CSE 527: Intro. to Computer Vision

www.cs.sunysb.edu/~cse527

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CSE 527: Intro. to Computer Vision

- **Prerequisites:**
  Signal Processing
  Linear Algebra and Probability
  Familiarity with Matlab
- **Textbooks and Reading material:**
  Computer Vision: A Modern Approach, David Forsyth and Jean Ponce., Prentice Hall, 2003.
  Robot Vision, Berthold Horn
  Selected journal articles

Grading

Problem Sets (~6) with lab exercises in Matlab. **Problem sets may be discussed, but all written work and coding must be done individually.**	**30%**	**30%**
Two take-home exams. **(Take-home exams may not be discussed.)**	**40%**	**0%**
No final exam	**0%**	
Final Project: –An original implementation of a new or published idea –A detailed empirical evaluation of an existing implementation of one or more methods **Project proposal not longer than two pages must be submitted and approved before the end of March.**	**30%**	**70%**

Internet Resources

- **Matlab:**
  University of Colorado Matlab Tutorials
  - A decent collection of Matlab tutorials, including one focusing on image processing.

  Matlab Image Processing Tutorial
  - A short introduction to the manipulation of images in Matlab, including an introduction to principal components analysis via eigenfaces.
- **Computer Vision:**
  Computer Vision Homepage
  Face Recognition Homepage
  Face Detection Homepage

Vision

- **What does it mean, to see?**
  "to know what is where by looking".
- **How to discover from images**
  what is present in the world,
  where things are,
  what actions are taking place.

from Marr, 1982

Vision Problems

- **Recognize objects**
  people we know
  things we own
- **Locate objects in space**
  to pick them up
- **Track objects in motion**
  catching a baseball
  avoiding collisions with cars on the road
- **Recognize actions**
  walking, running, pushing

Why study Computer Vision?

- **Images and movies are everywhere**
- **Fast-growing collection of useful applications**
  - building representations of the 3D world from pictures
  - automated surveillance (who's doing what)
  - movie post-processing
  - HCI
  - face finding
- **Various deep and attractive scientific mysteries**
  how does object recognition work?
- **Greater understanding of human vision**

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Structure from Motion
(Tomasi and Kanade 1992)

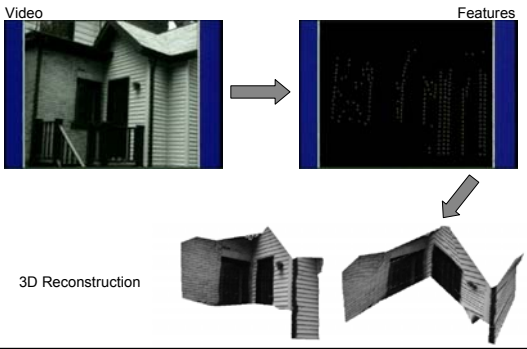
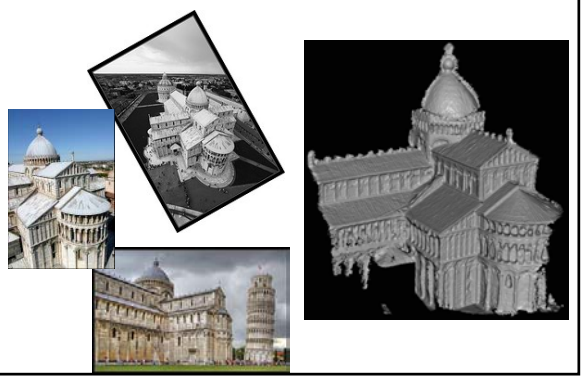


Photo Collections



Panoramic imaging

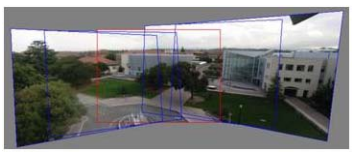
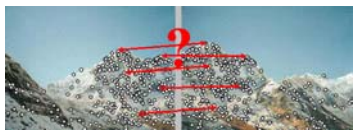


Image and video registration



Spatial warping operations

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Tracking

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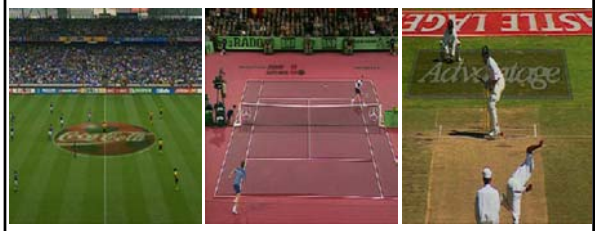
Detect ground plane in video and introduce pictures on them



