ECE 468: Digital Image Processing

Lecture 1

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ECE 468: Digital Image Processing

- Instructor:

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- Office:

  2107 Kelley Engineering Center
- Office Hours:

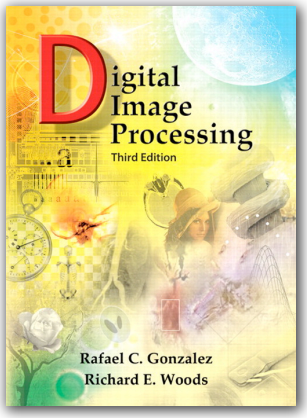
  Wednesday 3-4pm, or by appointment

- Classes:

  Tuesdays & Thursdays 8:30-9:50am, KEC 1001
- Class website:

  http://web.engr.oregonstate.edu/~sinisa/courses/OSU/ECE468/ECE468.html

Recommended Textbook



- "Digital Image Processing" by R.C. Gonzalez and R.E. Woods, 3rd edition, Pearson Prentice Hall, 2008
- Additional readings on the class website

Course Objectives

- Cover basic theory and algorithms widely used in image processing
- Develop hands-on experience in processing images
- Familiarize with MATLAB Image Processing Toolbox
- Develop critical thinking about the state of the art

Prerequisites

- Signals and systems: ECE 351 and ECE 352
- Undergraduate-level knowledge of:
  - Linear algebra
    - Matrices, Matrix Operations
    - Determinants, Systems of Linear Equations
    - Eigenvalues, Eigenvectors
  - Statistics and probability
    - Probability density function, Probability distribution
    - Priors, Posteriors, Likelihoods
    - Gaussian distribution
- Good programming skills

Requirements

- Weekly homework assignments due on Thursdays before class
  - Homework = Problem solving or Mini-project
  - Mini-project must be implemented in MATLAB
  - Homework must be an individual effort
  - No late homework will be accepted without prior approval
- Mid-term exam on February 10th, 8:30am, KEC 1001
- Final exam on March 20th, 9:30am, KEC 1001
- Participation in class discussions

Grading Policy

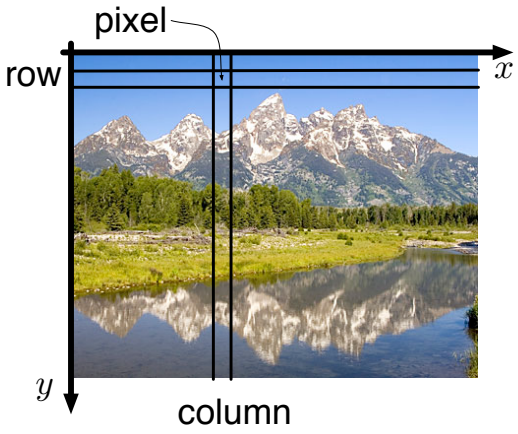
- Homework = 30%
- Midterm exam = 30%
- Final exam = 40%
- Optional makeup homework = 5%

Academic Honesty -- Examples of Cheating

- Bringing forbidden material or devices to the examination
- Working on the exam before or after the official time allowed
- Requesting a re-grade of work altered after the initial grading
- Submitting a homework that is not your own work

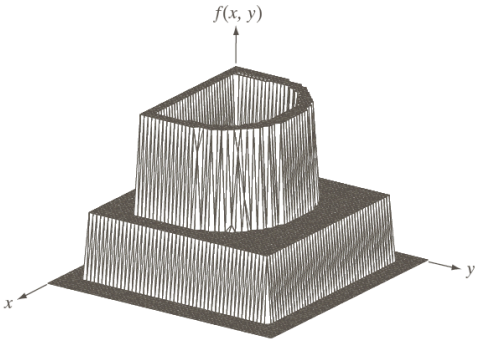
What is a Digital Image?

