

Digital Image Processing ECE 178



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Introduction

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On the WEB

For course information:

<http://www.ece.ucsb.edu/~manj/ece178>

Teaching Assistant

Jim Kleban

Introduction

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Today

- Course outline
- Introduction to image processing

Tomorrow

We will continue with the lecture instead of discussion.

Next Week

Introduction to Matlab 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/...
- Reference Book:
 - Gonzalez and Woods, 3rd Edition (2007)
 - <http://www.imageprocessingplace.com>
 - Read chapters 1 and 2

Grading

- H/W* 20%, due by 5pm on due date in the h/w box in HFH (3rd floor)
- Project 10%
- Midterms 20% (two mid-terms)
- Finals 50%

**All homeworks/class participation are required. A non-submission will affect your grade non-linearly. You will get a fail grade if you miss more than one h/w.*

*Participation in the discussion sessions is **REQUIRED**.*

Research @VRL/UCSB

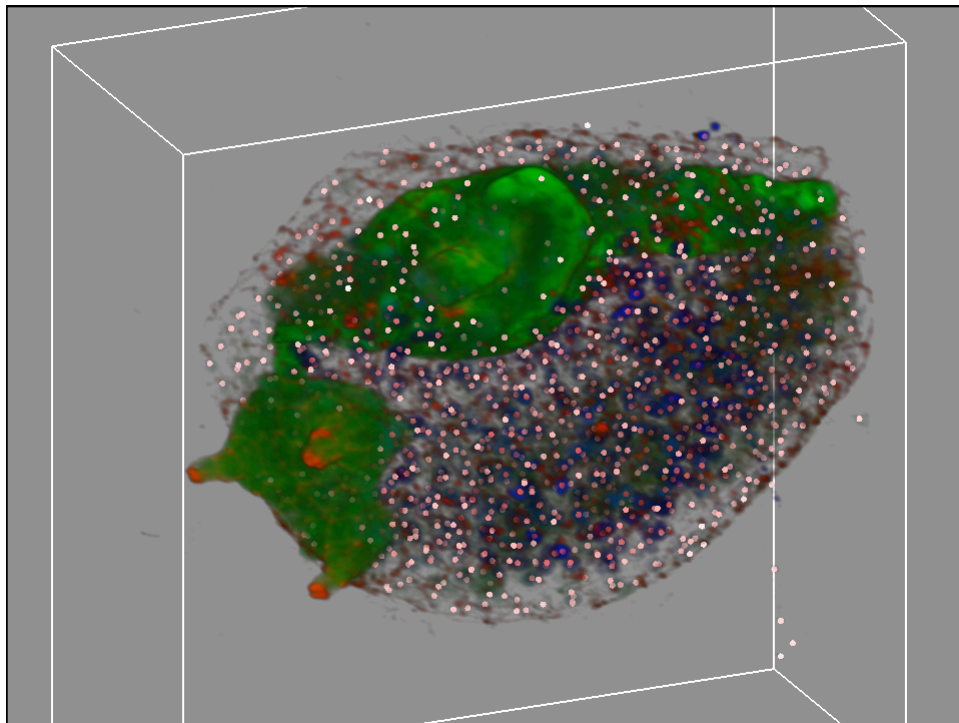
- Manjunath's Lab: Vision Research Lab and the Center for Bio-Image Informatics
- Matthew Turk, YF Wang (Computer Science)
 - FourEyes Lab (Turk and Hollerer)
- Miguel Eckstein, Psychology
-

UG Research Internships

- US Citizenship required
- Image informatics in general (emphasis on bioimage analysis)

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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 $\sim\sim$ 1.5 billion bits/second
→ 1.3 terra bytes / 2 hr program

Security

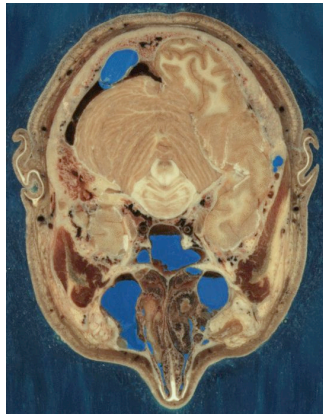
- Person Identification
 - Face recognition
 - Finger print identification
- Watermarking
 - Copyright protection and authentication
- Data hiding
 - Secret communication (Steganography)

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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/photos.html>

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An Ultrasound image

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



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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

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Image/video Processing Methods

- Image Enhancement
- Image Restoration
- Compression
- Image reconstruction
- Morphological image processing
- Feature extraction and recognition → computer vision ([next quarter, ECE/CS 181b](#))

Course Outline

FIGURE 1.23
Fundamental steps in digital image processing.

