Digital Image Processing
ECE 178
Winter 2004

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RM 3157 ENGR I

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On the WEB

For course information and slides and more:

http://www.ece.ucsb.edu/Faculty/Manjunath/courses/ece178

Teaching Assistants

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Today: Jan 06-2003

- 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:
  - Gonzalez and Woods, 2nd Edition (2002)
  - 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 I: Tuesday, February 3, 2004.
- Mid-Term II: Tuesday, February 24 (tentative)

- Final Examination: Friday, March 19, 8-11am (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, ultra-sound, …

Entertainment

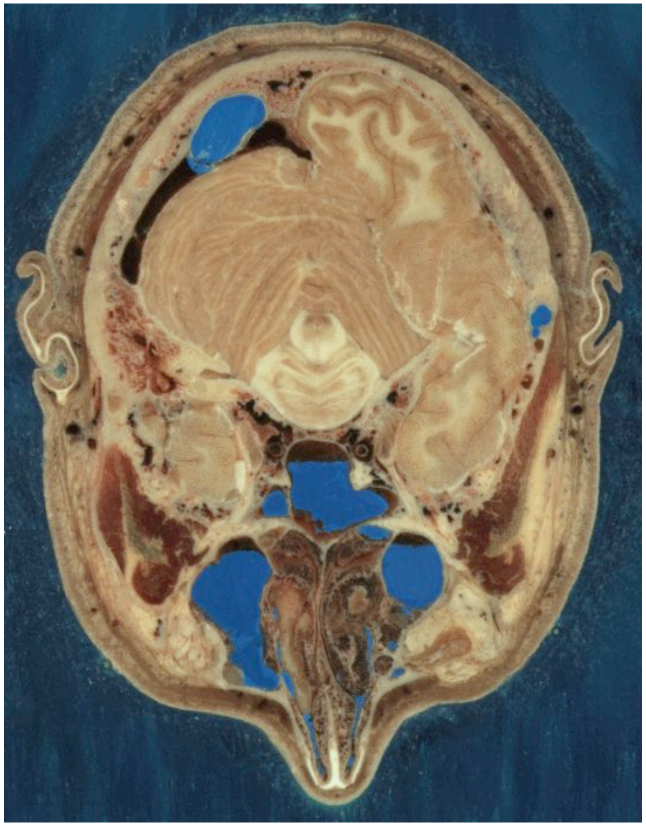
- Digital camcorders
- HDTV
- DVDs: High quality image/video compression (MPEG-2: about 5-10 Million bits/second)
- Digital Cinema
  - New compression technologies are needed
  - Consider a 2 hour movie: 1920 x 1080 x 30 bits/pixel x 24 frames/second ~~ 1.5 billion bits/second ➔ 1.3 terra bytes / 2 hr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



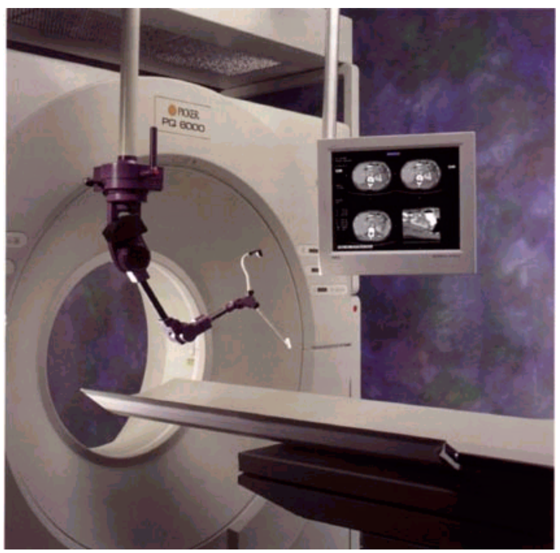
[545x700 24-bit color JPEG, 69069 bytes] Section through Visible Human Male - head, including cerebellum, cerebral cortex, brainstem, nasal passages (from Head subset)
http://www.nlm.nih.gov/research/visible/photos.html)

An Ultrasound image

Profile of a fetus at four months. This face is approximately 1 _ 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

FIGURE 1.23
Fundamental steps in digital image processing.

