Computer Vision

Lecture Set 01
Course Overview

林惠勇
Huei-Yung Lin

lin@ntut.edu.tw

Robot Vision Lab
Department of Computer Science and Information Engineering
National Taipei University of Technology
Taipei 106, Taiwan

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Course Information

- This course will be taught in English.
- Class Time and Place
  - M, 9:10 – 12:00 (Time change? Single long break or no break?)
  - Room 三教 211
- Instructor
  - Huei-Yung Lin（林惠勇）
  - E-mail: lin@ntut.edu.tw
  - Office Hour: M, 13:30 – 17:30
  - Room 1526
- Teaching Assistants
  - Tsai-Yu Hsu（許采玉）
  - E-mail: qqwweerr987@gmail.com
  - All communications will be done online (E-mail).

Course Information

- Course Webpage?
  - The TA might not have access to the school's system.
  - The lecture slides and course materials will be provided probably via Google Drive.
  - All homework assignments will be distributed online.
- Reference:
  - "Computer Vision: Algorithms and Applications", by Szeliski, Springer, 2011
  - "Multiple View Geometry in Computer Vision", 2nd Ed., by Hartley and Zisserman, Cambridge University Press, 2003
  - "Computer Vision: Models, Learning, and Inference", by Prince, Cambridge University Press, 2012
  - A bunch of books from O'Reilly: "Learning OpenCV 3", "Programming Computer Vision with Python", "Practical Computer Vision With SimpleCV"
- Online course link, https://meet.google.com/jpe-fsqs-yra, if necessary.

Grading

- Exams – 50%
  - One midterm and one final.
  - 25% each.
- Homeworks – 30%
  - 10% each, three homework assignments.
  - Both are computer homework (using C/Python).
  - Due in two weeks.
- Presentation – 20%
  - 15 minutes of an oral presentation.
  - Papers and schedule will be given in class.
- All weights are tentative and subject to change!
- No makeup exams.

Important Dates (TBC)

- 10/03 – Homework 1 assigned, due 10/17
- 10/24 – Exam I
- 10/31 – Homework 2 assigned, due 11/14
- 11/21 – Homework 3 assigned, due 12/5
- 11/28 – Paper assigned
- 12/05 – Presentation schedule
- 12/12 – Homework 4 assigned, due 12/26
- 12/19 – Presentation starts
- 1/09 – Exam II

Goal and Objectives

- To introduce the fundamental problems of computer vision
- To introduce the main concepts and techniques used to solve those
- To enable participants to implement solutions for reasonably complex problems
- To enable the students to make sense of the literature of computer vision
- This is a computer vision course with emphasis on sensing and perception.
- This is NOT a course teaching deep learning and neural networks.
- It is NOT a general AI course either.
- However, it is welcome to present recent papers using these techniques to solve computer vision problems.

Course Topics

- Digital Image Fundamentals
- Digital Snapshots
- Dealing with Image Noise
- Image Features
- Camera Calibration
- Stereo
- Motion
- Shape from Single Image Cues
- Recognition
- Locating Object in Space
- Assigned Papers

See you next Monday.

(9:10 – 12:00)

Announcements – 9/19/22

- Important Dates
  - 10/17: HW1 due (assigned on 10/03)
  - 10/24: Exam I
  - 11/14: HW2 due (assigned on 10/31)
  - 11/28: Paper assigned
  - 12/05: HW3 due (assigned on 11/21)
  - 12/05: Presentation schedule
  - 12/19: Presentation starts
  - 12/26: HW4 due (assigned on 12/12)
  - 1/09: Exam II
- Class Meeting Time
  - 9:10 – 11:50, Mon, with a 10-min break
- The last day of add/drop perdiod: 9/23

What is Computer Vision?

- Consider the problem associated with extracting information from image data
- What do we mean by information?
  - 3D structure of a scene
  - Presence and location of moving objects
  - Identity of a person, etc.
- Inverse problem of image formation
  - To recover useful information about a scene from its two-dimensional projections

What is Computer Vision?

- Vision as “Inverse Problem”
  - Given information about the scene geometry, surface reflectance property, lighting and camera model we can generate an image
  - The problem of computer vision is to infer these properties of the scene from the image data (a 2D array of numbers)
  - Inverse problems are notoriously difficult
- Target problem of computer vision
  - Computing properties of the 3-D world from one or more digital images
  - Including geometric (shape and position of an object) and dynamic (object velocities)
- Image Analysis, Scene Analysis, Image Understanding
- Vision = Geometry + Measurement + Interpretation

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)
  - Movie post-processing
  - Face finding and recognition
- Various deep and attractive scientific mysteries
  - How does object recognition work?
- Greater understanding of human vision

Computer Vision as a Sensor

- Information about distant objects
- Passive sensor (as opposed to sonar, laser)

- High bandwidth
  - 1 picture = ? Words
- Corresponds to the most complex human sensory function
  - Eat it? Run from it? Mate with it?

