CSE 527: Intro. to Computer Vision
www.cs.sunysb.edu/~cse527

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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 – auto navigation
- 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)
  - face finding
  - movie post-processing
  - HCI
- 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)

Video
Features
3D Reconstruction
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http://www.ri.cmu.edu/projects/project_271.html
Nintendo Game Boy Camera

- Several million sold (most of any digital camera). Imaging chip is Mitsubishi Electric’s “Artificial Retina” CMOS detector.

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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
Black or White

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

www.youtube.com/watch?v=ZI9OYMRwN1Q

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Game: Decathlete

Decathlete javelin throw

Optical-flow-based Decathlete figure motion analysis

Decathlete javelin throw
PART I: 2D Vision

- Image Formation
  - Cameras, Lenses, and Sensors
  - Color and Image Statistics

- Appearance-Based Methods
  - Statistical Linear Models: PCA, ICA, FLD
  - Non-negative Matrix Factorization, Sparse Matrix Factorization
  - Statistical Tensor Models: Multilinear PCA, Multilinear ICA
  - Person and Activity Recognition

- Feature Extraction
  - Linear filters and edges
  - Feature extraction (corners and blobs)
  - Representations: Gaussian Pyramids, Laplacian Pyramids, Steerable Pyramids
  - Application: face detection

- 2D Shape Models
  - Physically Based Models:
    - Mass-Spring Systems
    - Active Contours (Snakes) - energy minimization, regularization
  - Statistical Shape Models
  - Active Shape Models
  - Active Appearance Models
  - Kalman Filters
  - Particle Filters
  - Mean Shift
PART II: 3D Vision

- Estimation of 3D Geometry:
  - Camera calibration, Epipolar Geometry
  - Stereo, Multi-View Geometry
  - Shape from Shading
  - Structure from Motion, Optical Flow
  - Surface Reconstruction – energy minimization, regularization

General Comments

- Prerequisites:
  - Linear Algebra!!!
  - Some image processing, signal processing is useful, but not required

- Emphasis on programming projects!
  - Building something from scratch (Matlab!)

- Textbooks and Reading material:
  - Robot Vision, Berthold Horn
  - Selected journal articles

Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Problem Sets (~6) with lab exercises in Matlab</th>
<th>One take-home exam</th>
<th>Class Participation</th>
<th>Final Project</th>
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</thead>
<tbody>
<tr>
<td>Weight</td>
<td>40%</td>
<td>20%</td>
<td>10%</td>
<td>30%</td>
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<tr>
<td></td>
<td>Problems may be discussed, but all written work and coding must be done individually.</td>
<td>(Take-home exams may not be discussed.)</td>
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- An original implementation of a new or published idea
- A detailed empirical evaluation of an existing implementation of one or more methods
- 5-10 page report
- Project proposal not longer than two pages must be submitted and approved before the end of March.

Administrative Stuff

- Late Policy
  - Seven late days total, to be spent wisely

- Cheating
  - Let’s not embarrass ourselves
  - All resources must be acknowledged

- Software
  - MATLAB!!

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

Introductions

- Name, year, supervisor
- Why do you want to take this class?
- What are you hoping to learn?