Digital Image Processing
ECE 178

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Teaching Assistant

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Today

- Course outline

- 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/…

- **Reference Book:**
  - Gonzalez and Woods, 3nd Edition (2007)
  - http://www.imageprocessingplace.com
  - Read chapters 1 and 2

Grading

- H/W*   20%, due by 5pm on due date
- Project   15%
- Midterms   20% (two mid-terms)
- Finals   45%

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

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, ultra-sound, …

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
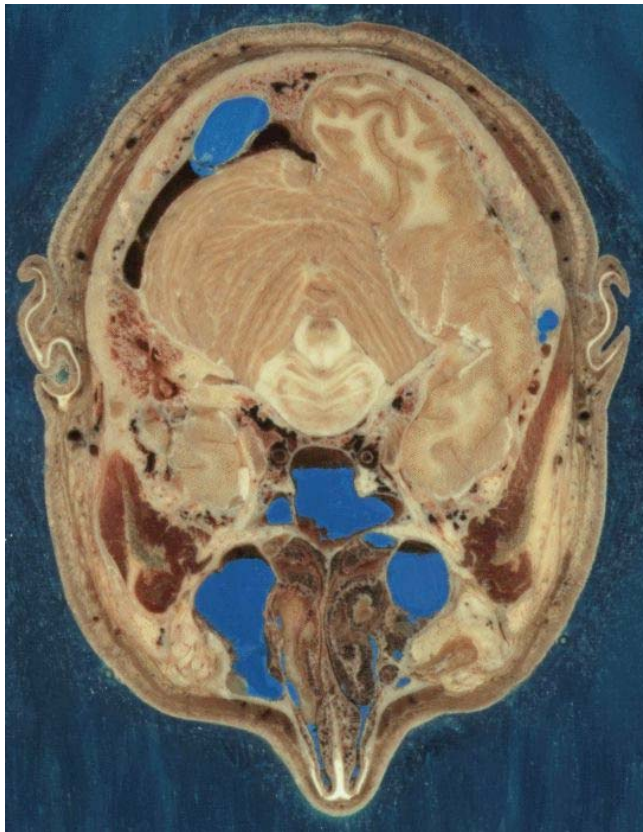
[545x700 24-bit color JPEG, 69069 bytes] Section through Visible Human Male - head, including cerebellum, cerebral cortex, brainstem, nasal passages (from Head subset)
http://www.nlm.nih.gov/research/visible/photos.html)

An Ultrasound image

Profile of a fetus at four months. This face is approximately 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 (next quarter, ECE/CS 181b)