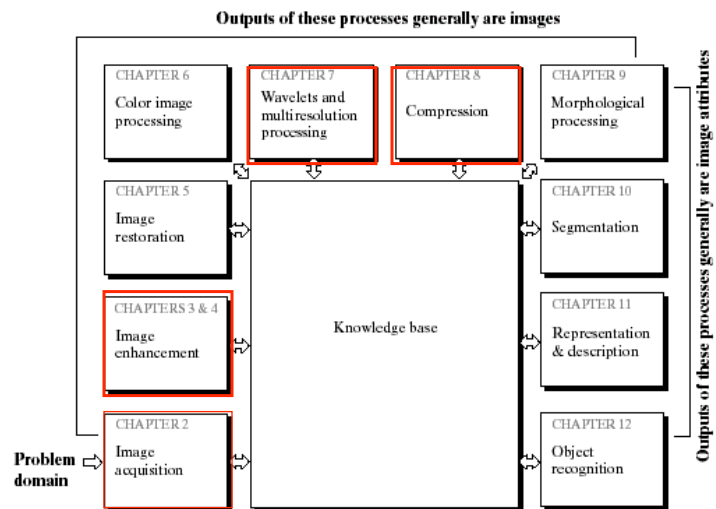


Image Enhancement



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

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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.
- Matlab site at http://www.mathworks.com/products/demos/image/deblur_wiener/deblur.html

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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

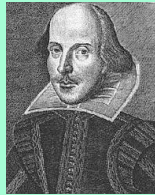
Course Outline

- Introduction
 - Chapters 1-2
- Spatial filtering
 - Linear systems and convolution
 - Chapter 3;
- Frequency domain filtering
 - 2D DFT
 - Sampling & Aliasing
 - Chapter 4
- Image Compression
 - Lossless and lossy compression
 - Transform and predictive coding
 - JPEG and MPEG standards
 - Wavelets (time permitting)
 - Chapter 8

Course Project...

- Why project?
 - Lectures focus on image intensity manipulation.
 - Project will explore a topic of current research interest (and not covered during lectures)
 - Independent reading + programming is needed
- Previous year projects
 - Streaming video
 - Data hiding
 - JPEG 2000
 - Image registration

Data Hiding



Droeshout engraving of
William Shakespeare
(192x240)

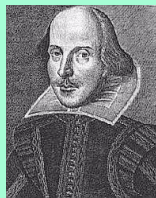
Steganography is the art and science of communicating in a way which hides the existence of the communication. In contrast to cryptography, where the "enemy" is allowed to detect, intercept and modify messages without being able to violate certain security premises guaranteed by a cryptosystem, the goal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

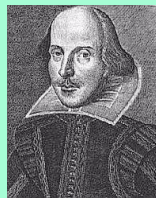
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Results of Embedding Text



Embedded image



Compressed image
(lossy JPEG 85%)

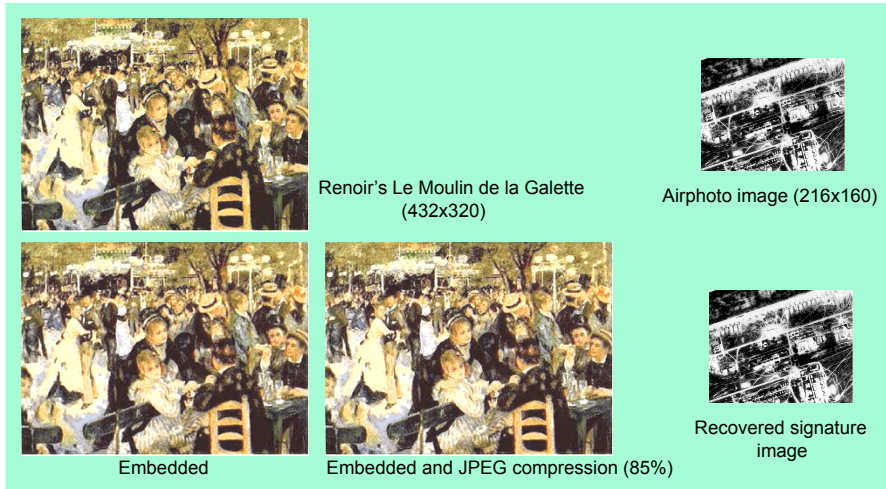
Steganography is the art and science of communicating in a way which hides the existence of the communication. In contrast to cryptography, where the "enemy" is allowed to detect, intercept and modify messages without being able to violate certain security premises guaranteed by a cryptosystem, the goal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

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Example: Image in Image



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Example: Video in Video



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Project W2005/F2009: Image Mosaicking

- What is mosaicking?
 - 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!