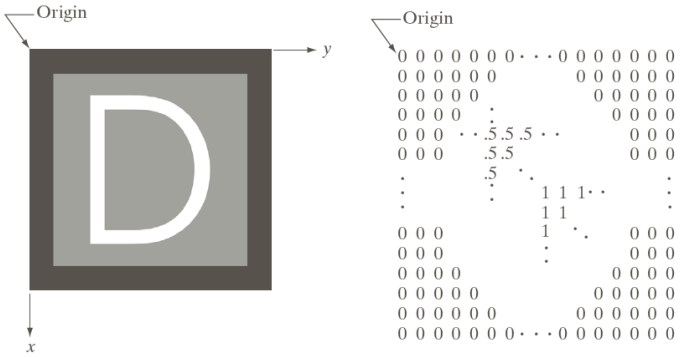
What is a Digital Image?



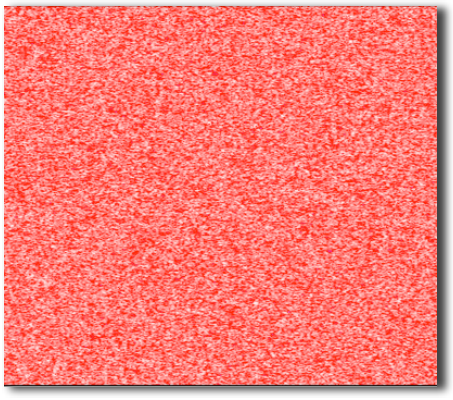
- Two-dimensional function *f(x,y)* or matrix
- *x, y, f(x,y)* are discrete and finite
- Image size = max_x x max_y -- e.g. 640x480
- Pixel intensity value $f(x,y) \in [0, 255]$