Course Outline

FIGURE 1.23
Fundamental steps in digital image processing.
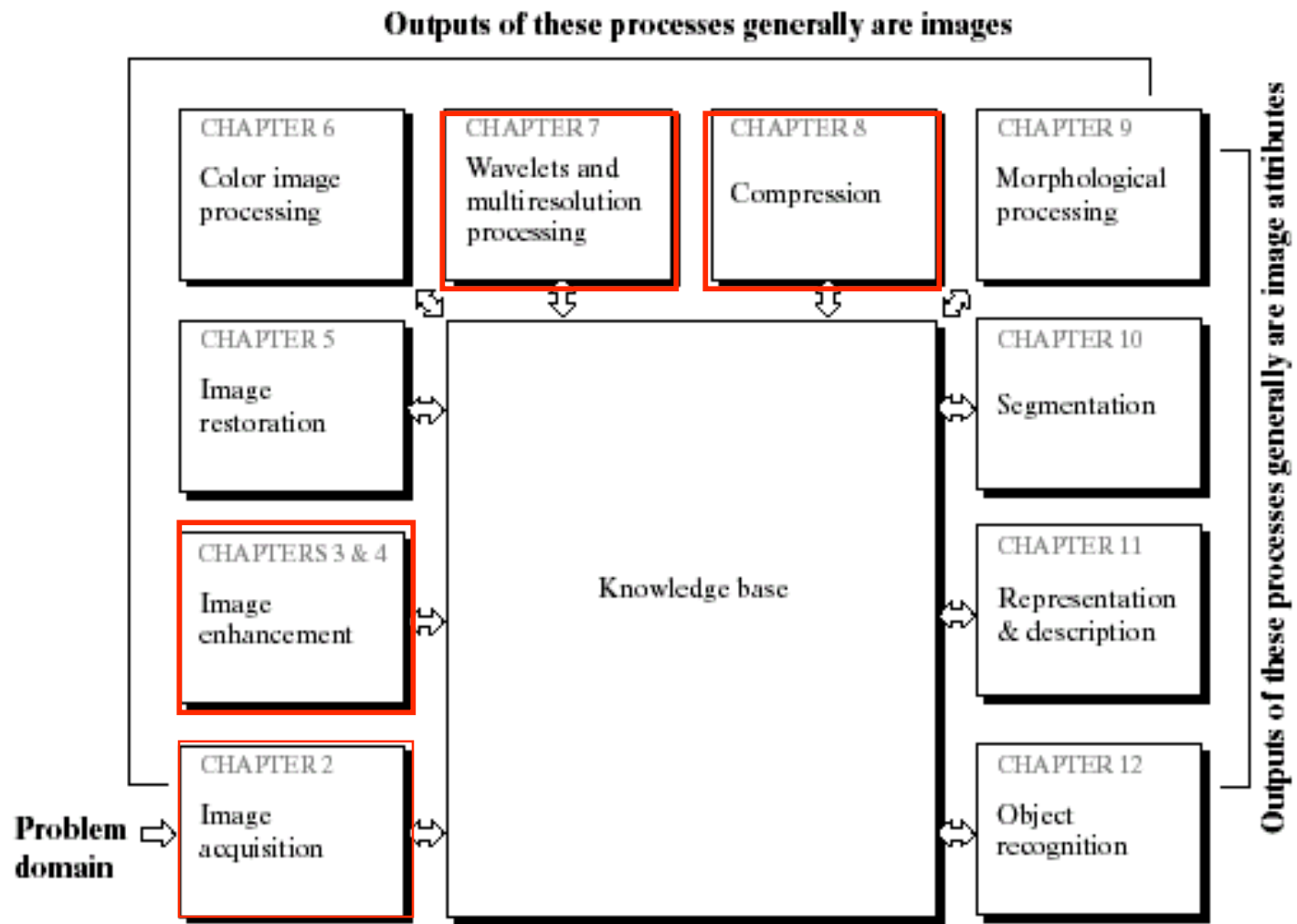
Image Enhancement

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

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

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 focus on geometric manipulation (primarily)
- **Previous year projects**
  - Streaming video
  - Data hiding
  - JPEG 2000

Data Hiding
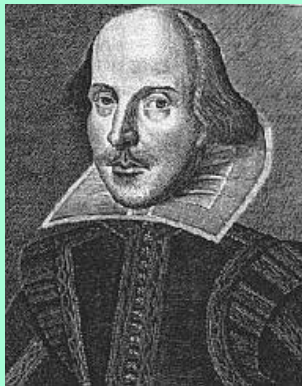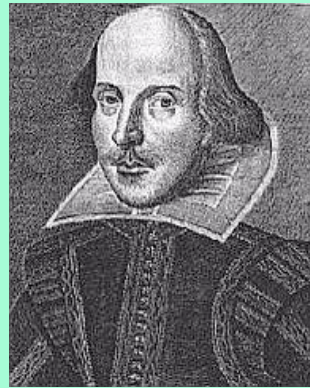

Droeshout engraving of
William Shakespeare
(192x240)