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Video mosaic



Challenges: Identifying robust control points in one or more images, Computing the proper image transformations (affine, projective transformations), and blending the images together.

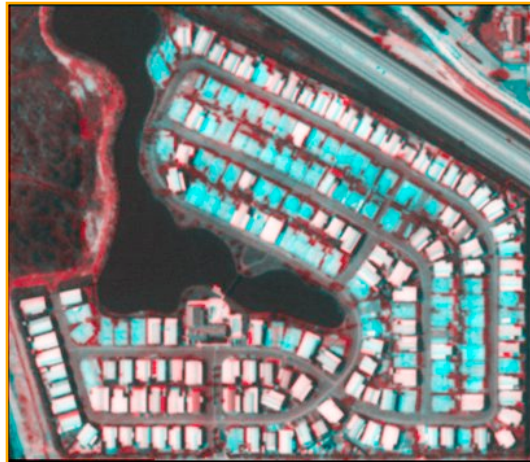
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Change detection



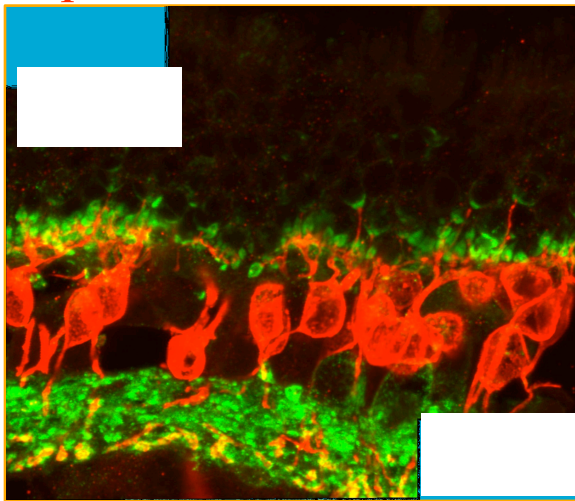
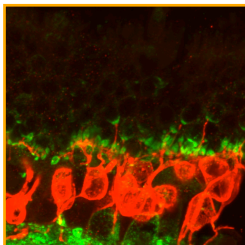
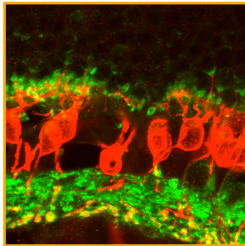
Images are taken about two years apart



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another example

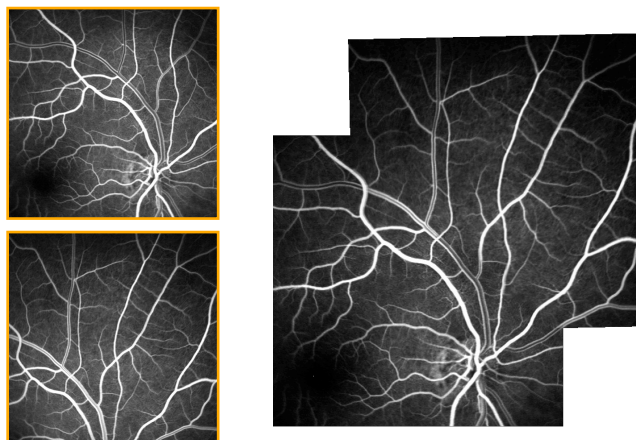


Generation of wide field of view in high resolution bypassing microscope limitations

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One more..(retina)



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2009 Fall

IMAGE FORENSICS

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Week 1: Reading Assignments

- Chapter 1.
- Chapter 2: You should be familiar with the following topics
 - Section 2.1
 - Structure of the human eye
 - Image formation in the eye
 - [Brightness adaptation and discrimination](#)
 - Sections 2.2 and 2.3

A note on human visual perception

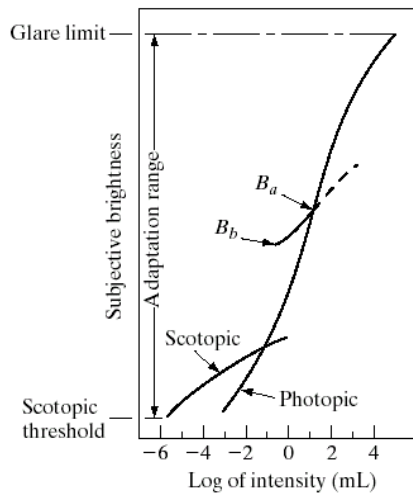
- Both the “hardware” and “software” of human visual perception are extremely complex and they work!
- A good understanding of the “acquisition” hardware (eyes)
- Very little known about higher level (perceptual) processing.
 - “To this day, the eye gives me a shudder”- Charles Darwin

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 this ability to adjust its(eye) sensitivity over a wide range of adaptation levels.