Pixel Values

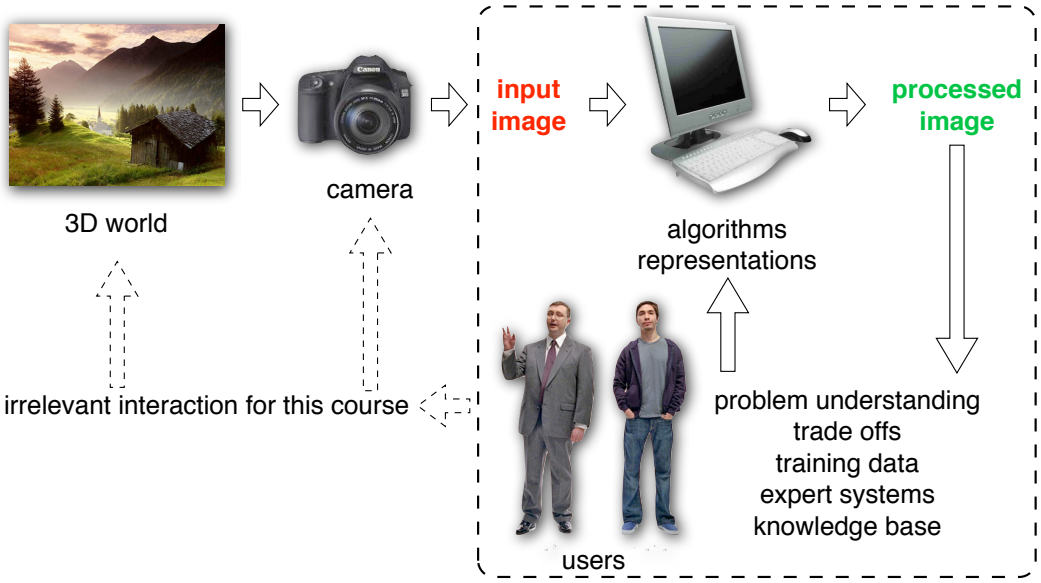




Images are not Collections of Random Pixels



A Typical Digital Image Processing System



Sources of Energy for Image Formation

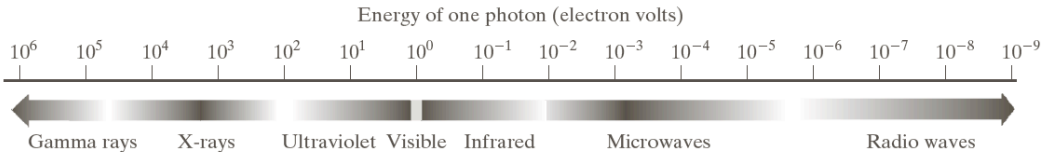
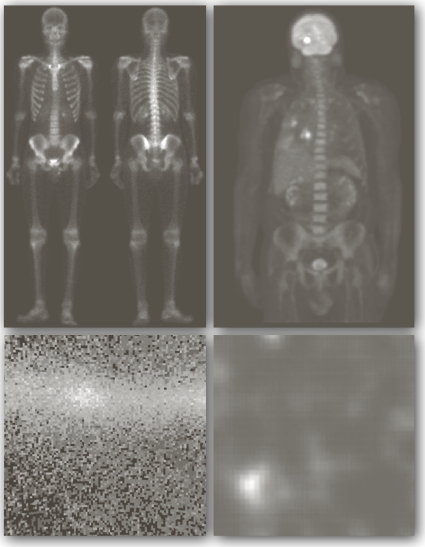


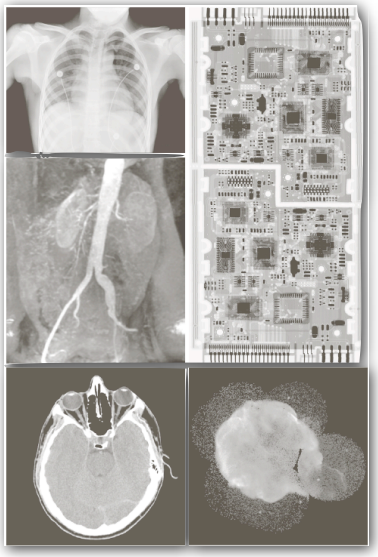
FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

