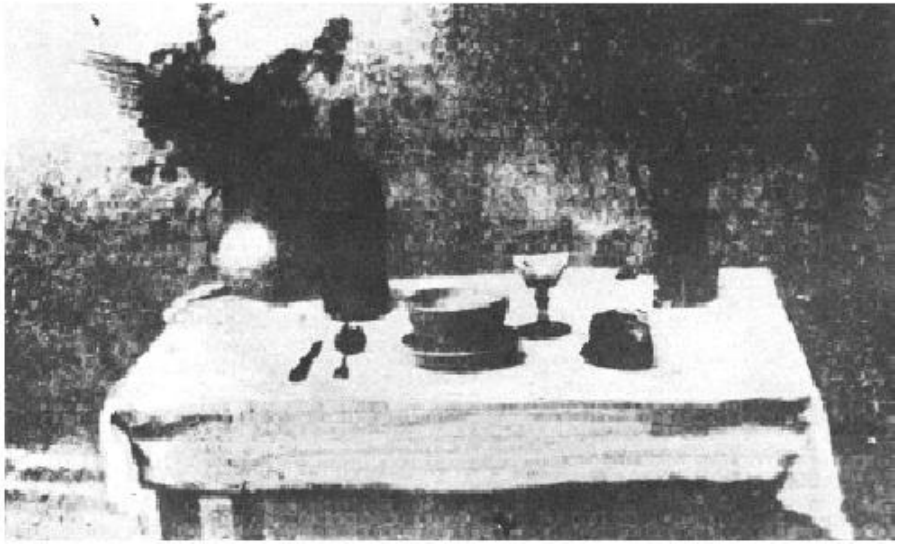


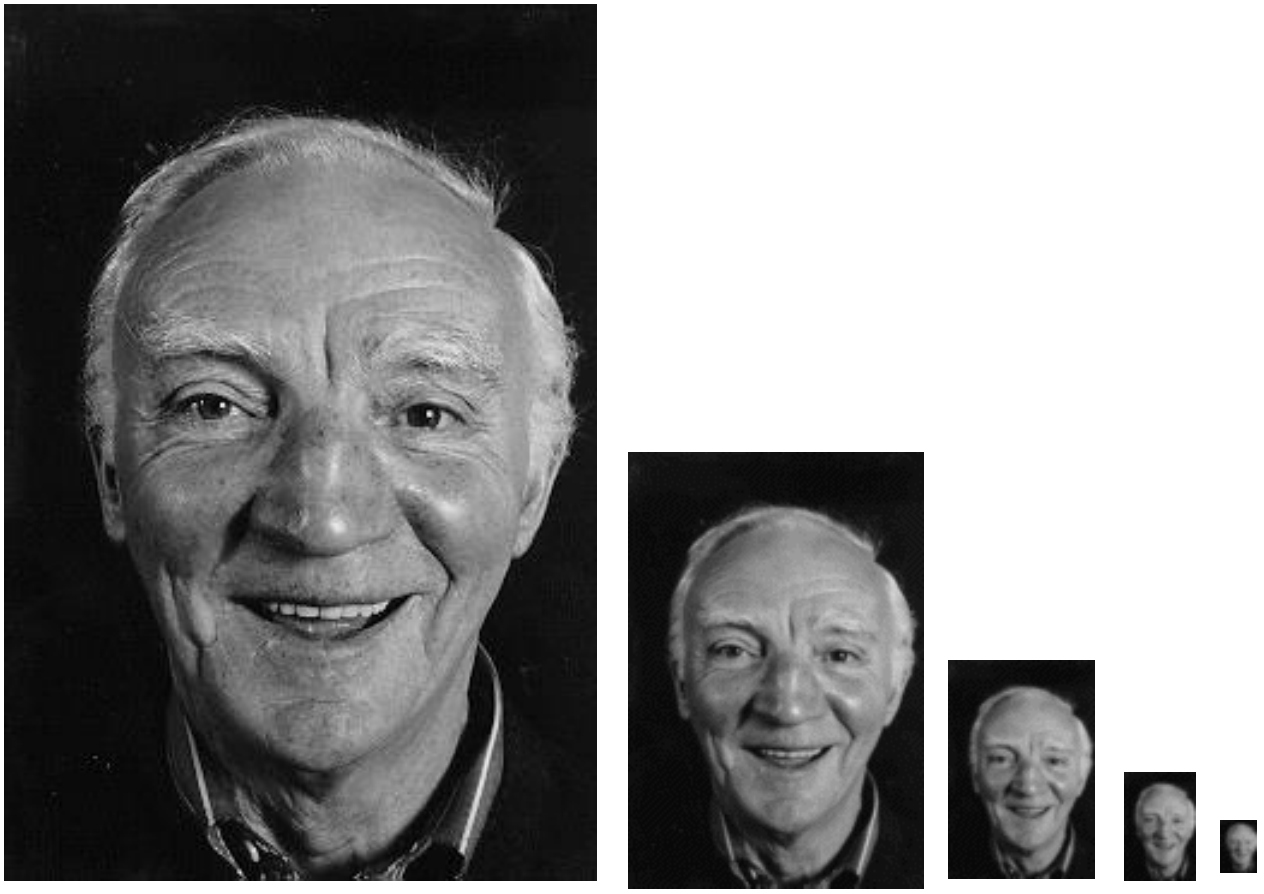
Figure 1.16 The first photograph on record, *la table servie*, obtained by Nicéphore Niepce in 1822. *Collection Harlinge–Viollet.*