Insert new objects

Video example: http://break.com/index/ufo-lands-on-guys-desk.html

Video Summary

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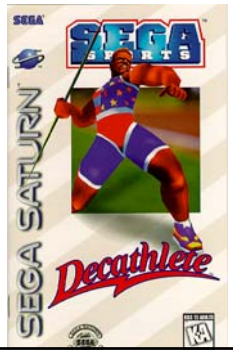
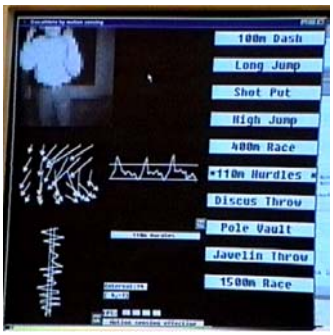
Game: Decathlete



Optical-flow-based Decathlete figure motion analysis



Decathlete javelin throw

Decathlete javelin throw

Decathlete 100m hurdles

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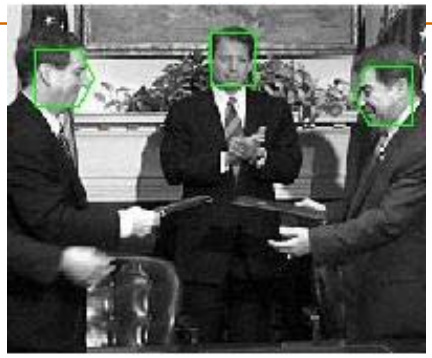
http://www.ri.cmu.edu/projects/project_271.html



http://www.ri.cmu.edu/projects/project_320.html

Nintendo Game Boy Ca

- **Several million sold (most of any digital camera). Imaging chip is Mitsubishi Electric's "Artificial Retina" CMOS detector.**

Black or White

- **Face Detection**
- **Face Localization**
- **Segmentation**
- **Face Tracking**
- **Facial features localization**
- **Facial features tracking**
- **Morphing**

www.youtube.com/watch?v=ZI9OYMRwN1Q

Course Outline

- **Cameras, lenses, and sensors**
- **Radiometry**
- **Color**
- **Low level vision**

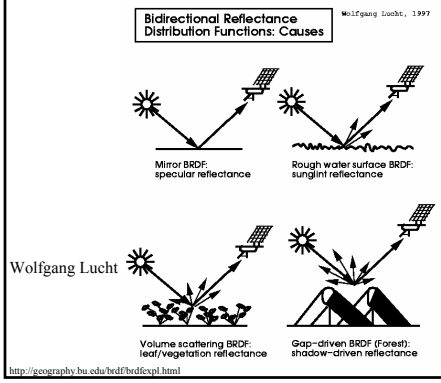
Cameras, lenses, and sensors

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

- Pinhole cameras
- Lenses
- Projection models
- Geometric camera parameters

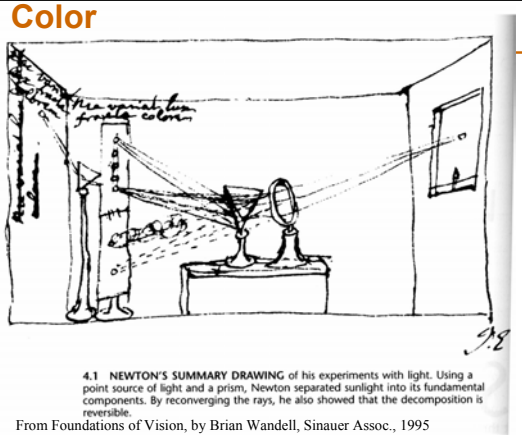
From Computer Vision, Forsyth and Ponce, Prentice-Hall, 2002.

Radiometry



http://geography.bu.edu/brdf/brdfexpl.html

Color



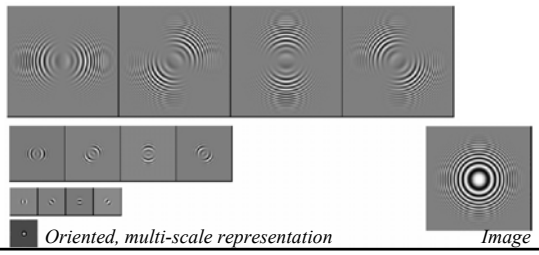
4.1 NEWTON'S SUMMARY DRAWING of his experiments with light. Using a point source of light and a prism, Newton separated sunlight into its fundamental components. By reconverging the rays, he also showed that the decomposition is reversible.

