



# CMPE 264 Image Analysis and Computer Vision

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## What is computer vision ?

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- 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 ?

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- 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



(a) Test Image



(b) Feature Image

(c) Low-Level Features

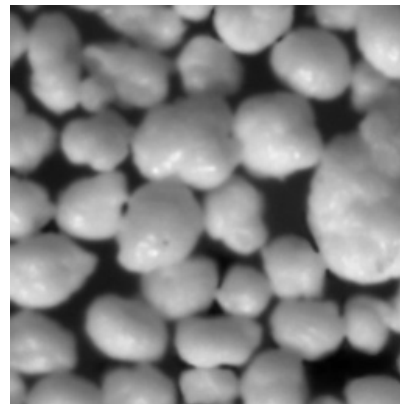
(d) Likelihood Maps

Courtesy of Antonio Colmenarez, Philips Research Lab.

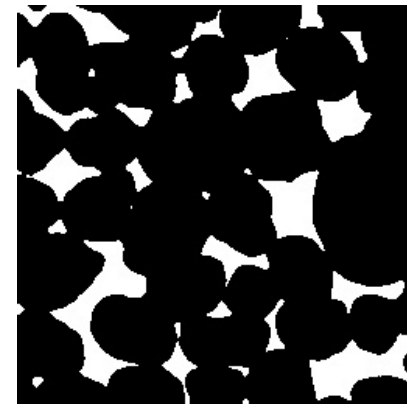


# Image segmentation

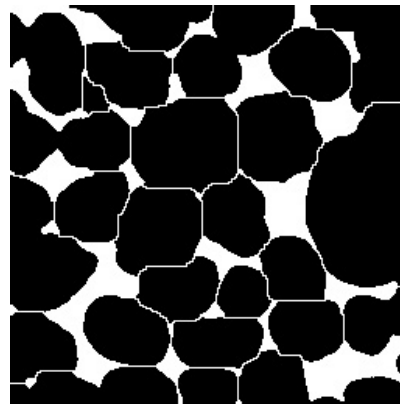
- Watershed segmentation



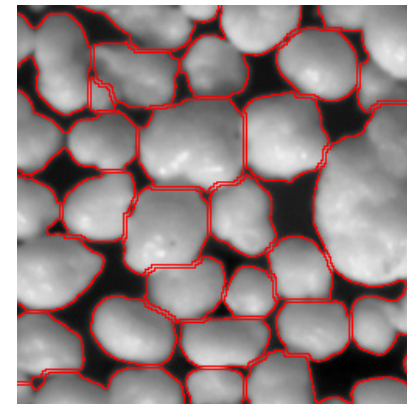
Original



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

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- Image based modeling from multiple views



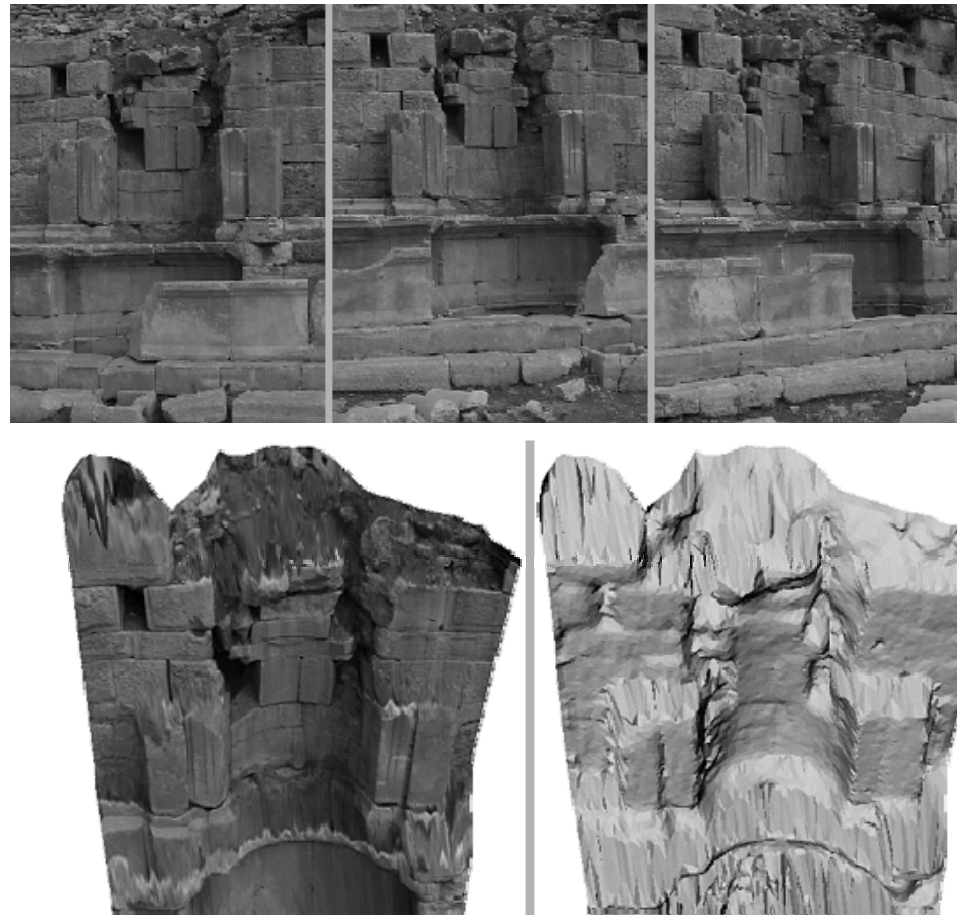
[VRML demo of the reconstructed model](#)