- Pinhole Cameras
- Lenses
- Camera Parameters and Calibration

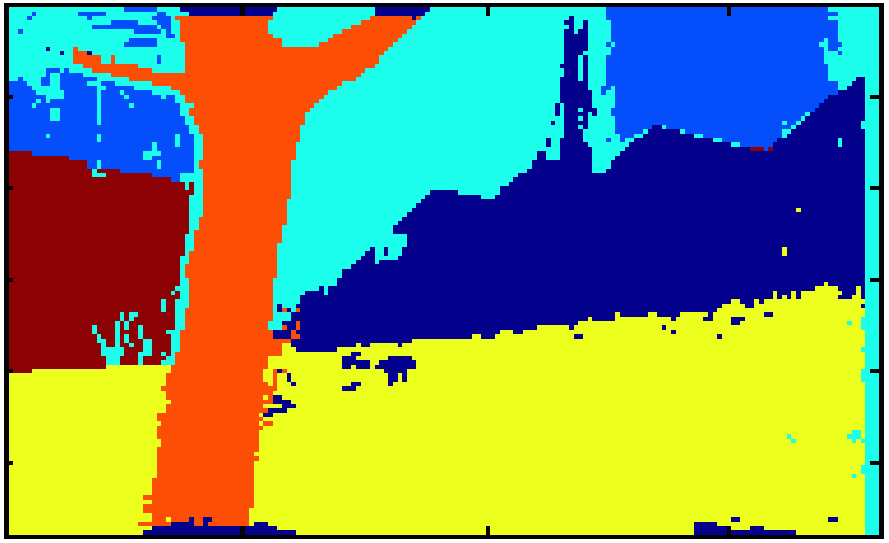
Image Filtering and Enhancing

- Linear Filters and Convolution
- Image Smoothing
- Edge Detection
- Pyramids

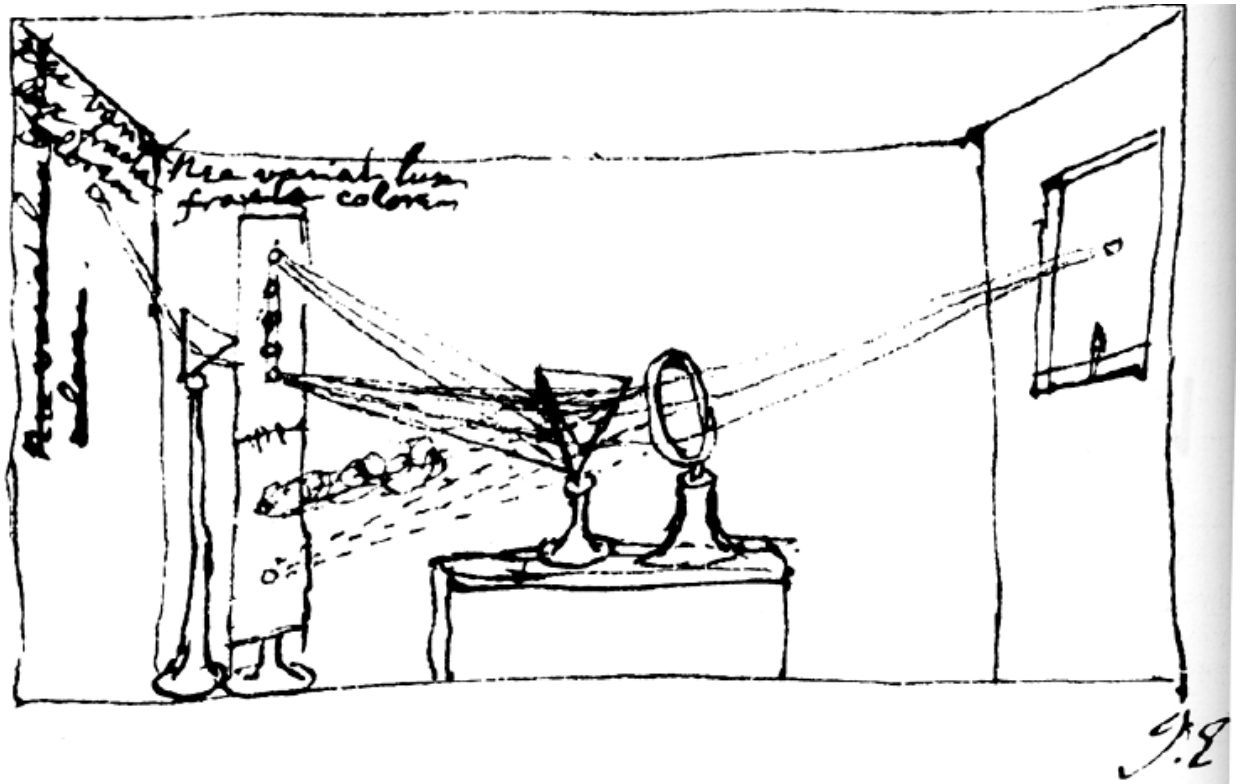
Image Filtering and Enhancing (cont.)



Region Segmentation



Color



4.1 NEWTON'S SUMMARY DRAWING of his experiments with light. Using a point source of light and a prism, Newton separated sunlight into its fundamental components. By reconverging the rays, he also showed that the decomposition is reversible.