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
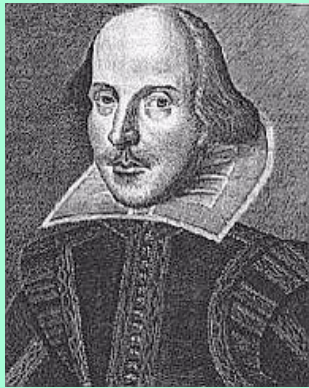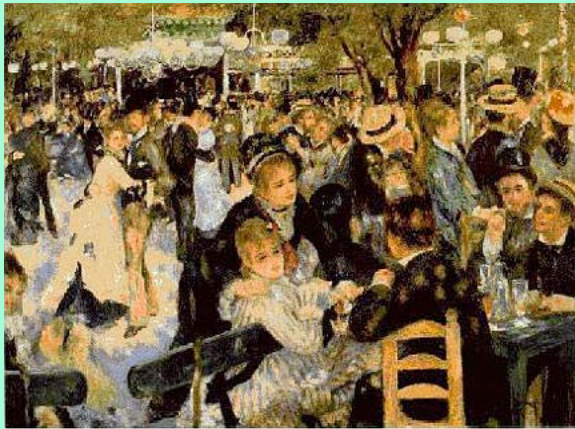

Embedded image

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

Introduction

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)

Project W2005: Image 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 mosacing: stitching together video frames.

- ## General procedure
  - Identify control points that are good for matching
  - Match them, thus establishing a correspondence

- ## Matching is difficult!

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.
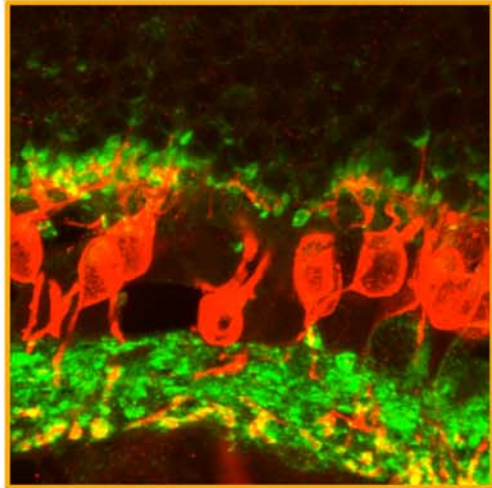
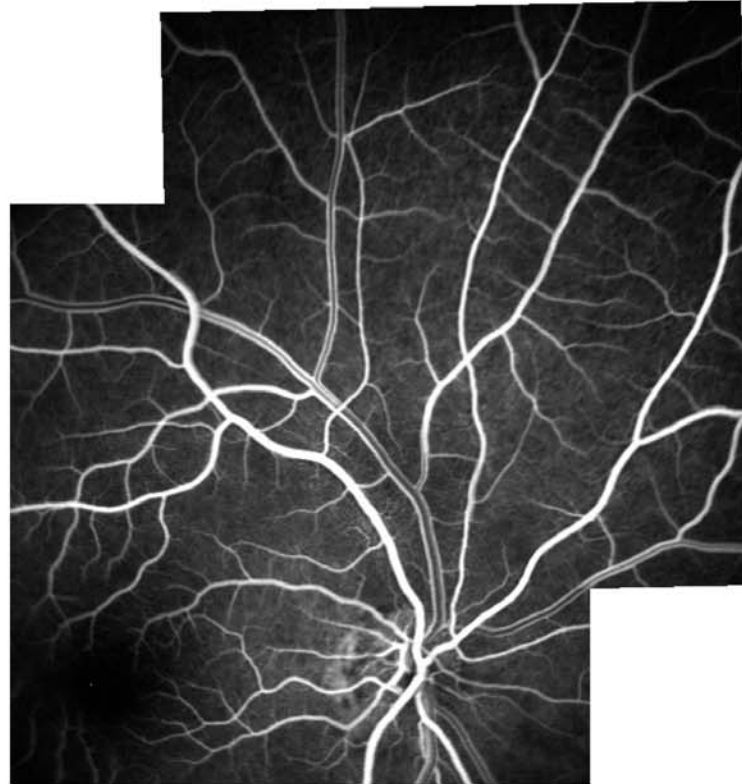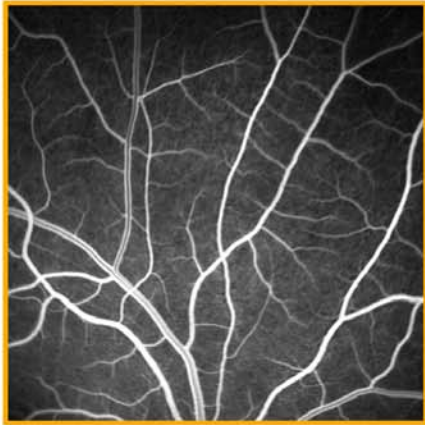# Change detection

