CmpE 537  
Computer Vision  

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Room 28

Aim of this course

• Introduce the basic applications and concepts of computer vision  
• Review techniques for segmentation, feature extraction, object recognition  
• Introduce more advanced topics such as motion and 3D

Textbook


Other texts available in the library:

– Forsyth and Ponce, Computer Vision  
– Computer Vision, Shapiro and Stockman,  
– Computer and machine vision, Haralick and Shapiro  
– Machine vision, Jain, Kasturi & Schunck  
– Digital Image Processing: Gonzalez& Woods  

Tentative schedule

• Introduction, applications  
• human visual system, color imaging geometry, camera calibration, image formation  
• Stereo, range, imaging devices, illumination.  
• Basic image processing operations; edge detection  
• Segmentation  
• Representation: Feature extraction  
• Object recognition  
• Motion and tracking

Topics in the book

• Chap. 2 Image formation  
• Chap 3 Image processing  
• Chap 4 Feature detection and matching  
• Chap 5 Segmentation  
• Chap 8 Dense motion estimation  
• Chap 14 Recognition: Applications
Grading

- Homeworks 30%
- Term Project 30%
- Final exam 40%

There will be a term project. The students will prepare a short survey related to the term project and give a short presentation, by the fourth week of the semester. They will propose an implementation or simulation related to the topic and carry it out until the last week. Then, the project presentations will be done the last week of the semester.

What is Computer Vision?

- Extract information about images

What is Image Processing?

- Image enhancement
- Image restoration
- Image filtering
- Image compression

Typical Computer Vision System

- Preprocessing: Filtering, Enhancement
- Segmentation: images in, boundaries and regions out
- Feature extraction: images in; patterns out
- Classification: Classify into one of predetermined classes

Application Areas

- Remote sensing
- Forensics; biometry / surveillance
- Military
- Biomedical imaging applications
- Human computer interaction
- Smart environments / smart cities / smart homes
- Inspection / quality control
- Robotics

What is computer vision?

Terminator 2
Every picture tells a story

- Goal of computer vision is to write computer programs that can interpret images

Can computers match (or beat) human vision?

- Yes and no (but mostly no!)
  - Humans are much better at “hard” things
  - Computers can be better at “easy” things

Human perception has its shortcomings…

Sinha and Poggio, Nature 1996

Current state of the art

- The next slides show some examples of what current vision systems can do

Earth viewers (3D modeling)

Image from Microsoft’s Virtual Earth

Photosynth
http://labs.live.com/photosynth/
Based on Photo Tourism technology, developed here in CSE!
by Noah Snavely, Steve Seitz, and Rick 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

Face detection
• Many new digital cameras now detect faces
  – Canon, Sony, Fuji, ...

Smile detection?

Object recognition (in supermarkets)
LaneHawk by EvolutionRobotics
“A smart camera is flush-mounted in the checkout lane, continuously watching for items. When an item is detected and recognized, the cashier verifies the quantity of items that were found under the basket, and continues to close the transaction. The item can remain under the basket, and with LaneHawk, you are assured to get paid for it…”

Face recognition
Who is she?
Vision-based biometrics

Login without a password…

Object recognition (in mobile phones)

Special effects: shape capture

Special effects: motion capture

Sports

• This is becoming real:
  – *Lincoln*  Microsoft Research
  – *Point & Find*, Nokia

The Matrix movies, ESC Entertainment, XYZRGB, NRC

Pirates of the Caribbean, Industrial Light and Magic

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

- Mobileye
  - Vision systems currently in high-end BMW, GM, Volvo models
  - By 2010: 70% of car manufacturers.

Vision-based interaction (and games)

- Nintendo Wii has camera-based IR tracking built in. See Lee’s work at CMU on clever tricks of using it to create a multi-touch display!
- Digimask: put your face on a 3D avatar.
- “Game turns moviegoers into Human Joysticks,” CNET Camera tracking a crowd, based on this work.

Vision in space

- 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.

Robotics

- NASA’s Mars Spirit Rover: captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

Medical imaging

- 3D imaging, MRI, CT
- Image guided surgery

Istanbul Application
Familiar faces


Also see canesta.com
Head pose and gaze estimation

3D head pose and gaze estimation, Kinoshita et al., FG2008.

Modeling ageing

Face recognition with temporal invariance, Park et al., FG 2008.

Facebook tagging

60,000 pictures from Facebook
65% tagging accuracy

Evaluation of face recognition technologies with application to Facebook, Becker et al., FG2008.

myheritage.com

Add pictures ➔ tag people ➔ organize photos ➔ discover likeness

3D Modelling

2D vs 3D
Bosphorus 3D face database

Region based 3D face recognition

Alyuz, Gokberk, Akarun, FG2008

3D movies

Smart Environments

i3D post project: creation of 3D content models from video

Stieflhagen, CHIL project

Unmanned Vehicles

Object Tracking
Proksima

- License plate recognition
- Red light evasion detection
- Traffic density detection

Hand gesture recognition

- Hand gesture recognition


Sign language teaching

A system for teaching sign language using live gesture feedback, Lichteneauer et al., FG 2008.

Our Sign Tutor
Signiary

Facial expressions

Model based tracking

Human Body tracking

In-car body tracking

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Project Timetable

• Today: Announce project:
• Next week (Oct 14th): Form groups; assign responsibilities
• 28th Oct: Survey and Proposal presentations
• 30th Dec: Final presentations

Project Topics

1. Motion capture
   • body tracking
     • Hand and arms tracking
     • Whole body tracking
     • Marker tracking, Kalman filtering; particle filter based tracking
   • 3D reconstruction
   • Motion segmentation
   • Motion analysis
   • Model based tracking and analysis
• Resources: Stereo camera, motion capture suit

2. Head motion analysis
   • Collect head motion data
   • Facial feature tracking
   • Active Appearance models
   • Head motion analysis
   • Pose and gaze detection
   • Classification
• Resources: webcam; BUHMAP database

3. Classify Activities in Video
   • Detect feature points in video
   • Detect objects in video
   • Track features across frames
   • Classify actions
• Resources: Labeled activity videos

Project Topics:

4. Multi-sensor robot vision
   • Use video from multiple cameras to track objects
   • Collect data
   • Sensor fusion at different levels
   • Obstacle avoidance
   • Object tracking
   • Environment sensing
   • Robot localization

Project People:

<table>
<thead>
<tr>
<th>Project</th>
<th>People</th>
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</thead>
<tbody>
<tr>
<td>Motion capture</td>
<td>Gökür, Ahmet, Safiye</td>
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<tr>
<td>Object tracking</td>
<td>Muzaffer, Hale</td>
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<tr>
<td>Head motion analysis</td>
<td>Beina, Barış, Fatma E.</td>
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<td>Remote sensing</td>
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<td>Robot</td>
<td>Tugçe, Okan, Özgür</td>
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<td>Activity analysis-assisted living</td>
<td>Melika, Mehmet, Onur, Sultan, Mete</td>
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<td>Biomedical application</td>
<td>Beyza, Kaan, Murat, Fatma, Volkan</td>
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<tr>
<td>Lipreading</td>
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Activity Analysis

3. Classify Activities in Video
   • Detect feature points in video
   • Detect objects in video
   • Track features across frames
   • Classify actions
• Resources: Labeled activity videos