Texture

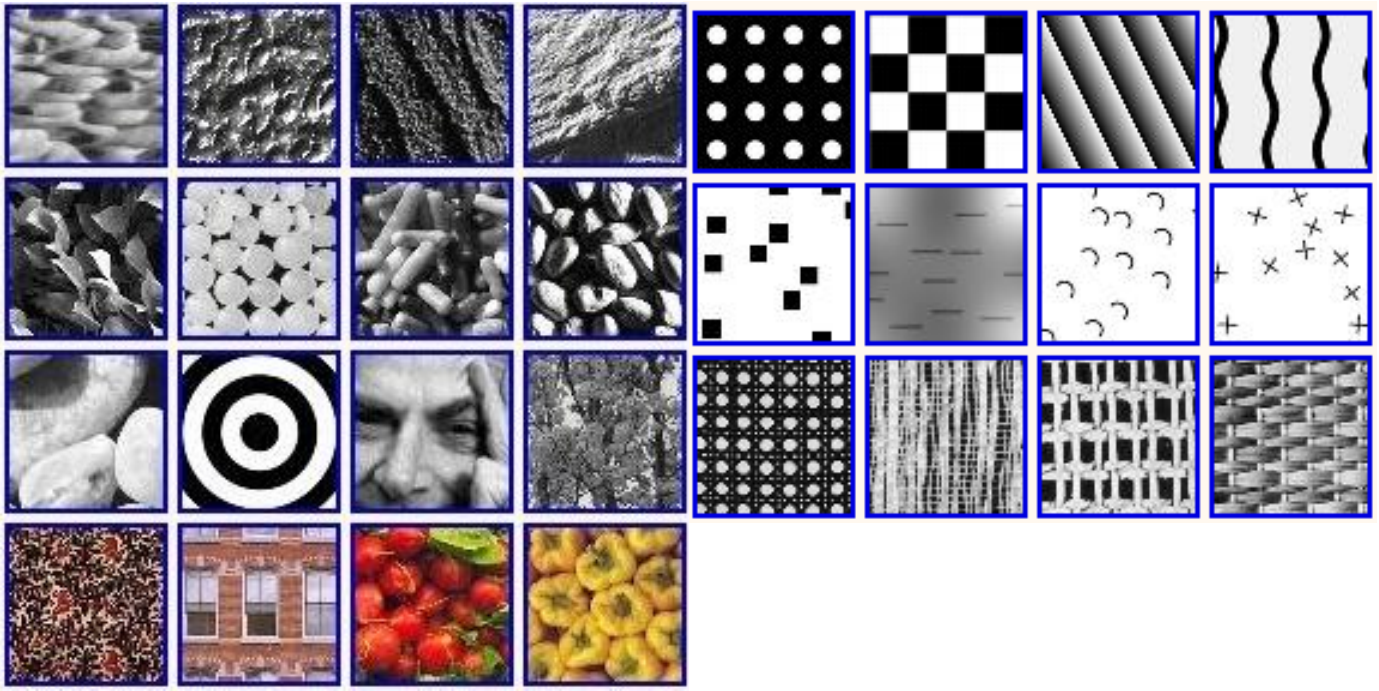
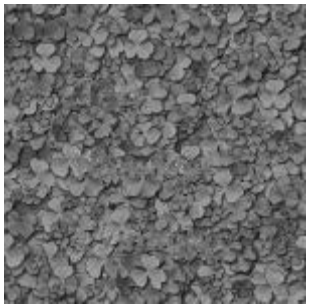
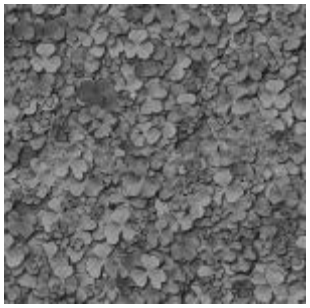