Images are taken about two years apart

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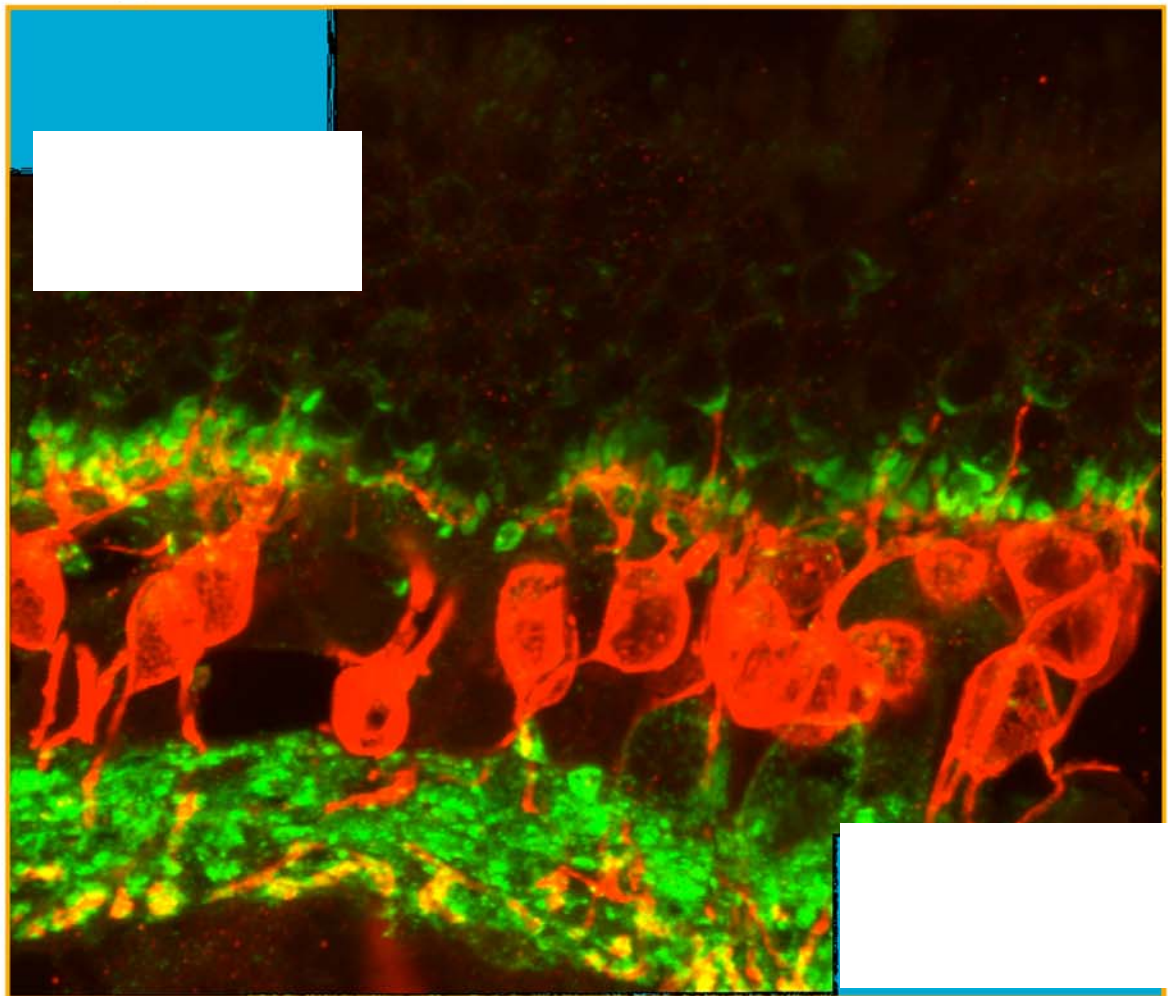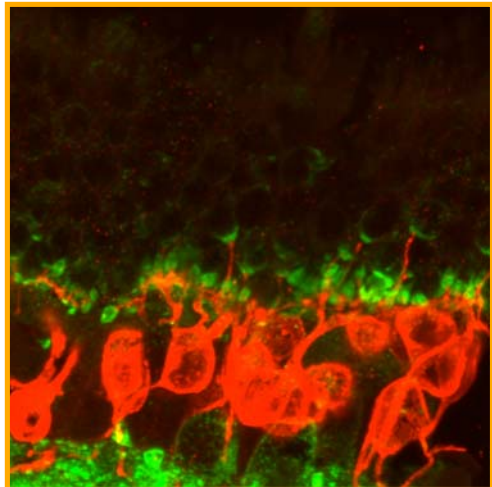
Generation of wide field of view in high resolution bypassing microscope limitations