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

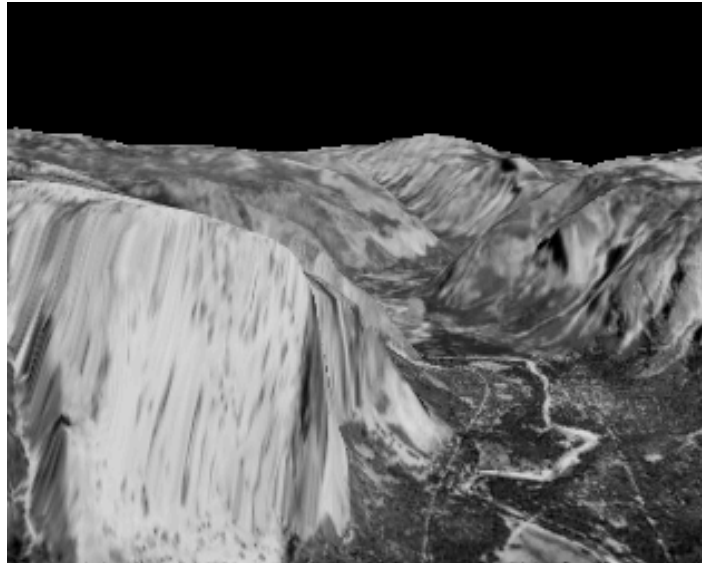


Courtesy of Marc Pollefeys, K.U.Leuven - ESAT/PSI, Belgium.

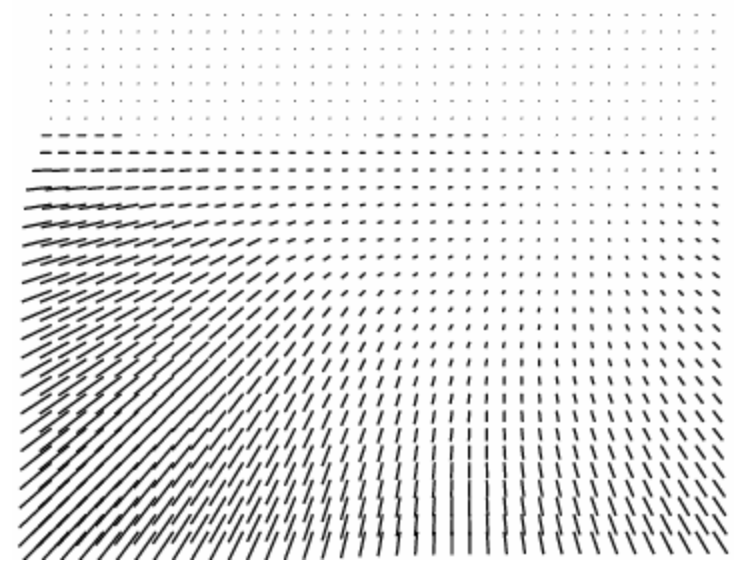


# Recover 2D and 3D motion

- 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

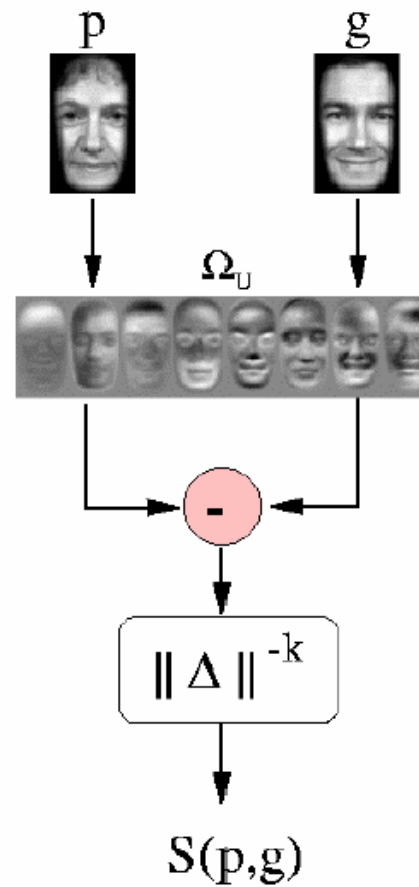


FERET face database.