Image Restoration

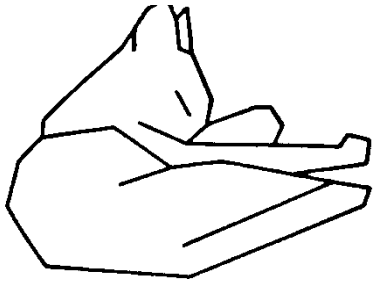


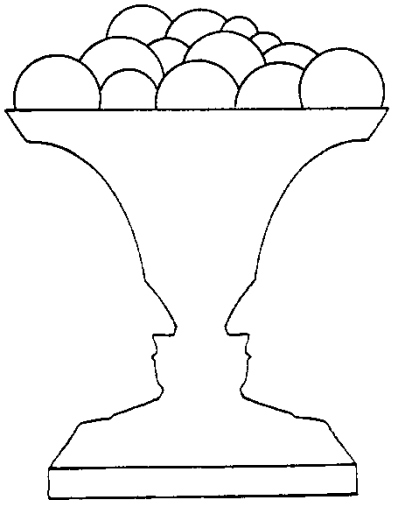
Original

Synthetic

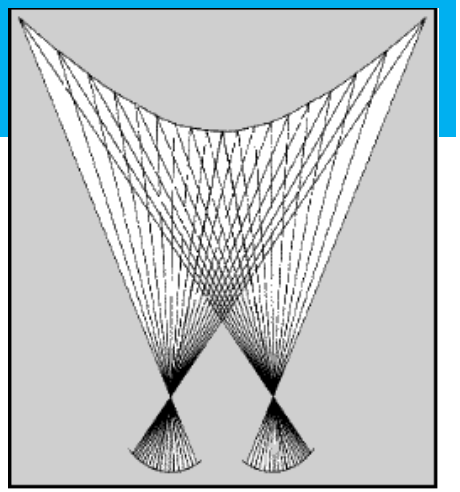


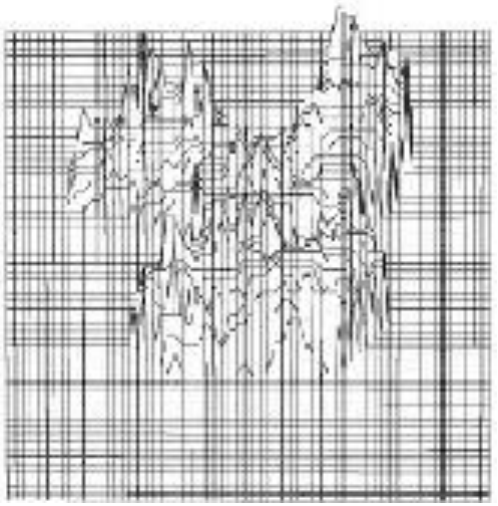
Shape Analysis



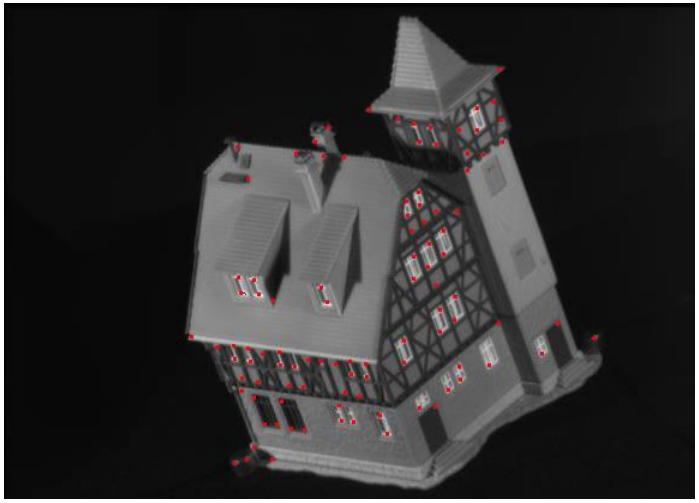


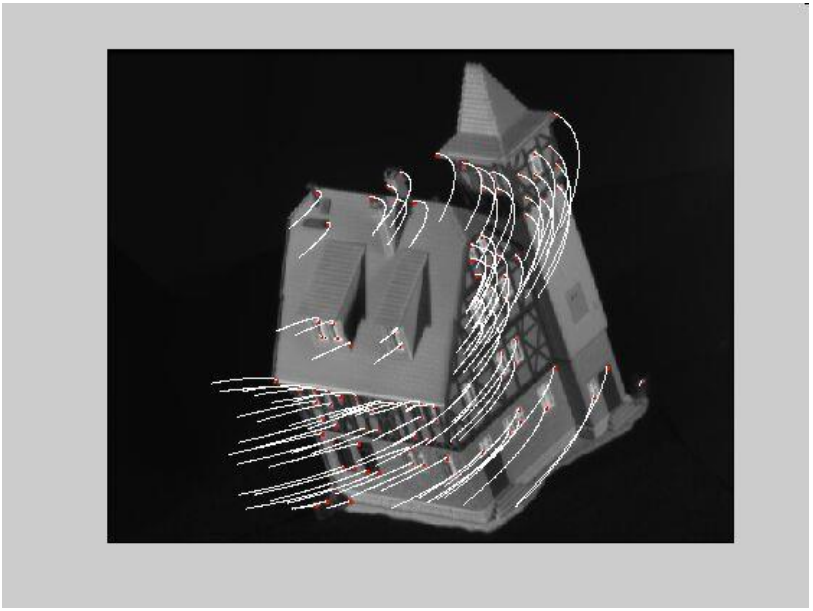
Stereo





Motion and Optical Flow





Course Syllabus (tentative)

Link: Course: Computer Vision(DE5) (nirmauni.ac.in)

https://lms.nirmauni.ac.in/course/view.php?id=5074

Course Assessment

Assessment scheme	CE				LPW		SEE
Component weightage	40%				20%		40%
	Class Test	Sessional Exam	Additional Test	Term Paper/ Innovative Assignment	Experiments	Viva Voce	
	35	35	35	30	75	25	100

Continuous Evaluation (CE), Laboratory and Project Work (LPW) & Semester End Examination (SEE)

Course Outcomes

- At the end of the course, students will be able to –
- Apply mathematical modeling methods for low, intermediate and high-level Image processing tasks.
- Comprehend the geometric relationships between 2D Images and the 3D world.
- Apply motion and shape analysis algorithms for computer vision applications.
- Perform experiments on computer vision problems

Course Topics

- Depth estimation and Multi-camera views
  - Projective geometry, Single-view and Multi-view geometry
  - Pinhole Camera model, camera calibration
- Basics of Image Processing and Feature Extraction
  - Fundamentals of Image formation, Image transformation and Image filtering, edge detection algorithms
- Image Segmentation
  - How can we group pixels into meaningful regions?
- Motion Analysis
- Shape from X
- Applications of Computer Vision

Textbook

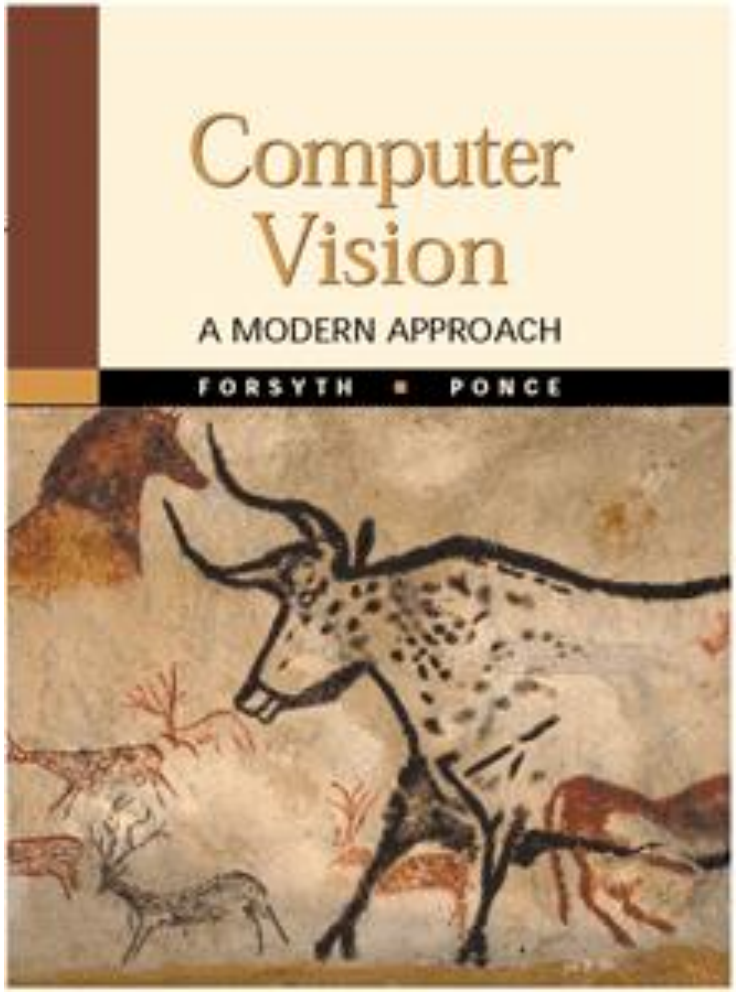
Computer Vision: Algorithms and Applications