Source: DIP/3e

Some Applications -- Medical Diagnostics



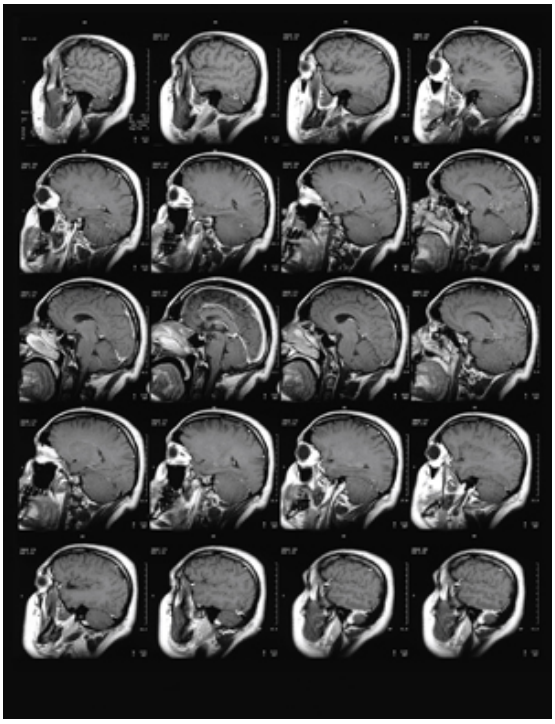
Gamma-ray imaging



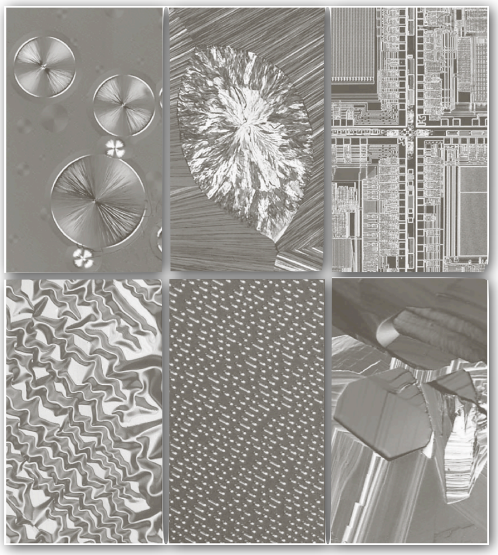
X-ray imaging

Source: DIP/3e

Some Applications -- Magnetic Resonance Imaging



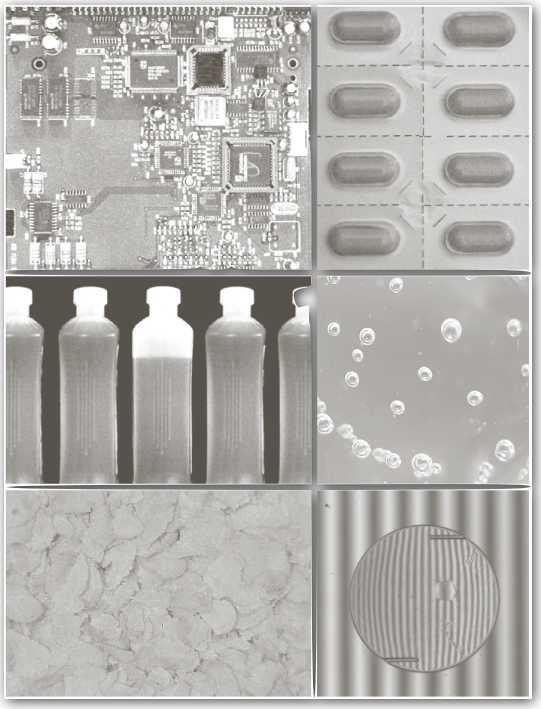
Some Applications -- Microscopy



Visible-light microscopy imaging

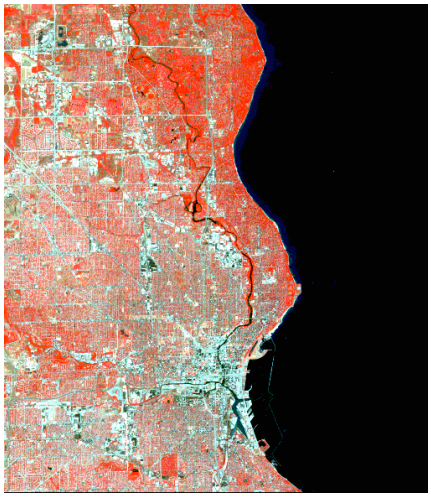
Source: DIP/3e

Some Applications -- Industrial Inspection



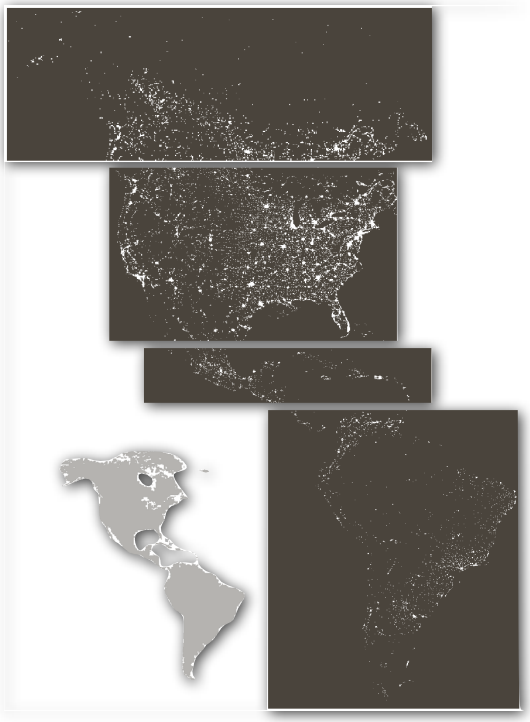
Some Applications -- Remote Sensing

Aerial images



Satellite images

Some Applications -- Infrared Satellite Images

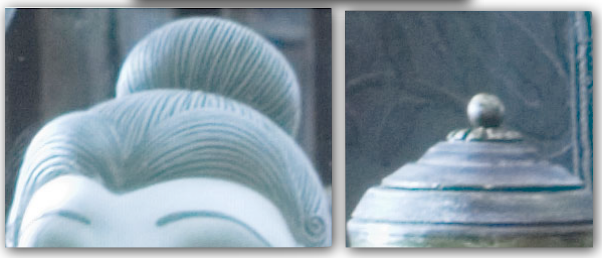


Source: DIP/3e

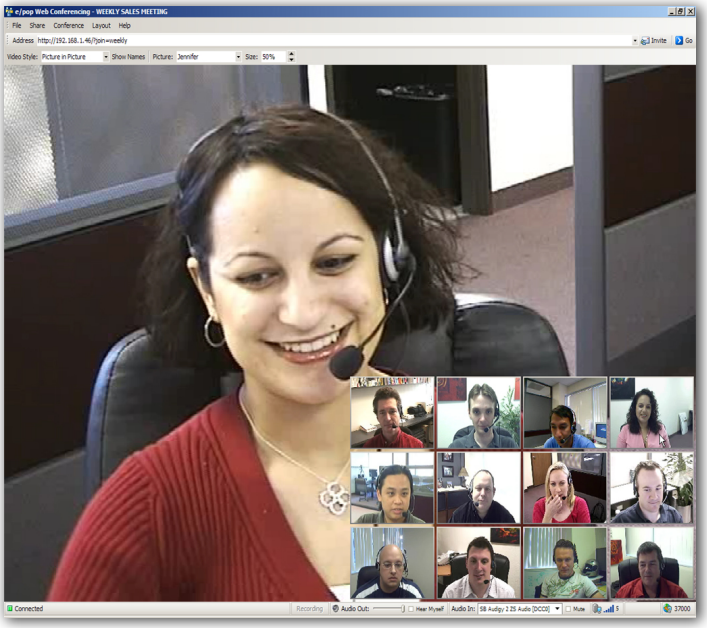
Some Applications -- Storing Images

Standard DVD