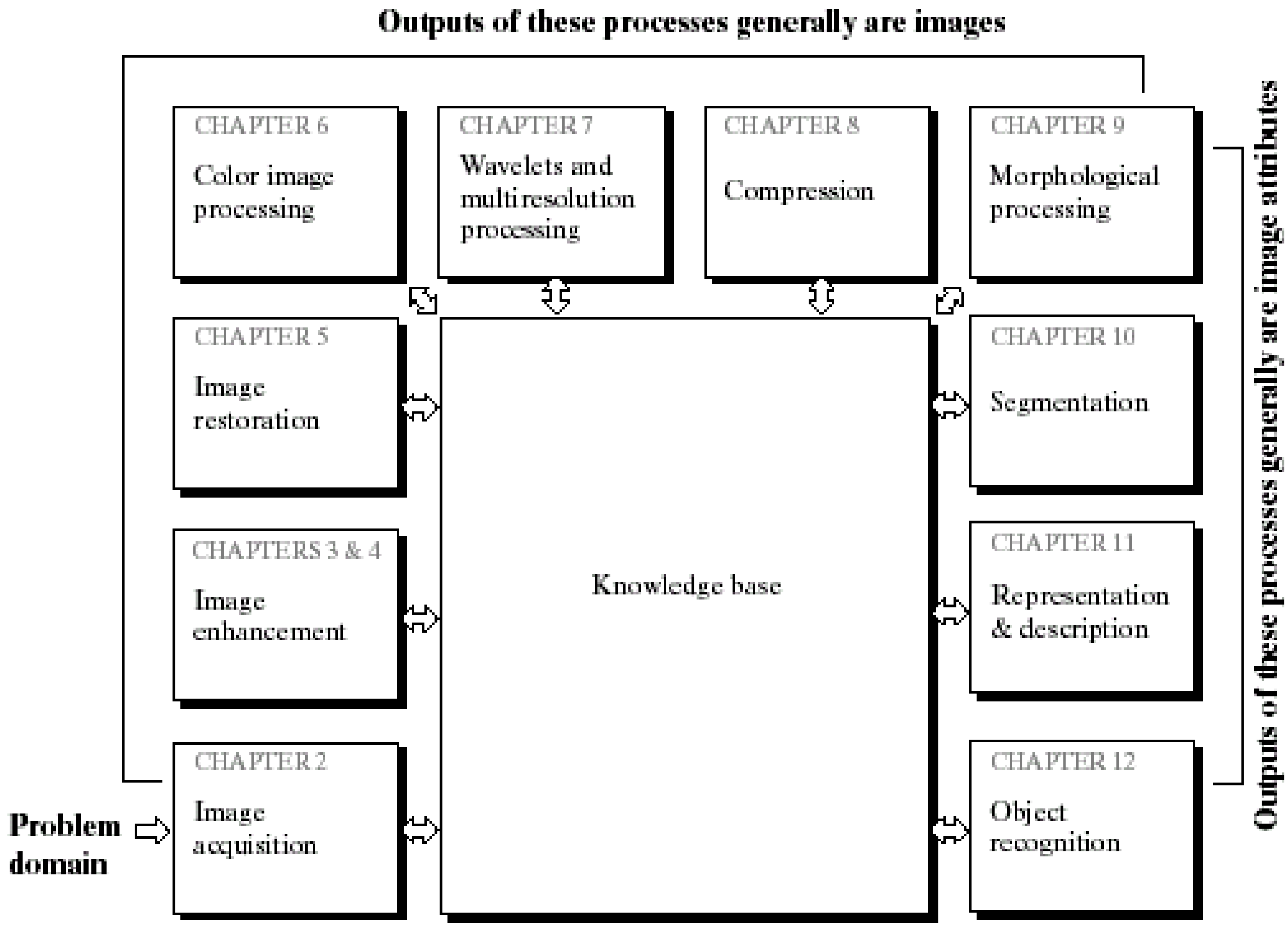
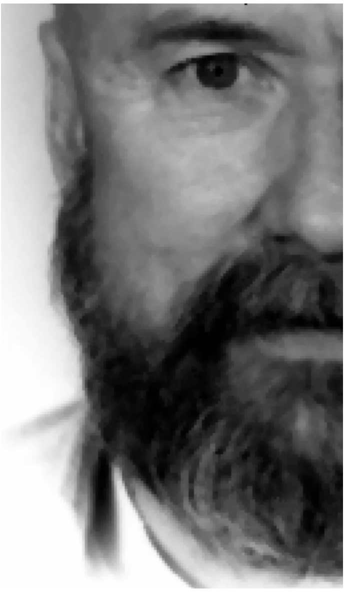