© 2010 Richard Szeliski, Microsoft Research

http://szeliski.org/Book/

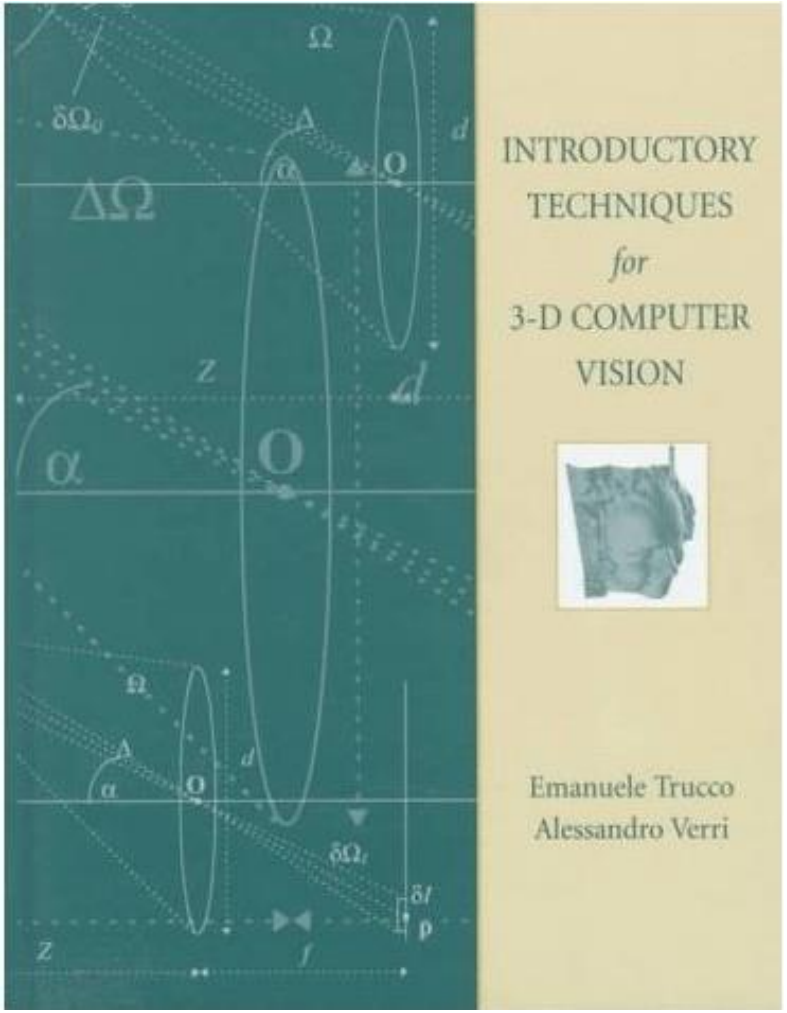
Optional Textbook

- Computer Vision: A Modern Approach, 2th Edition, by David Forsyth and Jean Ponce, Prentice Hall, 2003



Optional Textbook

- *Introductory Techniques for 3-D Computer Vision*, E. Trucco and A. Verri, Prentice Hall, 1998. ISBN 0-13-261108-2



Prerequisites

- **Linear algebra**, basic calculus, and probability
- Experience with image processing or Matlab will help but is not necessary

About You …

What do you know already?