One more..(retina)

Week 1: Reading Assignments (Gonzalez book available in Library)

- Chapter 1.
- Chapter 2: You should be familiar with the following topics
  - Section 2.1
    - Structure of 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.
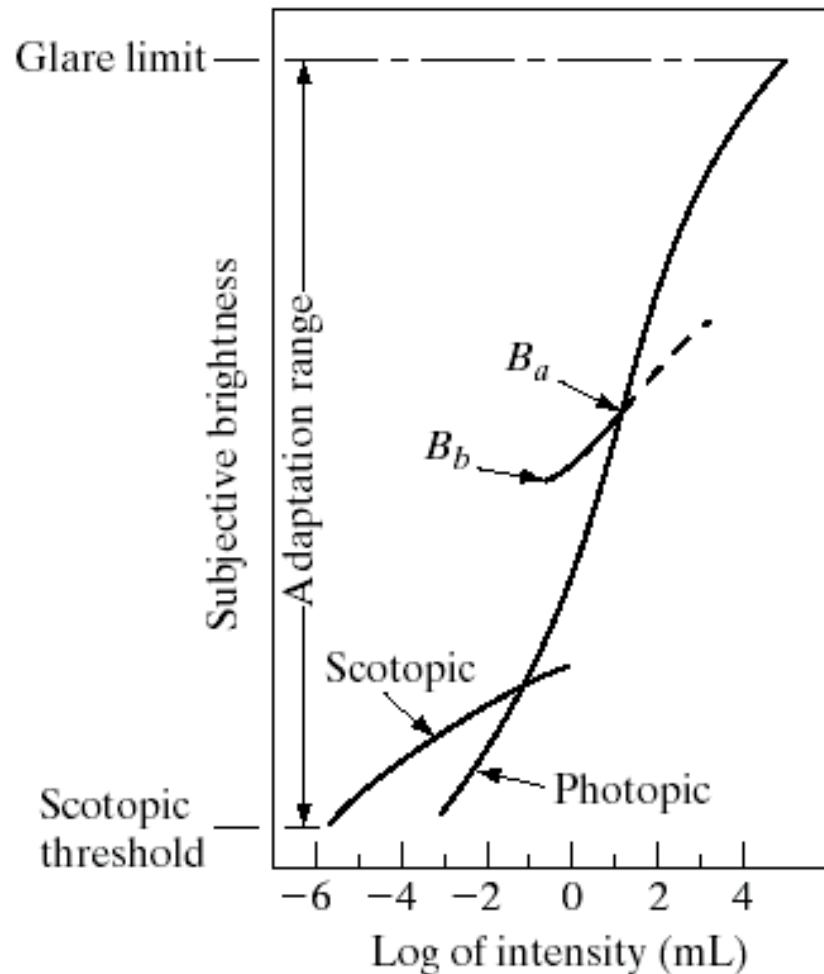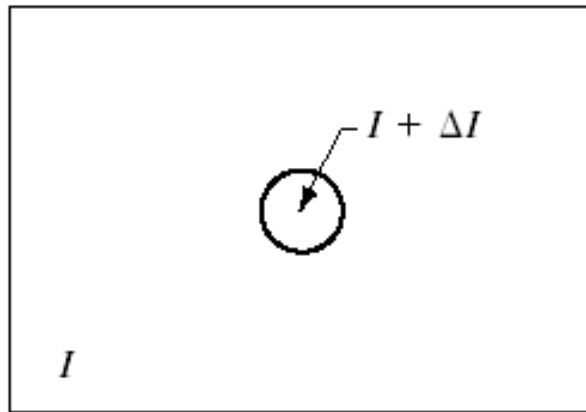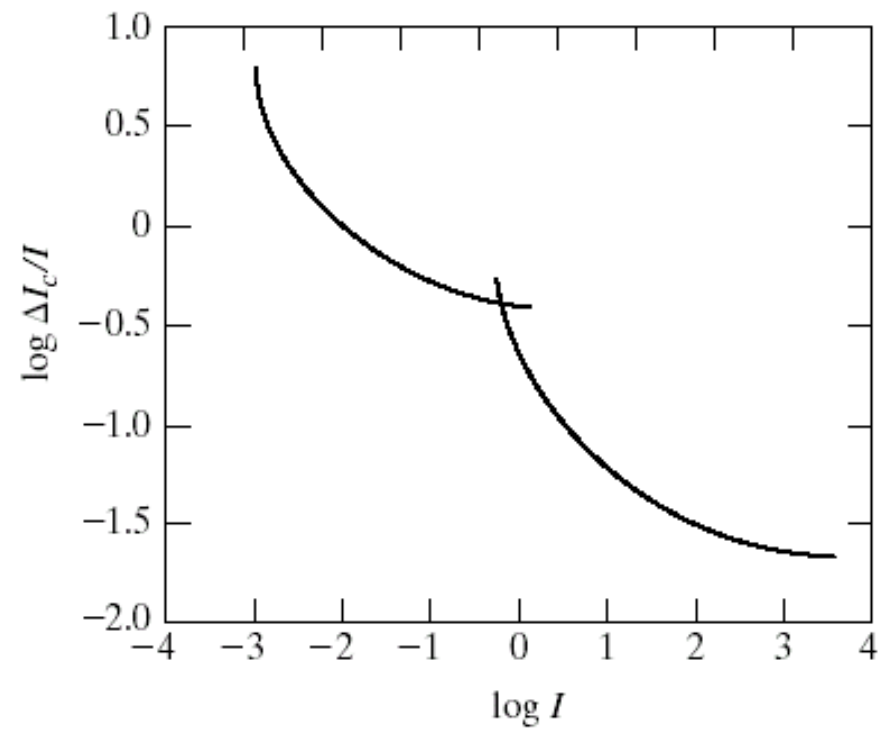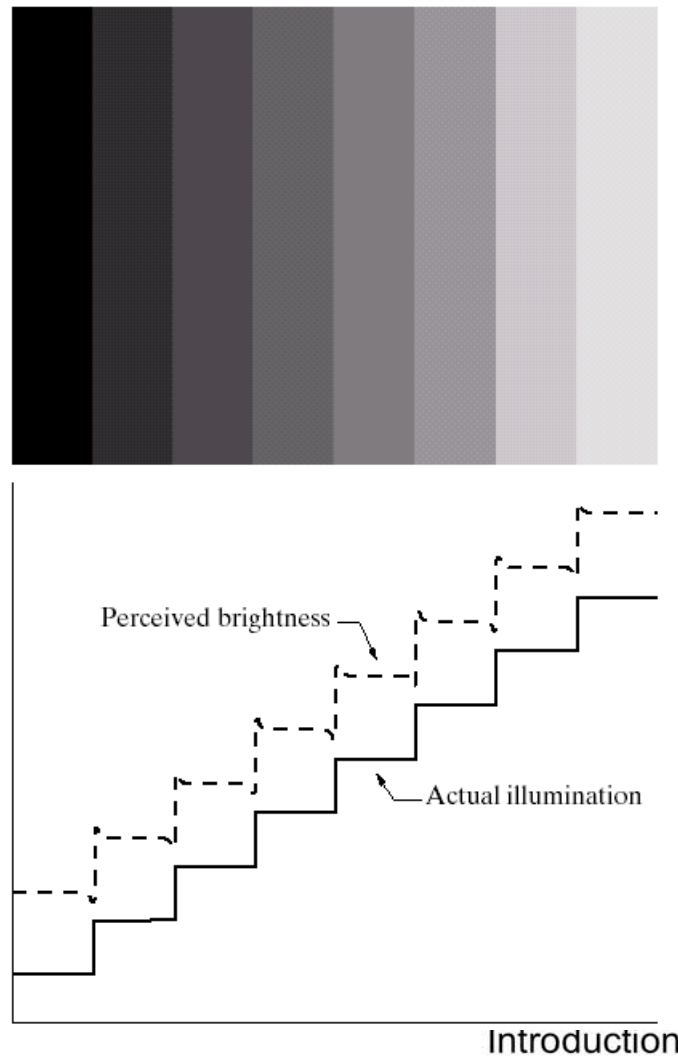
Brightness Discrimination