Image Enhancement





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.
- A page from Matlab examples or the matlab site at http://www.mathworks.com/products/demos/imagetlbx/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 Project

- 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 2004: This quarter we will explore Steganography

Previous year projects

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

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.

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

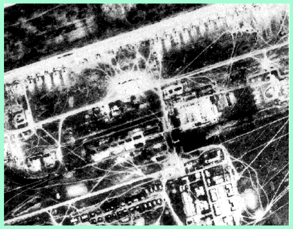
Compressed image
(lossy JPEG 85%)

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

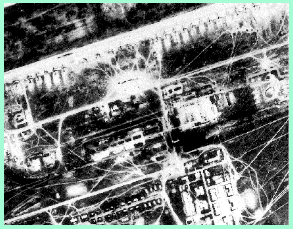
Renoir's Le Moulin de la Galette (432x320)



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.

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 mosacing: stitching together video frames.
- General procedure
  - Identify control points that are good for matching
  - Match them, thus establishing a correspondence
- Matching is difficult!

Steganography Project: Timeline

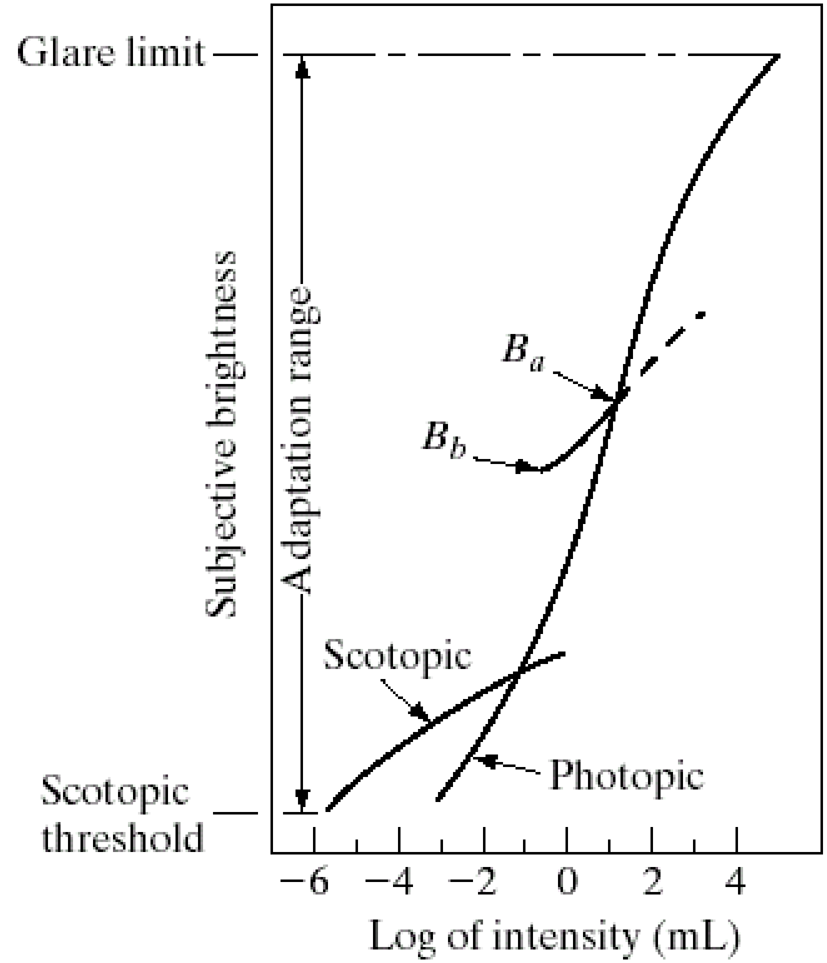
- **Plan in advance**; you have only ten weeks!!
- Jan 16: Project details will be provided (e-mail and on web)
- Jan 15: form groups-not exceeding 5/group and inform TA (mix COMPENG with EE 50-50).
  - If you need help in deciding, contact me.
- Week of Feb 9: Meet with instructor to discuss progress (individual groups).
- Dead week: project presentations in class
- March 12: 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

