

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>

1/07/2003

W03/Lecture 1

1

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)

1/07/2003

W03/Lecture 1

2

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.

1/07/2003

W03/Lecture 1

3

Today: Jan 07-2003

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

1/07/2003

W03/Lecture 1

4

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:
 - Gonzalez and Woods, 2nd Edition (2002)
 - <http://www.imageprocessingbook.com>

1/07/2003

W03/Lecture 1

5

Grading

- HW /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.*

1/07/2003

W03/Lecture 1

6

Important Dates

- Mid-term I: Tuesday, February 4, 2003.
- Mid-Term II: Tuesday, February 25 (tentative)
- Final Examination: Monday, March 17, 12-3pm (as per schedule)

1/07/2003

W03/Lecture 1

7

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, ...

1/07/2003

W03/Lecture 1

8

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

1/07/2003

W03/Lecture 1

9

Security

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

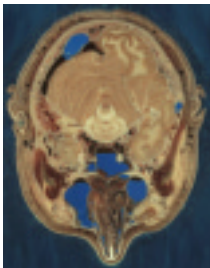
1/07/2003

W03/Lecture 1

10

Some Applications

- X-ray imaging and radiology
- Computer Tomography



[545x700 24-bit color JPEG, 69069 bytes] Section through Visible Human Male - head, including cerebellum, cerebral cortex, brainstem, nasal passages (from Head subset)

<http://www.nlm.nih.gov/research/visible/visible.html>

1/07/2003

W03/Lecture 1

11

An Ultrasound image

Profile of a fetus at four months. This face is approximately 1 1/2 inches (4cm) long. (<http://www.parenthood.com>)



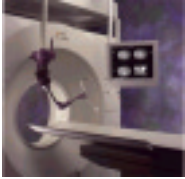
1/07/2003

W03/Lecture 1

12

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

1/07/2003

W03/Lecture 1

13

Image/video Processing Methods

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

1/07/2003

W03/Lecture 1

14

Chapter 1: Introduction

FIGURE 1.73
 Fundamental steps in digital image processing.



1/07/2003

W03/Lecture 1

15

Image Enhancement



Enhancement: Improve the visual quality of the image.
 Eg. Noise removal using median filtering
 (from <http://www.nist.gov/lispix/imlab/noise/shotfc.html>)

1/07/2003

W03/Lecture 1

16

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](http://www.mathworks.com/products/demos/magetlbox/examples/deblur/deblur.html) or the matlab site at <http://www.mathworks.com/products/demos/magetlbox/examples/deblur/deblur.html>

1/07/2003

W03/Lecture 1

17

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

1/07/2003

W03/Lecture 1

18

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

1/07/2003

W03/Lecture 1

19

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

1/07/2003

W03/Lecture 1

20

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)

1/07/2003

W03/Lecture 1

21

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.

1/07/2003

W03/Lecture 1

22

Previous year (2002) projects

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

1/07/2003

W03/Lecture 1

23

Data Hiding

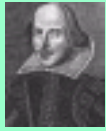


Droeshout engraving of William Shakespeare (192x240)

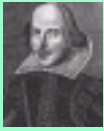
Steganography is the art and science of communicating in a way which hides the existence of the communication. In contrast to cryptography, where the "enemy" is allowed to detect, intercept and modify messages without being able to violate certain security premises guaranteed by a cryptosystem, the goal 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].

A text message (1535 bytes)

Results of Embedding Text



Embedded image



Compressed image
(lossy JPEG 85%)

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].

Recovered message (loss-less)

Example: Image in Image



Renoir's Le Moulin de la Galette
(432x320)



Airphoto image (216x160)



Embedded



Embedded and JPEG compression (85%)



Recovered signature
image

Example: Video in Video



(a) Host frame
(cm1002.02500, 352x240)



(b) Embedded frame
(2M bps, 30 f/s PSNR 31.5dB)



(c) Recovered frame
(PSNR 35.7dB)



(d) Signature frame
(cm1002.11700, 352x240)



(e) Recovered signature frame
(PSNR 45.0dB)

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.

1/07/2003

W03/Lecture 1

28

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!

1/07/2003

W03/Lecture 1

29

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.

1/07/2003

W03/Lecture 1

30

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.

1/07/2003

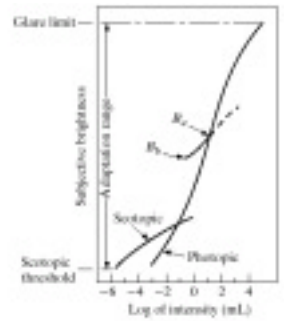
W03/Lecture 1

31

Brightness Adaptation

FIGURE 2.4
Range of subjective brightness sensations showing a particular adaptation level.

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



1/07/2003

W03/Lecture 1

32

Brightness Discrimination



FIGURE 2.5 Basic experimental setup used to characterize brightness discrimination.

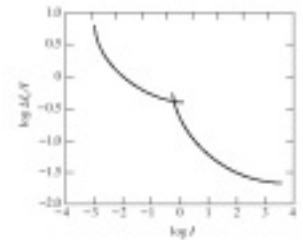
1/07/2003

W03/Lecture 1

33

Weber Ratio

FIGURE 2.6
Typical Weber ratio as a function of intensity.



1/07/2003

W03/Lecture 1

34

Perceived Brightness



FIGURE 2.7
Can be example showing that perceived brightness is not a simple function of intensity. The relative vertical positions between the two profiles in (b) have the expected significance they would have for (a).

1/07/2003

35

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.

1/07/2003

W03/Lecture 1

36