Blue-ray DVD



Some Applications -- Transmitting Images



Video conferencing

Some Applications -- Image Forensics

Fundamental Steps in Digital Image Processing

Fundamental Steps in Digital Image Processing

- Acquisition
- Spatial and frequency transforms
- Enhancement (subjective)
- Restoration (objective)
- Color processing
- Multi-resolution processing
- Compression
- Morphological processing
- Segmentation

Image Acquisition

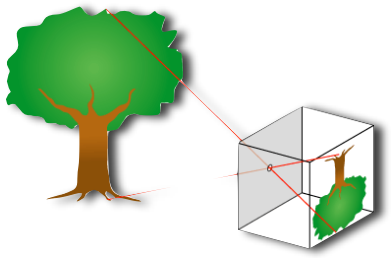
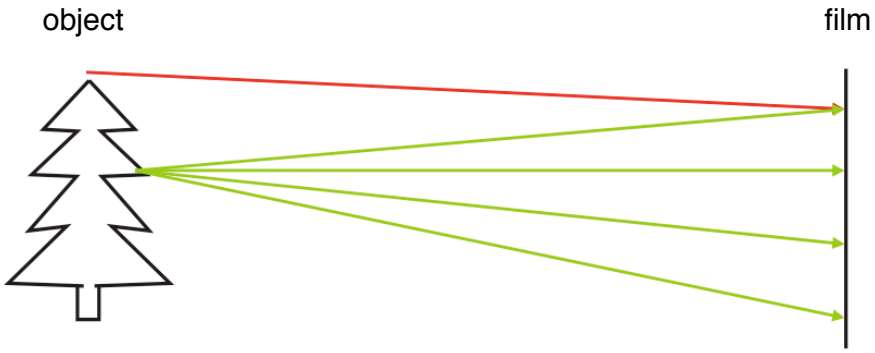


Image properties depend on:

- Image acquisition parameters
  - Camera distance, viewpoint, motion
  - Camera intrinsic parameters (e.g., lens aberration)
  - Number of cameras
  - Illumination
- Visual properties of the 3D world captured

