Digital Image Processing  
ECE 178  
Winter 2003

B. S. MANJUNATH  
RM 3157 ENGR I  
Tel:893-7112  
manj@ece.ucsb.edu  
http://vision.ece.ucsb.edu/Manjunath

On the WEB

For course information and slides and more:  
http://varuna.ece.ucsb.edu/ECE178

Teaching Assistants  
Jelena Tesic (jelena@ece.ucsb.edu)  
Marco Zuliani (zuliani@ece.ucsb.edu)

Class e-mail list/Discussion sessions

- **ALL Registered students**: please send an e-mail to zuliani@ece.ucsb.edu today:  
  - subject = “ECE 178”  
  - with your name (last, first)  
  - e-mail address (if different)  
  - If you have any schedule conflicts for either of the two discussion sessions (12-1250 or 0100-0150PM) on Fridays.  
- Your e-mail address is needed to send course related information/announcements.

Today: Jan 07-2003

- Course outline  
- Requirements for the course  
- Introduction to image processing  
- Matlab basics and the image processing toolbox

About this course

- **Prerequisites**  
  - Strong motivation, basic calculus  
  - MATLAB is the programming environment, but no prior background in MATLAB is assumed.  
- **Who can take this course?**  
  - Juniors/Seniors/Graduate students in ECE/CE/CS/ME/MATP/...  
- **Text Book:**  
  - http://www.imageprocessingbook.com

Grading

- H/W/Comp* 20% due by 11:59pm on the due date  
- Project 20%  
- Midterms 20% (two mid-terms)  
- Finals 40%  

* All homeworks are required. A non-submission will affect your grade non-linearly.
Important Dates

- Mid-Term II: Tuesday, February 25 (tentative)
- Final Examination: Monday, March 17, 12-3pm (as per schedule)

Why Image Processing?

- The future is multimedia information processing......
- Images (and video) are everywhere!
- Many and diverse applications
  - Astronomy, biology, geology, geography, medicine, law enforcement, defense, Industrial inspection, ...
  - Different imaging modalities: visual, X-ray, ultrasound, ...

Entertainment

- Digital camcorders
- HDTV
- DVDs: High quality image/video compression (MPEG-2: about 5-10 Million bits/second)
- Digital Cinema
  - New compression technologies are needed
  - Consider a 2 hour movie: 1920 x 1080 x 30 bits/pixel x 24 frames/second → 1.5 billion bits/second → 1.3 terra bytes / 2 hr program

Security

- Person Identification
  - Face recognition
  - Finger print identification
- Watermarking
  - Copyright protection and authentication
- Data hiding
  - Secret communication (Steganography)

Some Applications

- X-ray imaging and radiology
- Computer Tomography

An Ultrasound image

Profile of a fetus at four months. This face is approximately 1 ½ inches (4cm) long. (http://www.parenthood.com)
Computer Tomography

- Generating 3-D images from 2-D slices.
- CAD, CAM applications
- Industrial inspections

CT Scanner Picker PQ 6000 Model
- GE Medical High Speed Advantage scanner
- Picker PQ 6000

Image/video Processing Methods

- Image Enhancement
- Image Restoration
- Compression
- Image reconstruction
- Morphological image processing
- Feature extraction and recognition → computer vision

Chapter 1: Introduction

Image Enhancement


Image Restoration

- same as image enhancement, but you have additional information concerning the quality degradation. Example: removing motion blur in an image of a fast moving object.
- A page from Matlab examples or the matlab site at http://www.mathworks.com/products/demos/imagetbx/examples/deblur/deblur.html

IP methods (cont.)