Defined by Image and Model

Output \ Input	Image	Model
Image	Image Processing	Computer Graphics
Model	Computer Vision	Computational Geometry

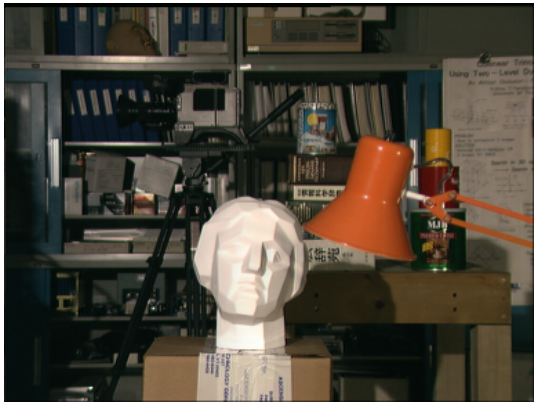
Main Topics

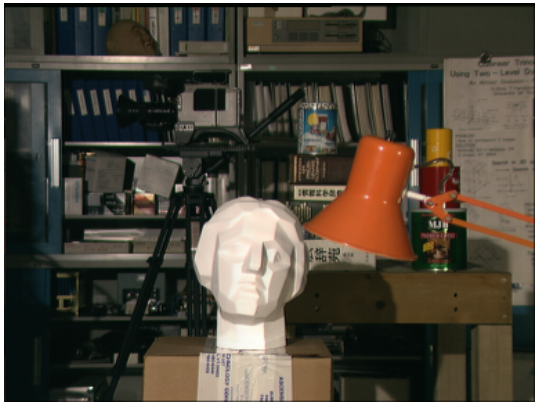
- Camera & Light
  - Geometry, radiometry, color
- Digital images
  - Filters, edges, texture, optical flow
- Shape (and motion) recovery
  - Multi-view geometry
  - Stereo, motion, photometric stereo, ...
- Segmentation
  - Clustering, model fitting, probalistic
- Tracking
  - Linear dynamics, non-linear dynamics
- Recognition
  - Templates, relations between templates

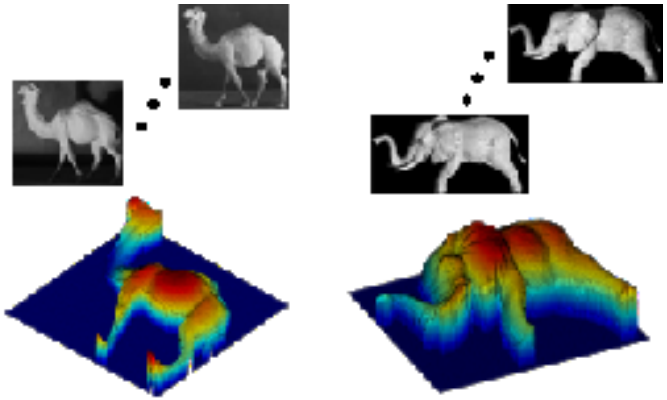
Introductory Examples (Techniques)

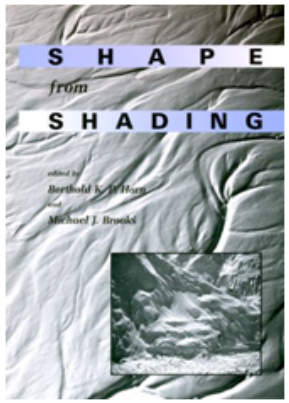
- Shape Recovery
  - "What is the 3D shape of what I see?"
- Motion Estimation
- Feature Extraction
- Segmentation
  - "What belongs together?"
- Tracking
  - "Where does something go?"
- Recognition
  - "What is it that I see?"
- Localization
- Scene Representation

Shape from ...