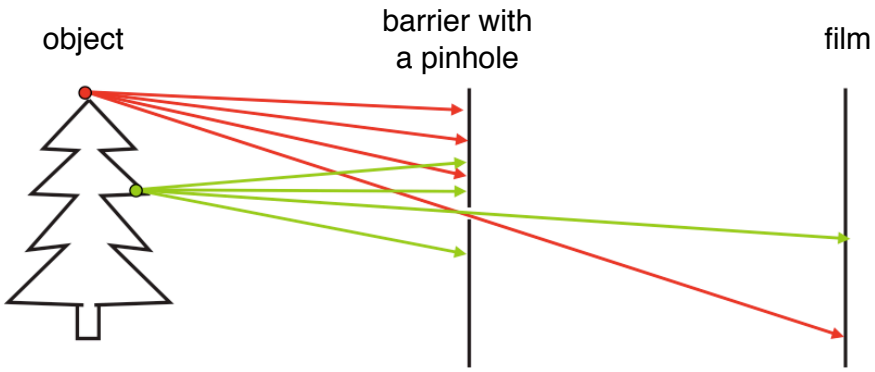
How to Design a Camera?



Do we get a reasonable image if we put a film in front of an object?

source: S. Savarese

Pinhole Camera

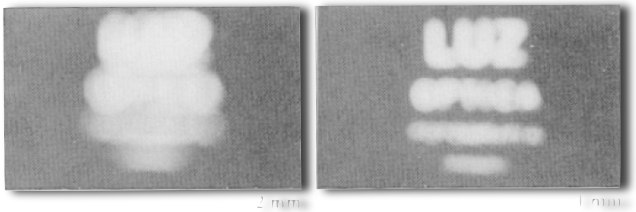


- The barrier block off most of the rays
- This reduces blurring
- Aperture = Opening of the pinhole

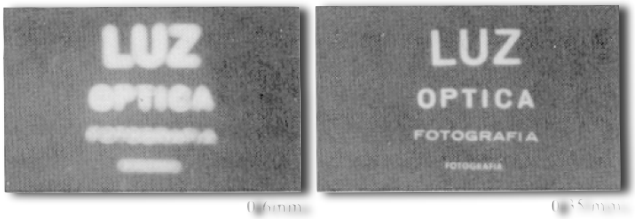
source: S. Savarese

Shrinking the Aperture...