Brightness Discrimination

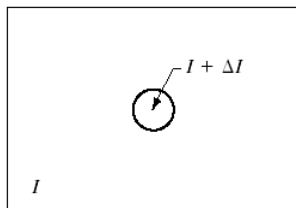
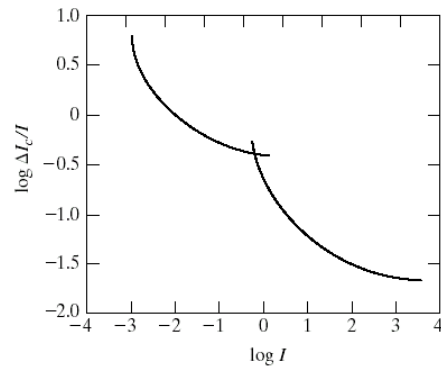


FIGURE 2.5 Basic experimental setup used to characterize brightness discrimination.

Weber Ratio

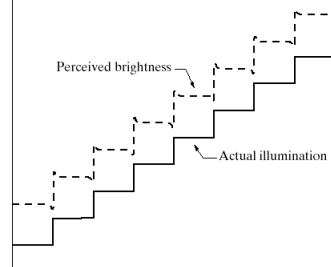
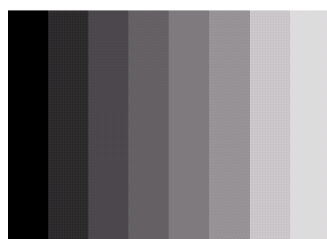
FIGURE 2.6
Typical Weber
ratio as a function
of intensity.



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Perceived Brightness



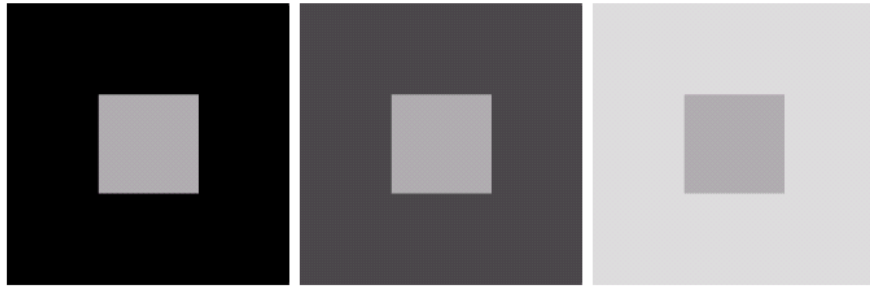
a
b

FIGURE 2.7
(a) An example
showing that
perceived
brightness is not a
simple function of
intensity. The
relative vertical
positions between
the two profiles in
(b) have no
special
significance; they
were chosen for
clarity.

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Simultaneous Contrast

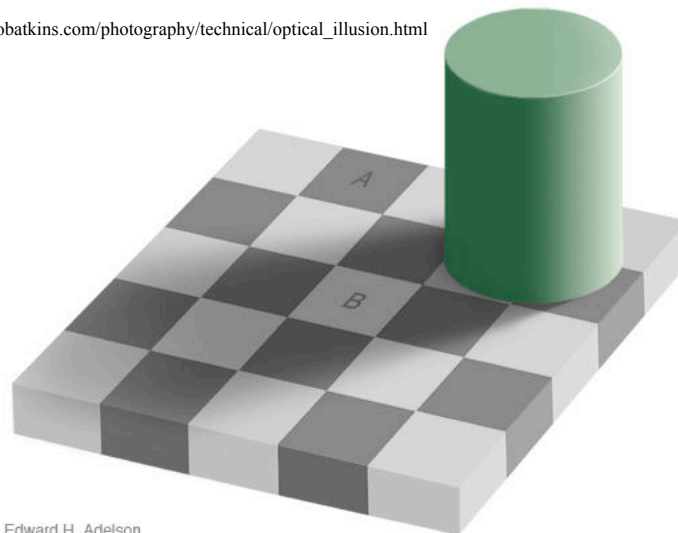


a b c

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.

What you see is not what you “see”

http://www.bobatkins.com/photography/technical/optical_illusion.html



Edward H. Adelson

Dr. Edward H. Adelson of MIT's Dept. of Brain and Cognitive Sciences and Artificial Intelligence Lab