CS 556: Computer Vision

Lecture 1

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Oregon State University
CS 556: Computer Vision

• Instructor:
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• Office:
  2107 Kelley Engineering Center

• Office Hours:
  Tue 1-2pm, or by appointment

• Classes:
  MW 5-6:20pm, KEC 1003

• Class website:
  http://web.engr.oregonstate.edu/~sinisa/courses/OSU/CS556/CS556.html
Recommended Textbooks


• “Multiple View Geometry in Computer Vision,” by R. Hartley and A. Zisserman, Academic Press, 2nd ed, 2004


• Additional readings on the class website
Prerequisites

• Undergraduate-level knowledge of:
  • Linear algebra
    • Matrices, Matrix Operations
    • Determinants, Systems of Linear Equations
    • Eigenvalues, Eigenvectors
  • Statistics and probability
    • Probability density function, Probability distribution
    • Priors, Posteriors, Likelihoods
    • Gaussian distribution
• Good programming skills
  • MATLAB, Mathematica
  • C, C++
Requirements and Grading Policy

• Homework assignments -- individual work (40%)
  • HW1 -- Jan 19
  • HW2 -- Jan 26
  • HW3 -- Feb 14
  • HW4 -- Feb 23
  • HW5 -- Mar 3
  • HW6 -- Mar 18

• Exam 1 (30%) -- Jan 31

• Exam 2 (30%) -- Feb 28
Requirements and Grading Policy

• Homework assignments -- individual work (40%)

• Late policy: Zero tolerance without prior approval
Homework

- Six mini projects
- Individual work, but discussing the ideas is allowed
- Use any helpful source code that is available online
- Implement homework in any programming language
- Turn in homework as hardcopy, in class, on the due date
- Instructions on the class website
Homework Report
Homework Report

• Introduction
  • Problem statement: What vision problem has been addressed
  • Overview of your approach
  • Motivation for using your approach
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  • Overview of your approach
  • Motivation for using your approach

• Literature Review
  • Brief review of prior work addressing the same problem
    • Positive aspects
    • Negative aspects, restrictive assumptions, complexity
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• Details of each step of your approach
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• Details of each step of your approach

• Experimental Evaluation
  • Quantitative results
  • Qualitative results
  • Show a few examples where your approach fails and explain why
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• Conclusion
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• Details of each step of your approach

• Experimental Evaluation
  • Quantitative results
  • Qualitative results
  • Show a few examples where your approach fails and explain why

• Conclusion

• References
Requirements and Grading Policy

• Active participation in class discussions
What is Computer Vision?

Develop

algorithms, representations
for automatic interpretation, e.g.,
recognition, segmentation,
taxonomic organization, etc.,
of meaningful entities of the 3D world, e.g.,
objects (parts), scenes, activities, events, etc.,
and their 3D spatiotemporal relations, e.g.,
de depth, partial occlusion, 3D orientation,
velocity, moving direction, frequency, etc.,
captured in images or video
COMPUTER VISION

- IMAGE PROCESSING
- NEUROSCIENCE PSYCHOLOGY
- PHYSICS IMAGING
- COMPUTER GRAPHICS
- APPLIED MATH STATISTICS
- MACHINE LEARNING
- DATA MINING
- CONTROLS ROBOTICS
PATTERN RECOGNITION
IMAGE CLASSIFICATION
STRUCTURAL PATTERN REC
SYNTACTIC PATTERN REC

IMAGE PROCESSING
NEUROSCIENCE PSYCHOLOGY
PHYSICS IMAGING
COMPUTER GRAPHICS
APPLIED MATH STATISTICS
MACHINE LEARNING
DATA MINING
CONTROLS ROBOTICS
IMAGE RETRIEVAL
VISUAL KNOWLEDGE BASE
IMAGE GRAPH MINING
ROBOT NAVIGATION
INFORMATION FUSION

- IMAGE PROCESSING
- NEUROSCIENCE PSYCHOLOGY
- PHYSICS IMAGING
- COMPUTER GRAPHICS
- APPLIED MATH STATISTICS
- MACHINE LEARNING
- DATA MINING
- CONTROLS ROBOTICS
HARMONIC ANALYSIS
MULTISCALE FILTERING
IMAGE COMPRESSION
ENHANCEMENT
DEBLURRING