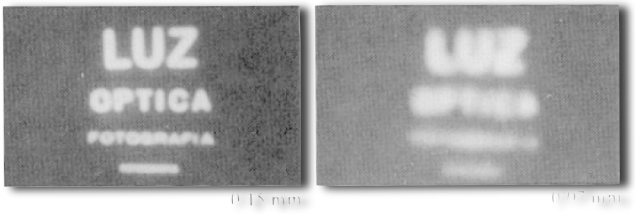
pinhole too big:
bright and blurred



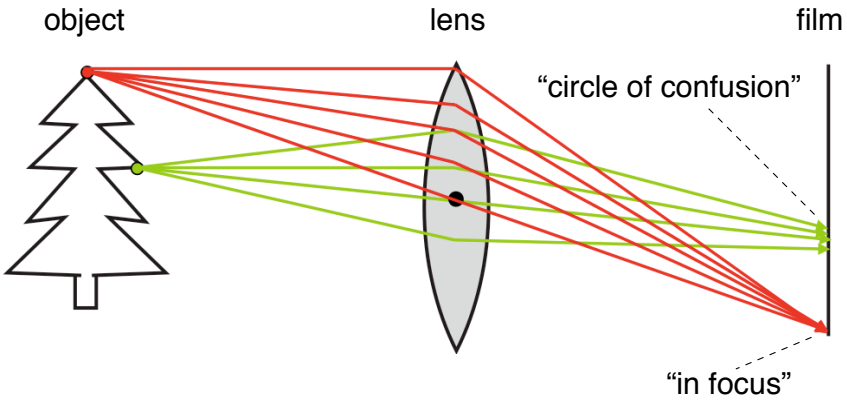
pinhole right size:
dark and crisp



pinhole too small:
dark and diffraction blur



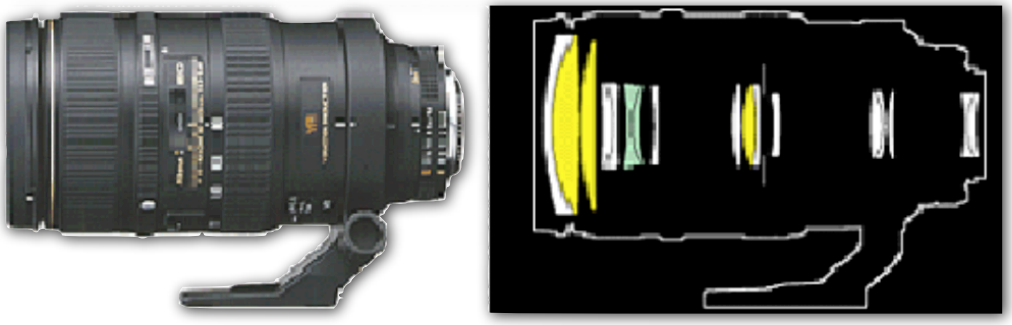
Adding Lens...



The lens focuses light onto the film

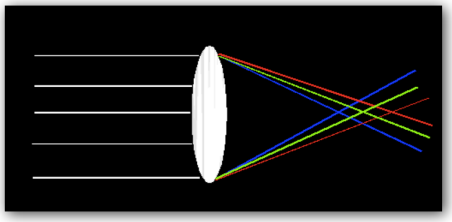
source: S. Savarese

Combining Lenses...



source: S. Savarese

Issues with Lenses: Chromatic Aberration



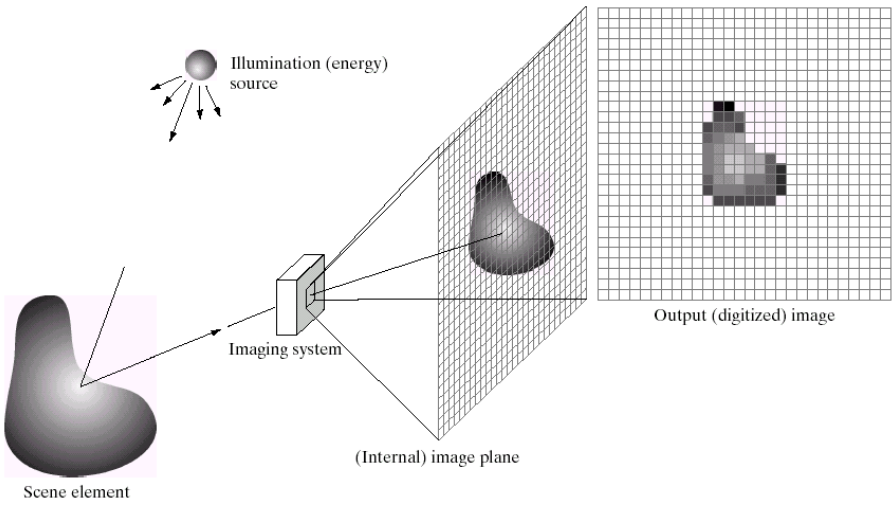
different refractive indices for different light wavelengths