- Reconstruction: reconstruction from projections. Used in constructing 3D data from 2D projections in computer tomography.
- Image representation using features
  - Low level representations using color, texture, shape, motion, etc.
  - High level features for recognitions; e.g., facial features.
- Recognition and scene understanding
Image Processing, Pattern Recognition, Graphics, and Computer Vision

- **Image Processing**
  - This is about image to image transformation (image coding, enhancement, restoration, etc.)
  - ECE 178, ECE 278a.
- **Computer Graphics**: CS 180/280
- **Pattern Recognition**: ECE 277b
- **Computer Vision**: ECE 181b/281b
- **Multimedia computing**: ECE 160

Course Outline

- **Introduction**
  - Chapters 1-2
- **2-D Linear Systems**
  - Class notes;
- **Sampling and Quantization**
  - Class notes; Ch 2.4
- **Image Enhancement**
  - Ch. 3, 4
- **Image and Video Coding**
- **Project presentations**

Course Projects

- **Why project?**
  - To learn more about applications of image processing and get hands-on experience.
  - Typically, the material (needed) is NOT covered in class - thus requires independent study (ten weeks is too short to cover all interesting topics!)
- **Winter 2003**: This quarter we will explore
  - Image compression in more detail
  - Wavelets based image compression (~JPEG2000)

Image Compression using Wavelets

- **What are wavelets?** (we will learn more about them later on..)
- **Using wavelets for data compression**
  - JPEG 2000 standard is based on wavelets
  - JPEG (original) is based on the Discrete Cosine Transform — you will learn DCT based compression in our discussions on image coding.

Previous year (2002) projects

- **JPEG 2000**
- **Data hiding**
- **Streaming Video**
- **Image Mosaicing**

Data Hiding

Steganography is the art and science of communicating in a way which hides the existence of the communication. In contrast to cryptography, where the "enemy" is allowed to detect, intercept and modify messages without being able to violate certain security premises guaranteed by a cryptosystem, the goal of steganography is to hide messages inside other "harmless" messages in a way that does not allow any "enemy" to even detect that there is a second secret message present [Markus Kuhn 1995-07-03].
Steganography is the art and science of communicating in a way which hides the existence of the communication. In contrast to cryptography, where the "enemy" is allowed to detect, intercept and modify messages without being able to violate certain security premises guaranteed by a cryptosystem, the goal of steganography is to hide messages inside other "harmless" messages in a way that does not allow any "enemy" to even detect that there is a second secret message present [Markus Kuhn 1995-07-03].

Example: Image in Image

Stego image (loss-less)

Recovered message (loss-less)

Example: Video in Video

(b) Embedded frame

(c) Recovered frame (PSNR 35.7dB)

(d) Signature frame

(2M bps, 30 fps, PSNR 31.5dB)

Streaming video over wireless

- Video is high bandwidth data
- Wireless, at present, has limited bandwidth
- Needs efficient and effective compression
- Experiment with new coding techniques such as MPEG-4 etc.

Image/Video Mosaicing

- What is mosaicing?
  - Stitching together two or more images taken at different times or using different sensors, so as to create an image with larger viewing area.
  - Video mosaicing: stitching together video frames.
- General procedure
  - Identify control points that are good for matching
  - Match them, thus establishing a correspondence
- Matching is difficult!

Image Compression Project: Timeline

- Plan in advance: you have only ten weeks!!
- Jan 16: Project details will be provided (e-mail and on web)
- Jan 17: form groups not exceeding 3/group and inform TA (zuliani@ece.ucsb.edu) -- If you need help in deciding, contact me.
- Week of Feb 17: Meet with instructor to discuss progress (individual groups).
- March 11: project presentations in class (10 mins each)
- March 14: Final project reports due.
A note on human visual perception

- Both the “hardware” and “software” of human visual perception are extremely complex and they work!
- A good understanding of the “acquisition” hardware (eyes)
- Very little known about higher level (perceptual) processing.

Brightness Adaptation

The total range that our visual system can discriminate at a given time is rather small. Brightness adaptation refers to this ability to adjust its(eye) sensitivity over a wide range of adaptation levels.

Brightness Discrimination

Weber Ratio

Perceived Brightness

Simultaneous Contrast
Optical Illusions