FIGURE 2.5 Basic experimental setup used to characterize brightness discrimination.

Weber Ratio

FIGURE 2.6
Typical Weber ratio as a function of intensity.

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.

Perceived brightness

Actual illumination

Introduction

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Simultaneous Contrast
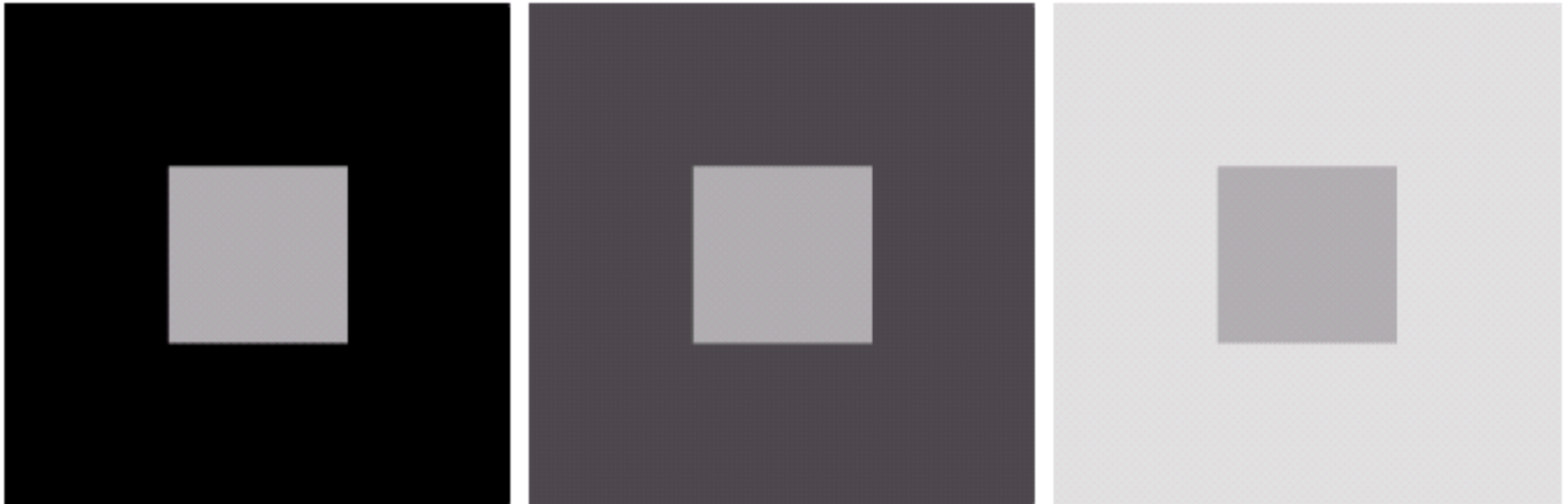
a b c

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.

More examples from the web

Matlab stuff