IMAGE PROCESSING
NEUROSCIENCE PSYCHOLOGY
PHYSICS IMAGING
COMPUTER GRAPHICS
APPLIED MATH STATISTICS
MACHINE LEARNING
DATA MINING
CONTROLS ROBOTICS
PSYCHOPHYSICS
VISUAL COGNITION
THEORY OF IMAGES

IMAGE PROCESSING
NEUROSCIENCE PSYCHOLOGY
CONTROLS ROBOTICS
PHYSICS IMAGING
DATA MINING
COMPUTER GRAPHICS
MACHINE LEARNING
APPLIED MATH STATISTICS
COMPUT. PHOTOGRAPHY
IMAGE SYNTHESIS

IMAGE PROCESSING
NEUROSCIENCE
PSYCHOLOGY

CONTROLS
ROBOTICS

DATA MINING

MACHINE LEARNING

APPLIED MATH
STATISTICS

PHYSICS
IMAGING

COMPUTER
GRAPHICS
A Typical Computer Vision System

3D world:
- objects
- scenes
- events

camera

algorithms
representations

problem understanding
- trade offs
- training data

image interpretation

users
Some Applications

Visual effects: Image manipulation

Source: Yung-Yu Chuang
Some Applications

Visual effects: Image manipulation

Source: Yung-Yu Chuang
Some Applications

Visual effects: Image manipulation

Source: Yung-Yu Chuang
Some Applications

Visual effects: Bullet-time photography
Some Applications

Automatic adjustment of camera focus, aperture, and shutter speed based on face detection
Some Applications

Monitoring driver alertness

Source: P. Smith, M. Shah, and N.V. Lobo
Some Applications

Autonomous Vehicle

DARPA Challenge
Some Applications

Flight stability and control of Micro Air Vehicles

Source: M. Nechyba
Some Applications

Surveillance
Some Applications

Medical imaging
Some Applications

Assistive tools for the disabled

Source: A. Yuille
Is There More to Computer Vision?
What is Computer Vision?

Develop algorithms, representations for automatic interpretation, e.g., recognition, segmentation, taxonomic organization, etc., of meaningful entities of the 3D world, e.g., objects (parts), scenes, activities, events, etc., and their 3D spatiotemporal relations, e.g., depth, partial occlusion, 3D orientation, velocity, moving direction, frequency, etc., captured in images or video.
“...Understanding vision is a key to understanding intelligence...”

T. Poggio
Computer Vision is Difficult

How do we define objects?

Common functionality?  Common appearance?
Computer Vision is Difficult

How do we define anomalies?
Computer Vision is Difficult

Is context important?
Computer Vision is Difficult

Is context important?
Computer Vision is Difficult

Cows may not be cooperative

Source: Alex Berg
Why is Computer Vision Difficult?
Why is Computer Vision Difficult?

- Loss of information in projection from 3D to 2D
Why is Computer Vision Difficult?

• Loss of information in projection from 3D to 2D

• Real world is too complex
  • Difficult to formalize the notion of object, scene, event
    • Appearance: photometric and geometric properties
    • Functionality
  • Difficult to formalize all spatiotemporal relations between objects in the scene
Why is Computer Vision Difficult?

• Loss of information in projection from 3D to 2D

• Real world is too complex
  • Difficult to formalize the notion of object, scene, event
    • Appearance: photometric and geometric properties
    • Functionality
  • Difficult to formalize all spatiotemporal relations between objects in the scene

• How to evaluate image interpretation?
  • Some quantitative measures are not suitable
  • Using only qualitative evaluation is not satisfying
Why is Computer Vision Difficult?
Why is Computer Vision Difficult?

• No formal definition of SIGNAL or INFORMATION
Why is Computer Vision Difficult?

- No formal definition of SIGNAL or INFORMATION
- Ill-posed problem:
  - Real world is too complex
  - Image interpretation is not clear
  - How do we evaluate interpretation?
  - Loss of information in projection from 3D to 2D
Why is Computer Vision Difficult?

• No formal definition of SIGNAL or INFORMATION

• Ill-posed problem:
  • Real world is too complex
  • Image interpretation is not clear
  • How do we evaluate interpretation?
  • Loss of information in projection from 3D to 2D

• Therefore we need:
  • Assumptions
  • Constraints
  • Exploitation of domain-specific knowledge
  • Extensive evaluation on many diverse datasets
Next Class

- Big picture: From image formation to image interpretation
- Theories of computer vision