- C/C++ (Visual C++)
- Matlab
- Images
- Python
- OpenCV

  http://sourceforge.net/projects/opencvlibrary/

  Install Python, Anaconda and OpenCV in your PC or laptop,

  Read the manual introduction

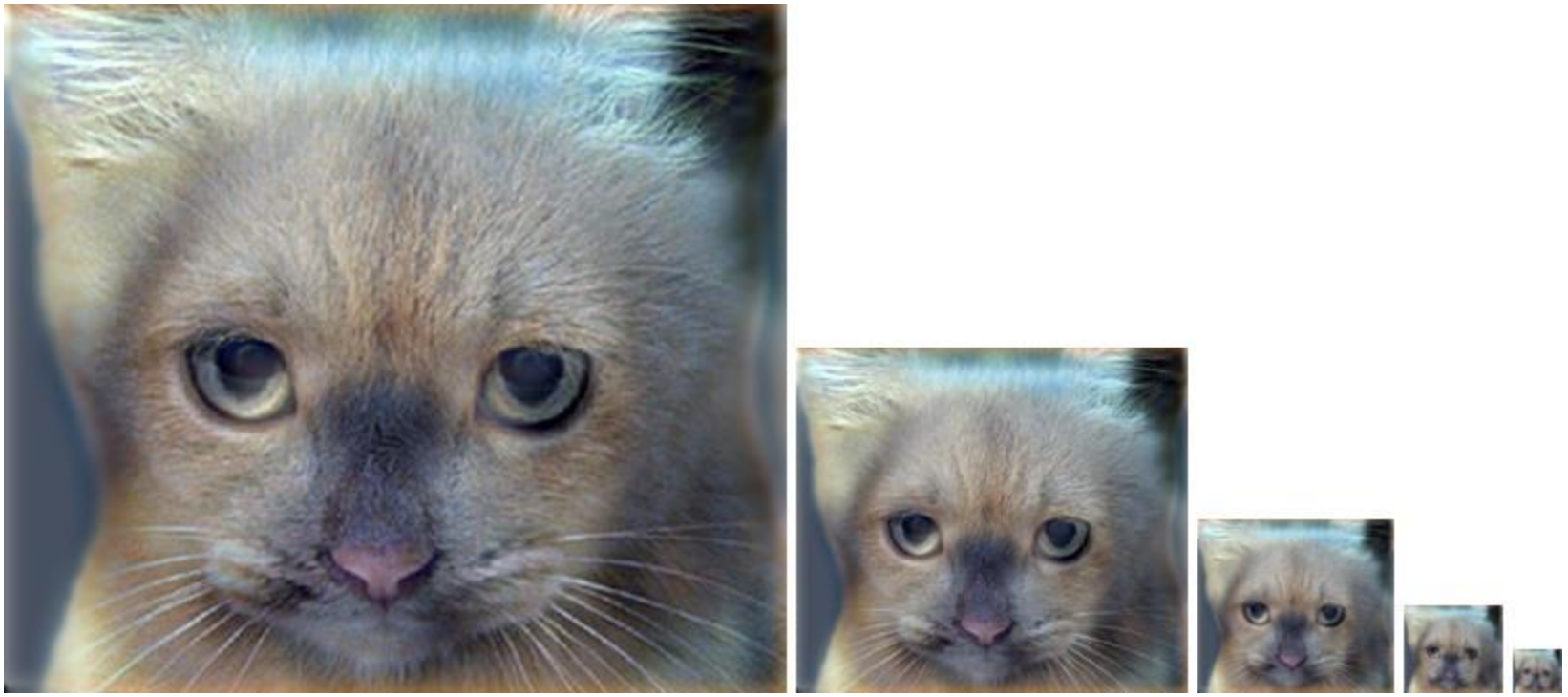
  Try to load and save images (homework #0)

Projects

- Image Filtering and Hybrid Images
- Local Feature Matching
- Camera Calibration and Fundamental Matrix Estimation with RANSAC
- Scene Recognition with Bag of Words
- Object Detection with a Sliding Window
- Recognition with Deep Learning

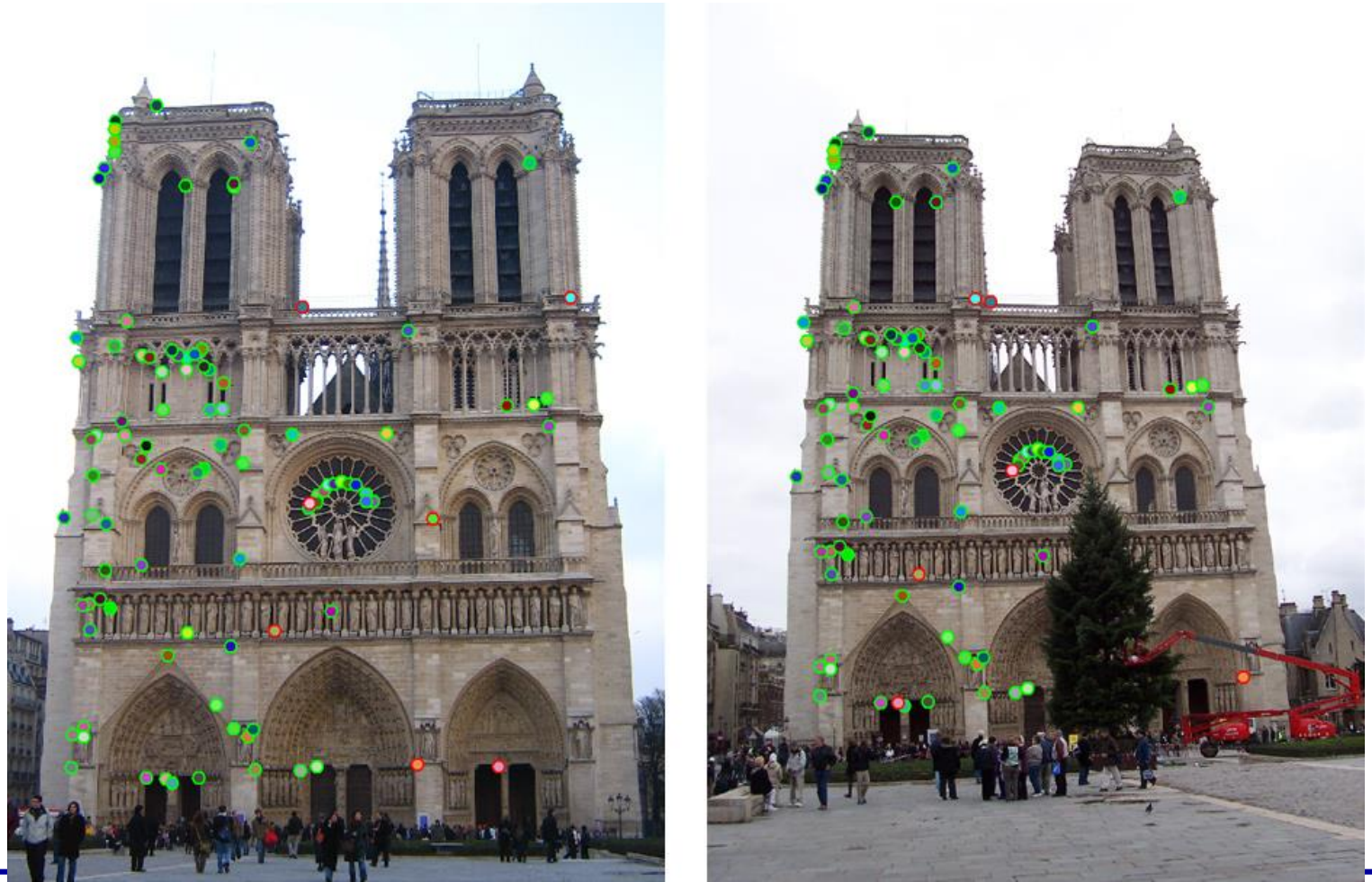
Project 1: Image Filtering and Hybrid Images

