Today’s Agenda

• Welcome
• Tentative Syllabus
• Topics covered in the course
Class Communication

Class website

http://www.cse.sc.edu/~tongy/csce763/csce763.html

Blackboard Learn (sc.edu)
Tentative Syllabus

- Prerequisites
- Objectives
- Textbook
- Grade
Prerequisites of This Course

This is a computer science course

• It will involve a fair amount of math
  – calculus, linear algebra, geometry
  – probability
  – analog/digital signal processing
  – graph theory etc.

• It will involve the modeling and design of a real system - one final course project
  – Programming skills with matlab, Python, or C++
The Objective of This Course

This is a graduate-level topic course

• Research oriented
  – Paper reading & presentation
  – Final project & presentation
  – Review on the state-of-the-art

• Understanding → Innovation
  – your own innovative and original work/opinion/result

• Basic knowledge → Research frontier
  – learn through reading recent papers
Textbook

Required:


We will cover many topics in this textbook.

We will also include special topics on recent progresses on image processing.
Others

Department seminars

Guest lectures
Requirement for Final Project

Option 1: A complete research project
- Introduction (problem formulation/definition)
- literature review
- the proposed method and analysis
- experiment
- conclusion
- reference

Option 2: A survey research
- A well-defined problem or topic
- a complete list of previous (typical) work on this problem (15+ papers under the topic)
- clearly and briefly describe the topic
- analyze each method/group and compare them
- give the conclusion and list of references
Requirement for Final Project

Requirements

• Select a topic and write a one-page proposal (due Oct 4\textsuperscript{th} )
• Progress report (discuss with the instructor)
• Research work and report writing
• Oral presentation
  – Section 001: in class presentation
  – Section J60: prerecorded video
• Final project report
Requirement for Final Project

Teamwork is acceptable for a research project (Option 1)

- <=2 people
- Get the permission from the instructor first
- Under a single topic, each member must have their own specific tasks
- One combined report with each member clearly stating their own contributions
- One combined presentation
Requirement for Final Project

Written report
- Report format: the same as a conference paper
- Executable code must be submitted with clear comments except for a survey study

Academic integrity (avoiding plagiarism)
- don’t copy other person’s work
- describe using your own words
- complete citation and acknowledgement whenever you use any other work (either published or online)
Requirement for Final Project

Evaluation

• written report (be clear, complete, correct, etc.)
• code (be clear, complete, correct, etc.)
• oral presentation
• discussion with the instructor
• quality: publication-level project – extra credits
Requirement for Final Project

Notes:

• You are encouraged to incorporate your own research expertise in, but the project topic must be related to the content of this course

• Discuss with the instructor on topic selection, progress, writing, and presentation

• Use the library and online resource
Paper Reading and Presentation

• A paper picked by yourself and approved by the instructor
  • Suggested paper source: To be provided

• Thorough understanding of the paper

• Prepare PPT slides
  • Clearly explain the main contributions in the selected paper
  • Critical comments – extra credit

• About 10 mins oral presentation for each student
  – Section 001: in class presentation
  – Section J60: prerecorded video
Major Topics Covered in Class

Image acquisition and digital image representation
Image enhancement
Image restoration
Color image processing
Image compression
Image segmentation
Morphological image processing
Special topics on recent progresses on digital image processing
Human Perception VS Machine Vision

• Limited vs entire EM spectrum

http://www.kollewin.com/blog/electromagnetic-spectrum/
Image Processing → Image Analysis

Low level
- Image acquisition
- Image enhancement
- Image compression
- Image segmentation
- Object recognition
- Scene understanding
- Semantics

Mid level

High level

Image processing

Image analysis (Computer vision, Pattern recognition, etc.)
**Image Acquisition and Representation**