From Foundations of Vision, by Brian Wandell, Sinauer Assoc., 1995

Low-level vision

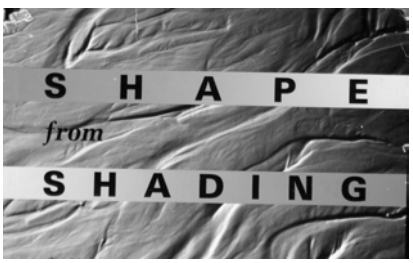
Image filtering

- **Review of linear systems, convolution**
- **Bandpass filter based image representations**
- **Probabilistic models for images**



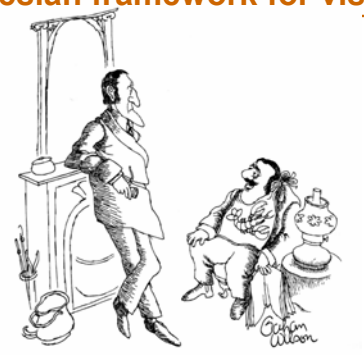
Oriented, multi-scale representation *Image*

Shape from shading



Shape from shading, Horn and Brooks, MIT Press, 1986

Bayesian framework for vision



"Good lord, Holmes! How did you come to know I'd seafood for lunch?"

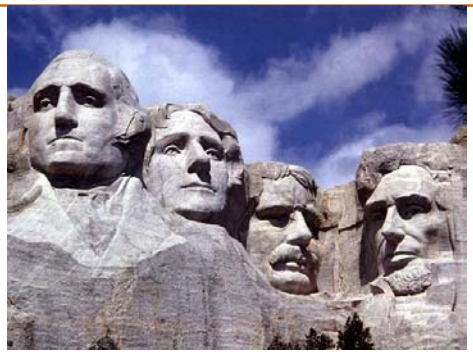
Gahan Wilson's Still Weird, Forge, 1994

Bayesian framework for vision

Coincidental appearance of face profile in rock?

http://www.cs.dartmouth.edu/whites/old_man.html

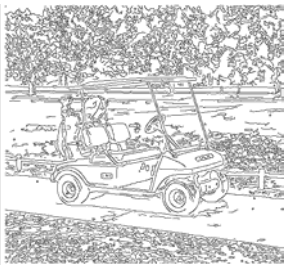
Bayesian framework for vision



Coincidental appearance of faces in rock?

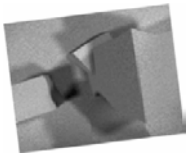
http://bensguide.gpo.gov/3-5/symbols/print/mountrushmore.html

Edge detection and optical flow

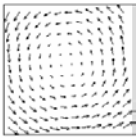


M. Heath, S. Sarkar, T. Sanocki, and K.W. Bowyer, "A Robust Visual Method for Assessing the Relative Performance of Edge-Detection Algorithms" IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 19, No. 12, December 1997, pp. 1338-1359.

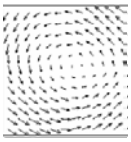
Edge detection and optical flow



Images



True optical flow



Estimated optical flow

in "Statistical Theories of the Brain", edited by R. Rao, B. Olshausen, and M. Lewicki, MIT Press, 2001

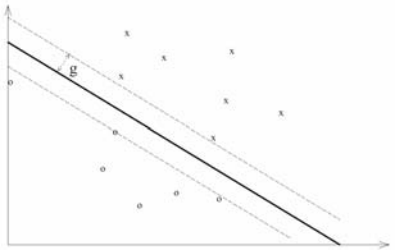
Learning and vision

Statistical classifiers

MIT Media Lab face localization results.

Applications: database search, human machine interaction, video conferencing.

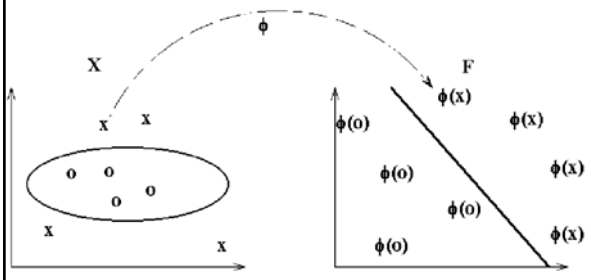
Support vector machines and boosting



Large-margin classifier

www.support-vector.net/nello.html

Support vector machines and boosting



"The kernel trick"

www.support-vector.net/nello.html

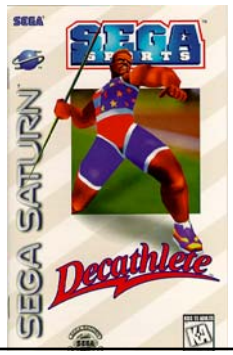
Applications

- **Computer vision for computer games**

Computer vision applications as ocean-going vessels

this application

Game: Decathlete



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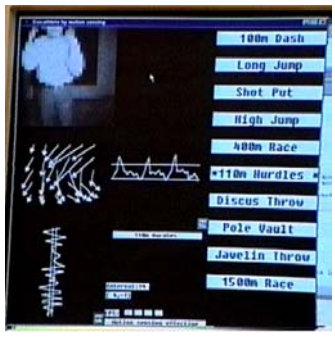

Decathlete 100m hurdles

Next

Image formation & camera basics