- Implement image filtering to separate high and low frequencies
- Combine high frequencies and low frequencies from different images to create an image with scale-dependent interpretation



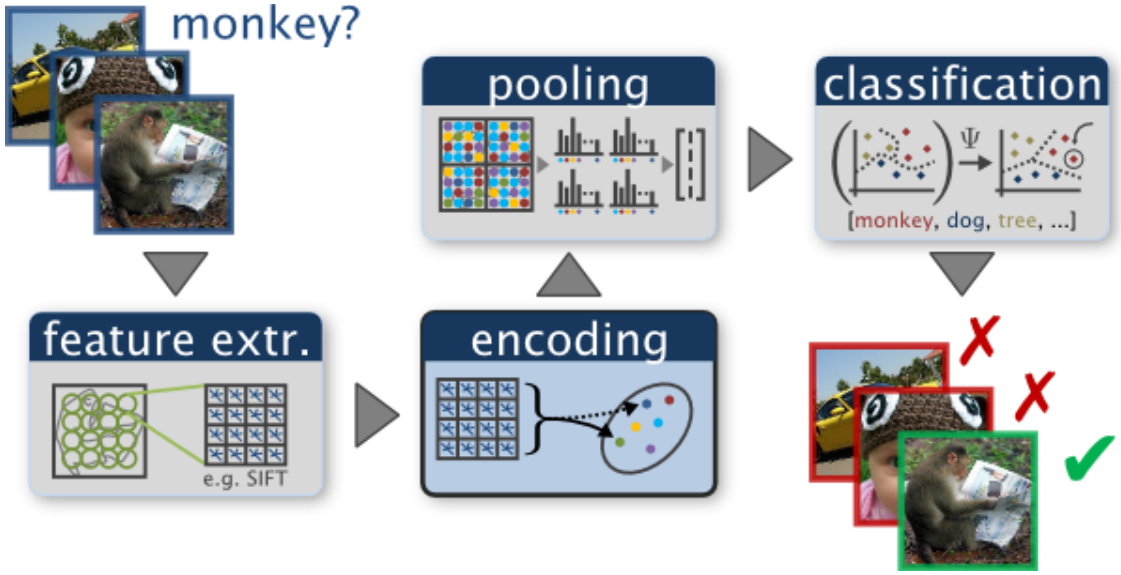
Project 2: Local Feature Matching

- Implement interest point detector, SIFT-like local feature descriptor, and simple matching algorithm.



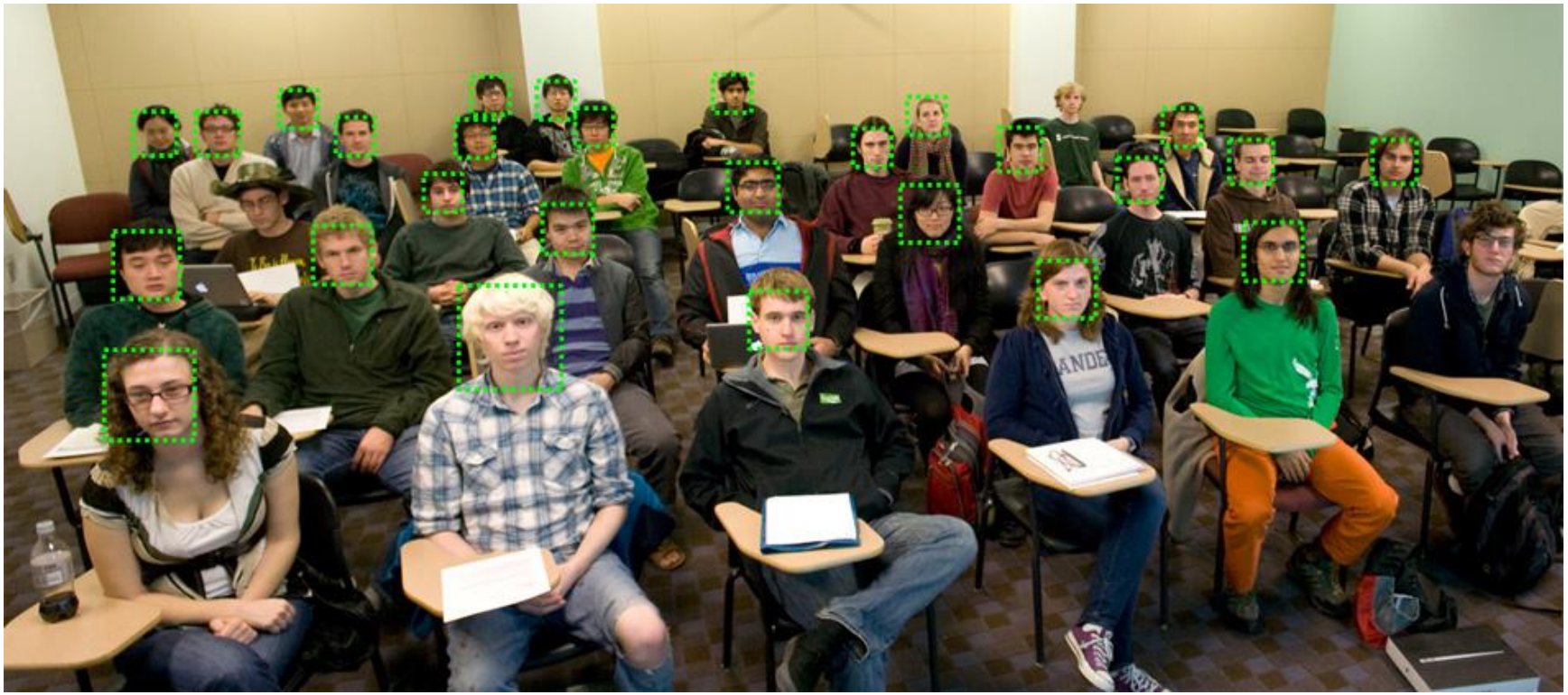
Project 3: Scene Recognition with Bag of Words