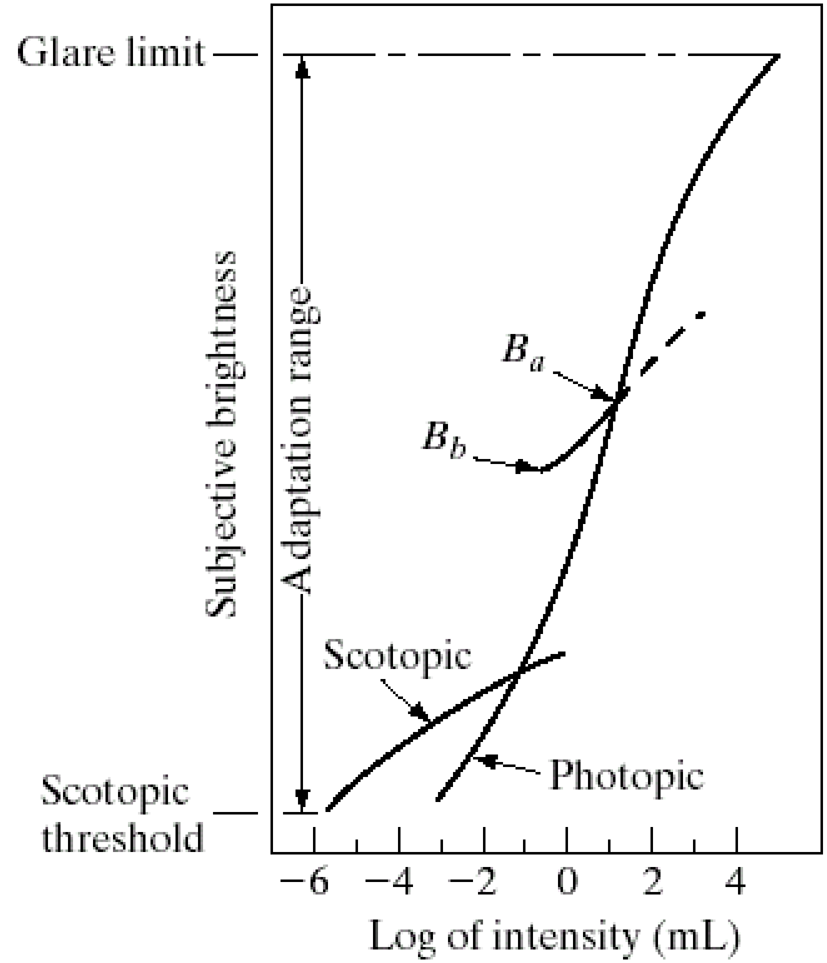
FIGURE 2.4
Range of subjective brightness sensations showing a particular adaptation level.