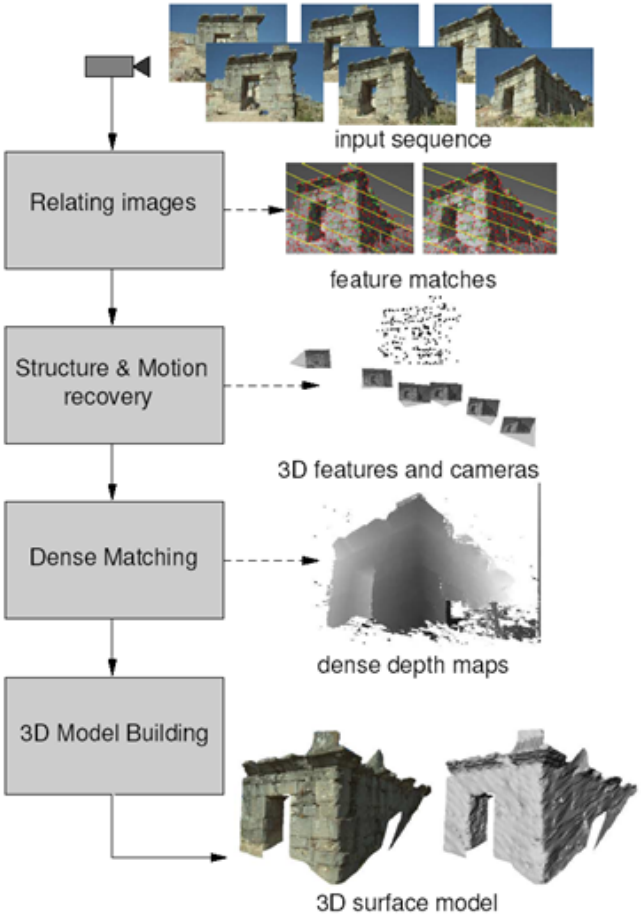








Structure from Motion



Segmentation

Tracking

Human Computer Interaction

Motion Detection

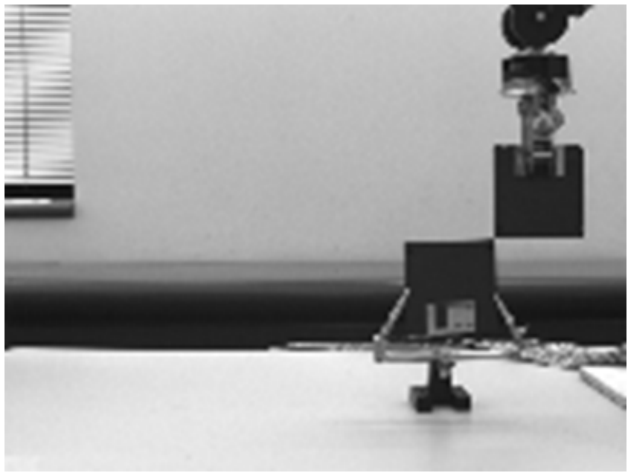
Image-Based Recognition

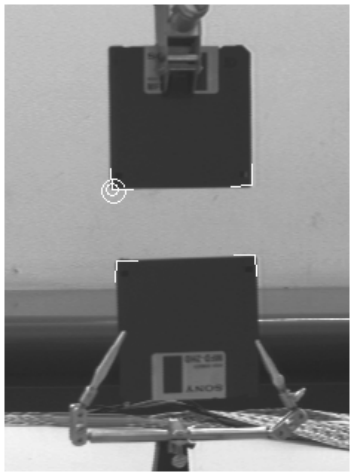
3D Surveillance

3D Reconstruction

Original photograph with marked edges | Recovered model | Model edges projected onto photograph | Synthetic rendering

Visual Servoing





Announcements – 9/26/22

Opportunities for Computer Vision

- Thanks to Moore's law – desktop machine have gotten faster and cheaper – many already come equipped with cameras

- Computer Vision as the input device of the future – your computer will be able to:
  - Recognize you by sigh
  - Watch what you do and respond accordingly
  - Build model of the world from image data

Related Fields – Image Processing

- Consider image properties, image-to-image transformation
- The task of information recovery is left to users
- Image enhancement, image recovery, image compression, etc.
- Emphasis in computer vision is on recovering information automatically, with minimal interaction
- Image processing algorithms are useful in early stages of computer vision tasks
  - Image enhancement, noise suppression, etc.

Related Fields – Computer Graphics

- Methods and techniques for converting data to or from graphic displays via computer
- To generate images from geometric primitive (line, circles, etc.)
- Inverse problem to computer vision problems
  - Computer graphics – synthesis of images
  - Computer vision – analysis of images
- Computer vision and computer graphics fields are merging in recent years (visualization, VR, AR, etc.)

Related Fields

- Artificial Intelligence
  - Analyze scene by computing a symbolic representation of the scene content
  - Three stages: perception, cognition, action
- Computation Geometry
  - Algorithms for solving geometric problems on a computer
- Photogrammetry
  - Obtain reliable and accurate measurements from non-contact imaging, higher accuracy
- Pattern Recognition
- Robotics
- Neuroscience
- Physics
- Applied Mathematics

Research Areas

- Image feature detection and tracking
- Feature-based segmentation
- Range image analysis
- Shape modeling and representation
- Stereo vision
- Motion analysis
- Illumination, reflectance, color
- Active vision
- Camera calibration
- Object detection, location, recognition
- Image re-synthesis

Application Areas

- Industrial inspection
- Quality control
- Reverse engineering
- Surveillance and security
- Face recognition
- Gesture recognition
- Autonomous vehicles
- Road monitoring
- Visual servoing
- Hand-eye robotics systems
- Medical image analysis
- MRI, CT, X-rays, sonar scan
- Image databases
- Virtual reality, tele-applications
- Space & Military
- Image based graphics
- Intelligent transportation
- Remote sensing

Resource on the Internet

- Google ...

- GitHub
- OpenCV
- CVonline
- Computer Vision Homepage
- ImageMagick
- OpenGL

Reference Publication

- ICCV (International Conference on Computer Vision)
- CVPR (IEEE Conference on Computer Vision and Pattern Recognition)
- ECCV (European Conference on Computer Vision)
- ACCV (Asian Conference on Computer Vision)
- WACV (Workshop on Applications of Computer Vision)
- ICPR (International Conference on Pattern Recognition)
- ICRA (International Conference on Robotics and Automation)
- IROS (International Conference on Intelligent Robots and Systems)
- NIPS (Neural Information Processing Systems)
- ICML (International Conference on Machine Learning)
- IJCAI (International Joint Conferences on Artificial Intelligence)