- Quantize local features into a “vocabulary”, describe images as histograms of “visual words”, train classifiers to recognize scenes based on these histograms.



Project 4: Object Detection with a Sliding Window

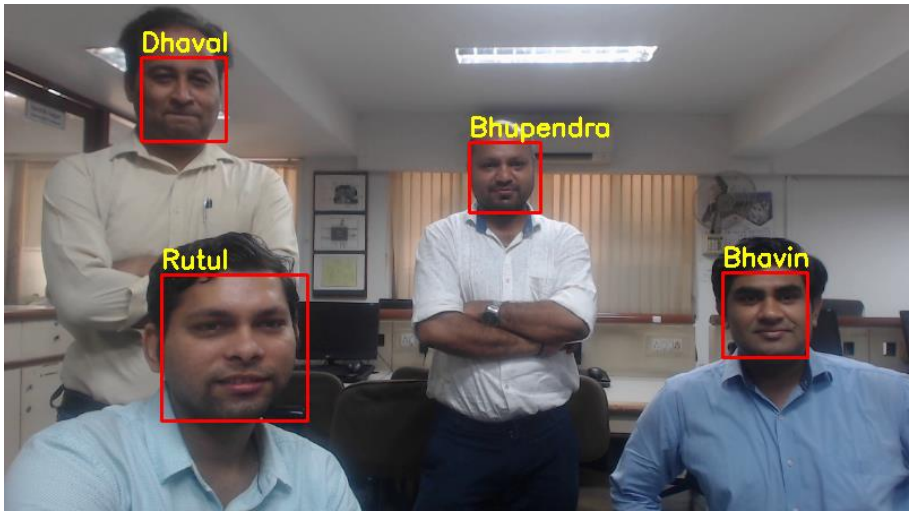
- Train a face detector based on positive examples and “mined” hard negatives, detect faces at multiple scales and suppress duplicate detections.

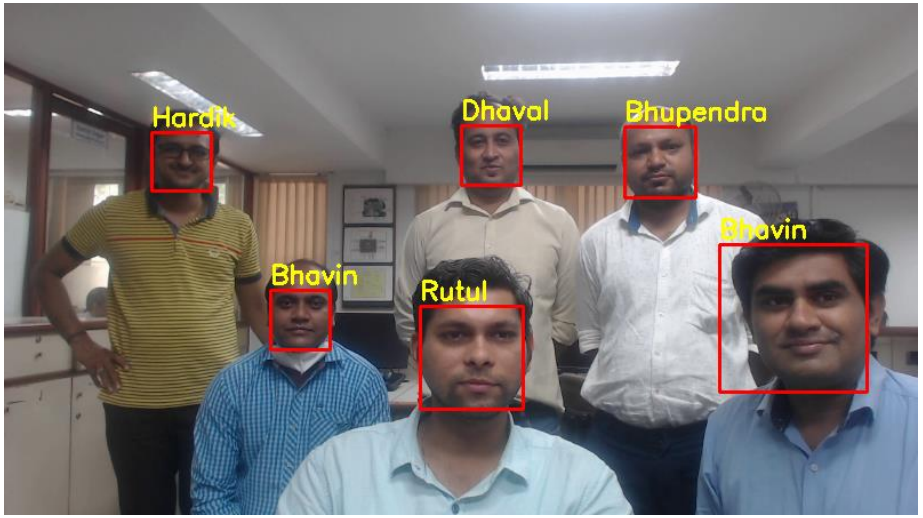


Project 5: panorama stitching

Indri Atmosukarto, 576 08sp

Project 6: Face Recognition





Final Project

- Open-ended project of your choosing
- (in teams of two)

Computer Vision Publications

- Journals
  - IEEE Trans. on Pattern Analysis and Machine Intelligence (TPAMI)
    - #1 IEEE, Thompson-ISI impact factor: 5.96
    - #1 in both electrical engineering and artificial intelligence
    - #3 in all of computer science
  - Internal Journal of Computer Vision (IJCV)
    - ISI impact factor: 5.358, Rank 2 of 94 in “CS, artificial intelligence
  - IEEE Trans. on Image Processing
  - …

Importance of CV

- From these major journal rankings, we can see the importance of Computer Vision research in the whole areas of
  - Computer Science
  - Electrical Engineering

Computer Vision Publications

- Conferences
  - International Conference on Computer Vision (ICCV), once every two years
  - Conf. of Computer Vision and Pattern Recognition (CVPR), once a year
  - Europe Conference on Computer Vision (ECCV), once every two years
  - …

Thank you