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

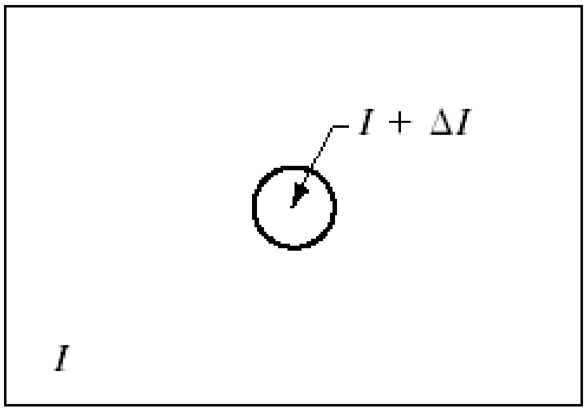
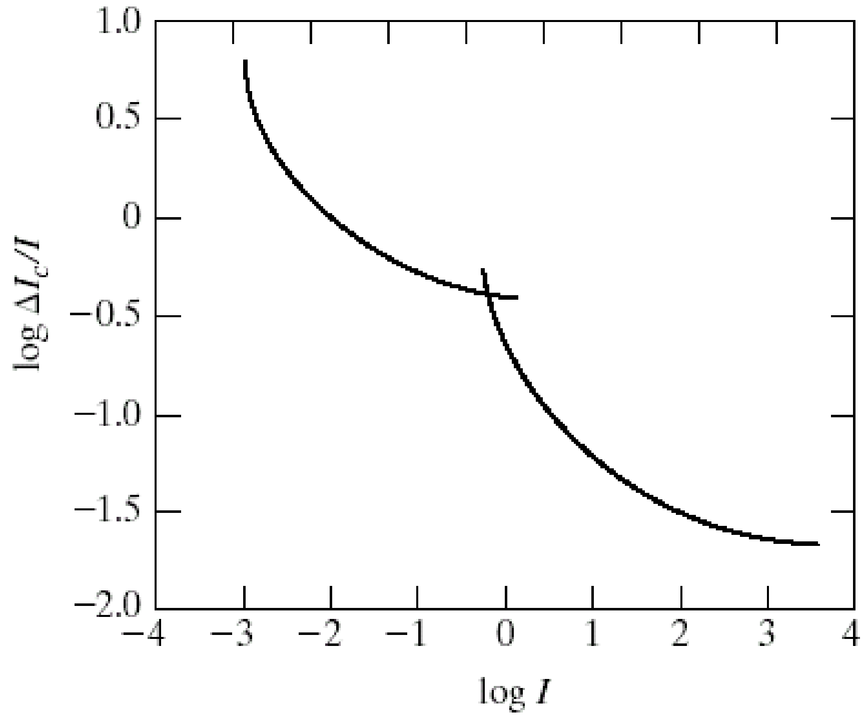


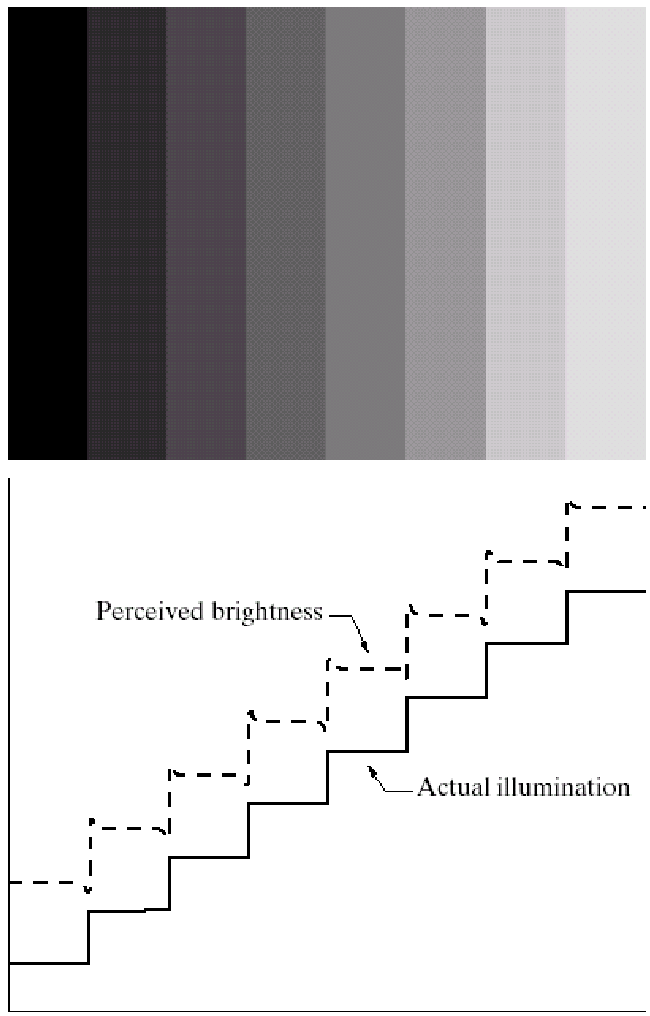
FIGURE 2.5 Basic experimental setup used to characterize brightness discrimination.

