CMPE 264  Image Analysis and Computer Vision

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What is computer vision?

- Computing geometric and dynamic properties of the 3D world from one or more digital images (Trucco & Verri)
- A machine vision system recovers useful information about a scene from its two-dimensional projections. Vision = Geometry + Measurement + Interpretation (R. Jain, R. Kasturi, & B. Schunck)
- The goal of computer vision is to make useful decision about real physical objects and scenes based on sensed images (L.G. Shapiro & G.C. Stockman)
What information to recover?

- 2D image features
- 2D and 3D scene geometry
- 2D and 3D scene motion
- Identify, locate, and track objects
- Object recognition
- Understand activities
Image feature detection

- Facial feature detection

Courtesy of Antonio Colmenarez, Philips Research Lab.
Image segmentation

- Watershed segmentation

Original Thresholding

Watershed Super-imposed
Recover 2D and 3D scene geometry

- Image modeling from single image

VRML demo of the reconstructed model

Courtesy of Dr. Antonio Criminisi, Microsoft Research. La Flagellazione di Cristo (1460), Urbino, Galleria Nazionale delle Marche by Piero della Francesca (1416-1492).
Recover 2D and 3D scene geometry

- Image based modeling from multiple views

VRML demo of the reconstructed model

Courtesy of Marc Pollefeys, K.U.Leuven - ESAT/PSI, Belgium.
Recover 2D and 3D scene geometry

- From multiple images to 3D geometry, e.g. Fountain

Courtesy of Marc Pollefeys, K.U.Leuven - ESAT/PSI, Belgium.
Recover 2D and 3D motion

- 2D optical flow

Synthetic sequence “Yosemite”

Optical flow in frame 11

Courtesy of Shanon X. Ju, Michael J. Black, Allan D. Jepson.
Object detection and location

- Example: detecting face in an image

Courtesy of Paul Viola and Mike Jones, MERL.
Object tracking

- Tracking = correspondence + constraints + estimation
- Example: human tracking
Object recognition

- Face recognition

FERET face database.
Face recognition

- Subspace face recognition

$p, g \xrightarrow{\Omega_i} - \xrightarrow{\|\Delta\|^{-k}} S(p,g)$
Face recognition

- Eigenface

Courtesy of Matthew Turk and Alex Pentland
Activity monitoring

- Understand activities from object tracking in multiple views

Courtesy of MIT AI Lab
Activity monitoring

- Combining data from multiple cameras

Courtesy of MIT AI Lab
Activity monitoring

- Object classification: people or car, male or female
- Activity classification/clustering
- Retrieval: e.g. all the persons came in the building around 4:00 pm
- Outlier detection: odd activities
Applications

- Industrial inspection and quality control
- Surveillance and security
- Face detection and recognition
- Gesture recognition
- Traffic monitoring
- Image database
- Medical imaging
- Autonomous vehicles
- Vision-based graphics
- and many more …
Related fields

- **Image processing**
  - 2D Low level image transformation and processing. Used in low level vision for enhancing and extracting features such as points, lines, contours, and regions.

- **Computer graphics**
  - Synthesize images using geometric primitives, physical properties of objects, and illumination conditions. It is the inverse of computer vision. Vision-based graphics is becoming popular.

- **Photogrammetry**
  - Study the geometric relationship between 3D scenes and their 2D projections to obtain accurate measurements from noncontact imaging.

- **Pattern recognition and machine learning**
  - Statistical and syntactical techniques for classifying patterns. The techniques are widely used in computer vision, especially in object detection and recognition.

- **Artificial Intelligence**
  - Computational intelligence that includes perception, cognition, and action. Computer vision can be viewed as a subfield of AI
Syllabus

1. Introduction
2. Image and video acquisition
3. Camera model I
4. Image features - edge, corners, lines, Hough Transform, deformable contours
5. Camera model II and calibration
6. 3D camera motion estimation
7. Stereopsis
8. 2D motion analysis - optical flow estimation, differential techniques
9. Shape from X - reflection model, shape from shading, shape from texture, shape from defocusing and focusing
10. Tracking - Kalman filtering, correlation-based tracking, change-based tracking, 2D layer tracking, tracking of articulated objects
11. Image segmentation
12. Object recognition - Feature, invariants, subspace method, face detection and recognition
Course information

Evaluation:
- Homework - 20%
- Midterm - 35%
- Final project - 45%

Final project:
- Proposal due by Oct. 26, 2006

Programming tools
- Matlab, C++

Web page
- http://www.soe.ucsc.edu/classes/cmpe264/Fall06
Homework

- Write Matlab programs to
  - read a BMP color image
  - display a color or gray image
  - write an image to a file