**FIGURE 2.15** An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.
Examples

1. Brain MRI
2. Cardiac CT
3. Fetus Ultrasound
4. Satellite image
5. IR image

Image Acquisition

Camera + Scanner → Digital Camera: Get images into computer
Image Representation

Discrete representation of images
- we'll carve up image into a rectangular grid of pixels $P[x,y]$;
- each pixel $p$ will store an intensity value in $[0, 1]$;
- $0 \rightarrow$ black; $1 \rightarrow$ white; in-between $\rightarrow$ gray;
- Image size $mxn \rightarrow (mn)$ pixels.
Color Image

Red
(1,0,0)

Green
(0,1,0)

Blue
(0,0,1)

0 Colors along Red axis 1

RGB channels

0.6
0.0
0.8
Video: Frame by Frame

30 frames/second
Image Enhancement
Image Restoration
Image Compression

100% fidelity
Image is 725kB

90%
250kB

10%
37kB

1%
20kB

→ Video compression
Image Processing → Image Analysis

- **Low level**
  - Image acquisition
  - Image enhancement
  - Image compression
  - Image segmentation

- **Mid level**
  - Object recognition
  - Scene understanding

- **High level**
  - Semantics

**Image processing**

**Image analysis**
(Computer vision, Pattern recognition, etc.)
Image Segmentation

Microsoft multiclass segmentation data set
Image Completion

Interactively select objects. Remove them and automatically fill with similar background (from the same image)

I. Drori, D. Cohen-Or, H. Yeshurun, SIGGRPAH’03
More Examples
Morphological Image Processing
Object Detection / Recognition
Content-Based Image Retrieval
Biometrics
Super-Resolution
Applications of Digital Image Processing

Digital camera
Photoshop
Human computer interaction
Medical imaging for diagnosis and treatment
Surveillance
Automatic driving

... 

Fast-growing market!
Basic Concepts in Digital Image Processing
Now,

Introducing some basic concepts in digital image processing

• Human vision system
• Basics of image acquisition

Reading: Chapter 2.
Elements of Human Visual Perception

Human visual perception plays a key role in selecting a technique

Lens and Cornea: focusing on the objects

Two receptors in the retina:
  • Cones and rods
  • Cones located in fovea and are highly sensitive to color
  • Rods give a general overall picture of view, are insensitive to color and are sensitive to low level of illumination

Distribution of Rods and Cones in the Retina

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**FIGURE 2.2**
Distribution of rods and cones in the retina.
Brightness Adaptation: Subjective Brightness

Scotopic:
- Vision under low illumination
- Rod cells are dominant

Photopic:
- Vision under good illumination
- Cone cells are dominant

The total range of distinct intensity levels the eye can discriminate simultaneously is rather small

Brightness adaptation level
Brightness Discrimination

Weber Ratio/Fraction

$$\frac{\Delta I_c}{I}$$

$I + \Delta I_c$:

- Short-duration flash
- Small ratio: good brightness discrimination
- Large ratio: poor brightness discrimination

FIGURE 2.5 Basic experimental setup used to characterize brightness discrimination.
Brightness Discrimination at Different Intensity Levels

FIGURE 2.6
Typical Weber ratio as a function of intensity.
Perceived Intensity is Not a Simple Function of the Actual Intensity (1)

FIGURE 2.7
Illustration of the Mach band effect. Perceived intensity is not a simple function of actual intensity.
PERCEIVED INTENSITY IS NOT A SIMPLE FUNCTION OF THE ACTUAL INTENSITY – SIMULTANEOUS CONTRAST

**FIGURE 2.8** Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.
Optical Illusions: Complexity of Human Vision

**FIGURE 2.9** Some well-known optical illusions.
More Optical Illusions

http://www.123opticalillusions.com/

http://brainden.com/optical-illusions.htm
Object Perception

How do we perceive separate features, objects, scenes, etc. in the environment?

- Perception of a scene involves multiple levels of perceptual analysis.

[Diagram with boxes labeled: Scenes, Objects, Groups of Features, Features]
What Do We Do With All Of This Visual Information??

“Bottom up processing”
• Data-driven
• Sensation reaches brain, and then brain makes sense of it

“Top down processing”
• Cognitive functions informs our sensation
• E.g., walking to refrigerator in middle of night