Weber Ratio

FIGURE 2.6
Typical Weber ratio as a function of intensity.



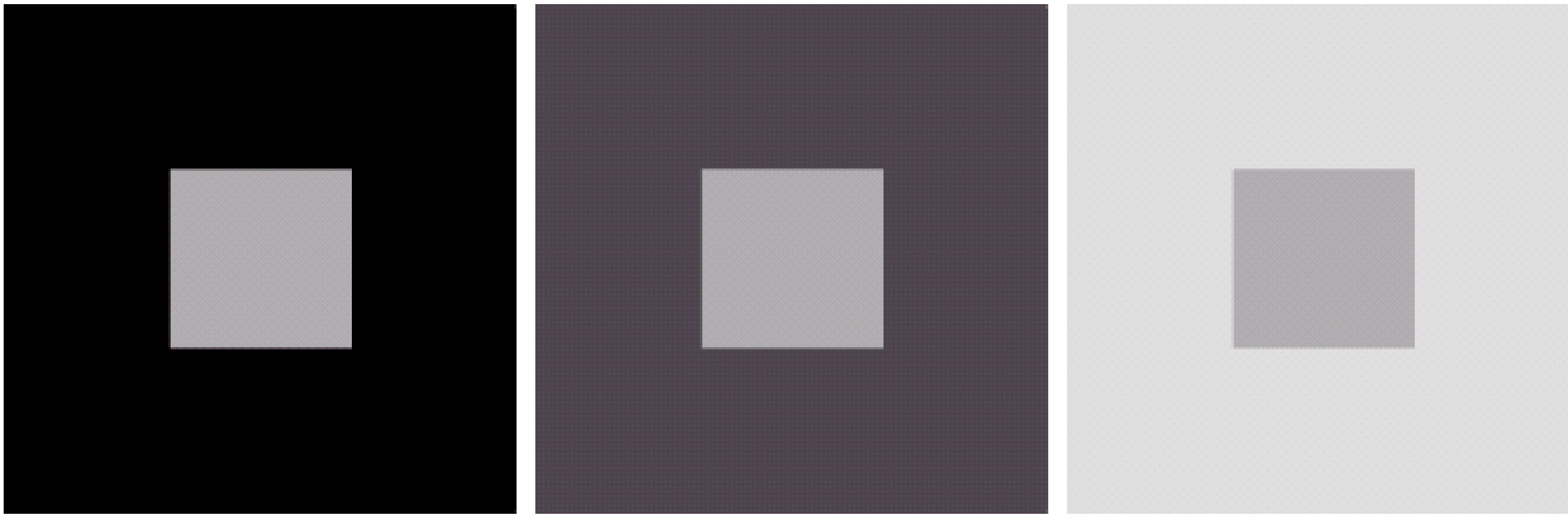
Perceived Brightness



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.

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.

Optical Illusions

a b
c d

FIGURE 2.9 Some well-known optical illusions.