# Face recognition

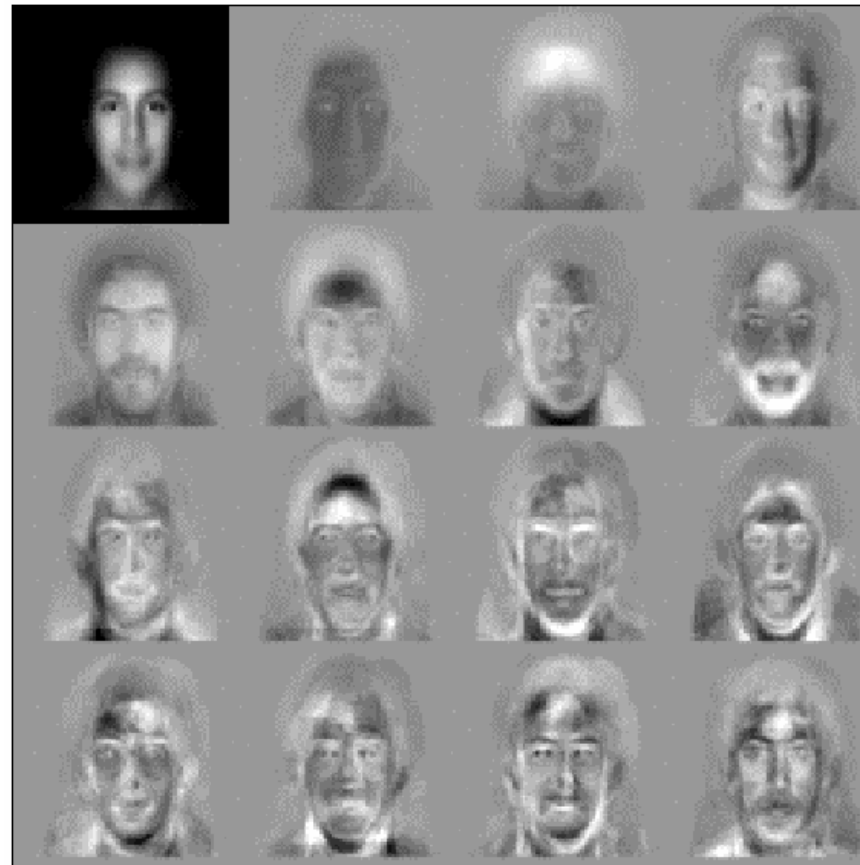
- Subspace face recognition





# Face recognition

- Eigenface

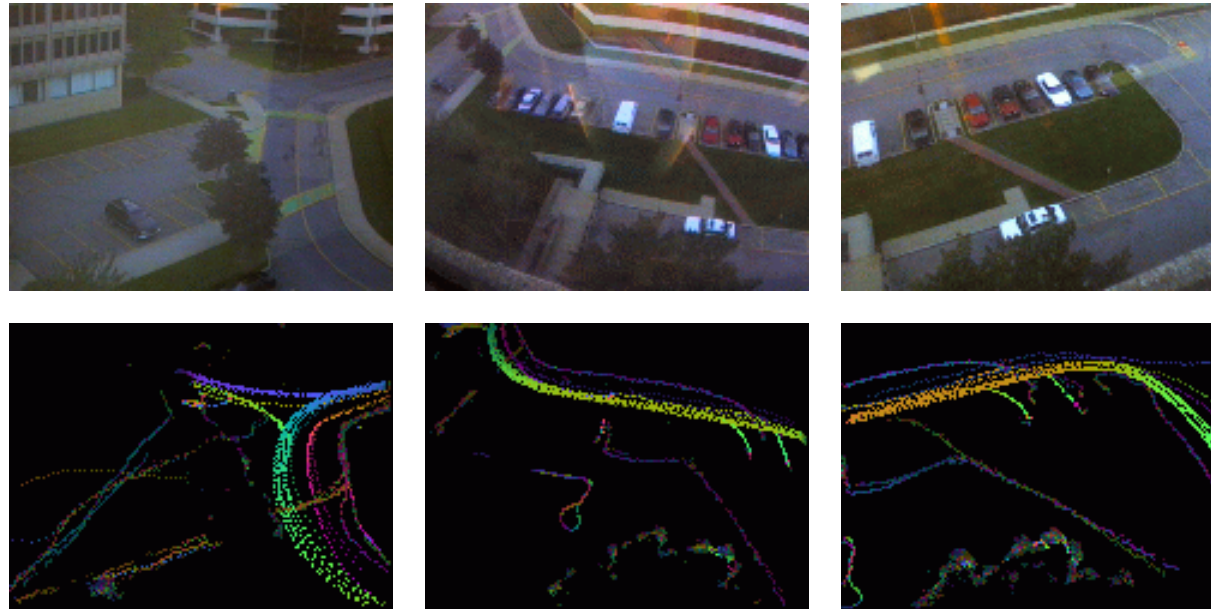


Courtesy of Matthew Turk and Alex Pentland



# Activity monitoring

- Understand activities from object tracking in multiple views

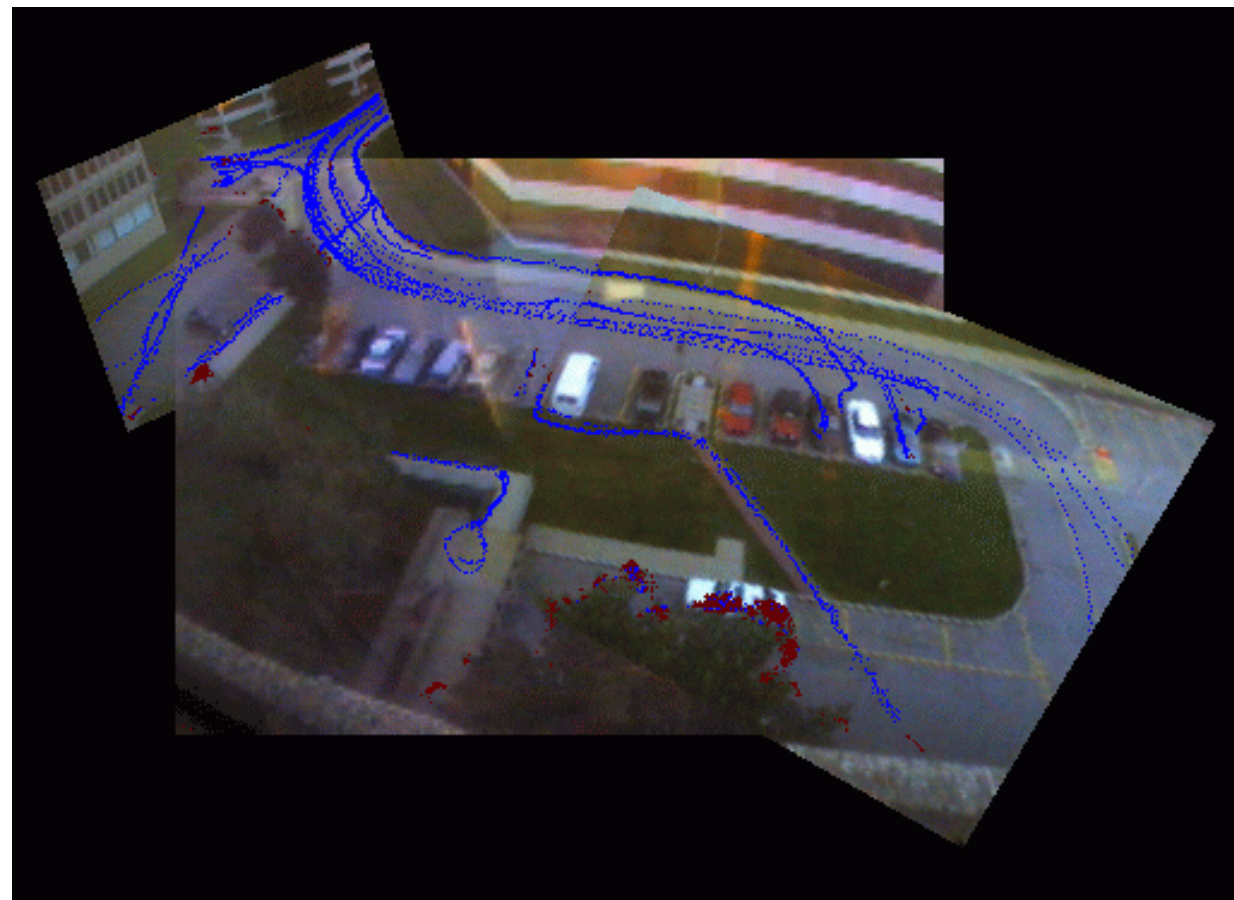


Courtesy of MIT AI Lab



# Activity monitoring

- Combining data from multiple cameras



Courtesy of MIT AI Lab



# Activity monitoring

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- 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

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- 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

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- 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

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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

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## 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

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