source: S. Savarese

Issues with Lenses: Radial Distortion

source: S. Savarese

Image Sampling and Quantization

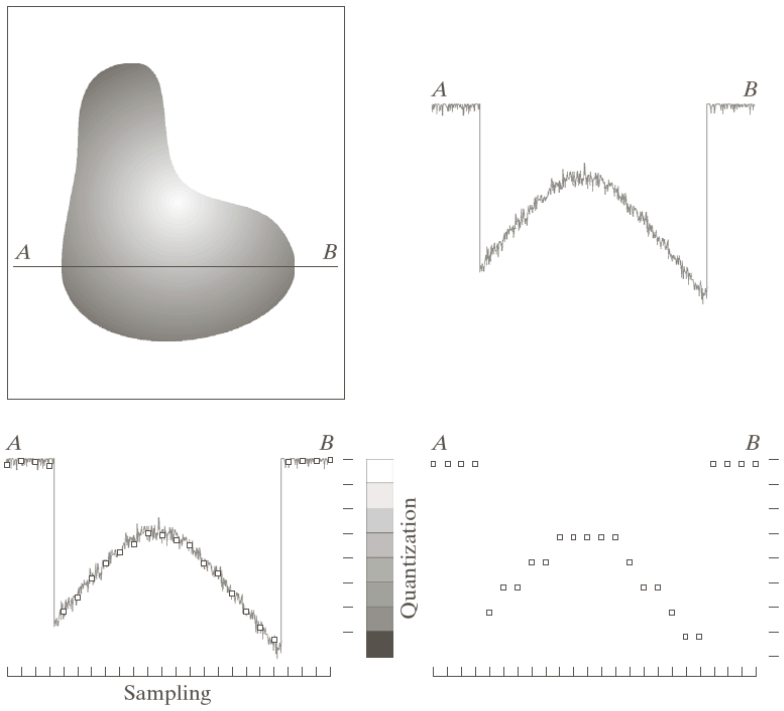


a b c d e

FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

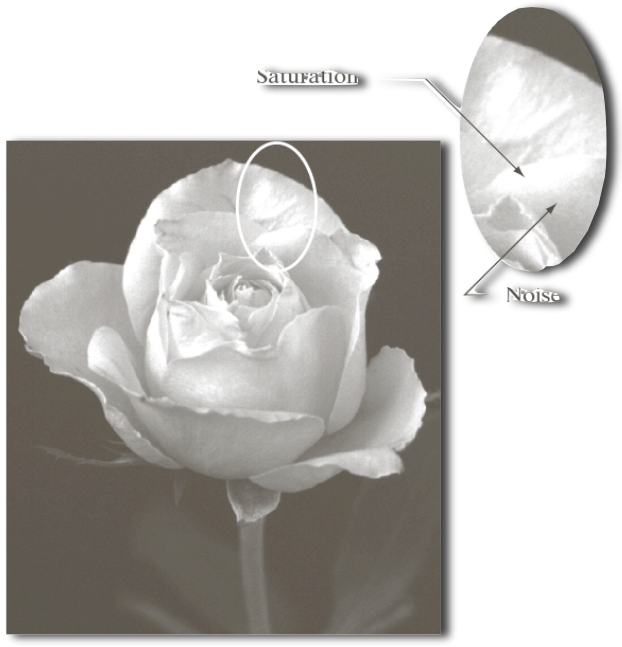
Source: DIP/3e

Image Sampling and Quantization



Source: DIP/3e

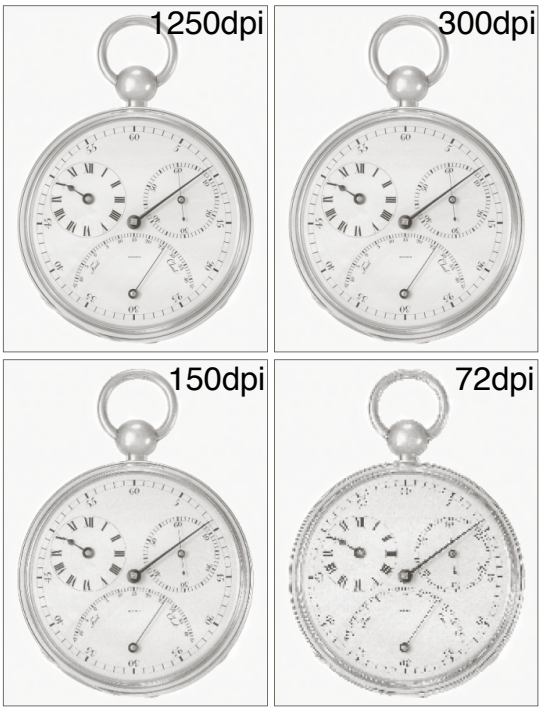
Saturation



Source: DIP/3e

Spatial Resolution

- Dots (pixels) per inch -- DPI
- Examples:
  - Newspapers 75dpi
  - Magazines 133dpi
  - Glossy brochures 175dpi



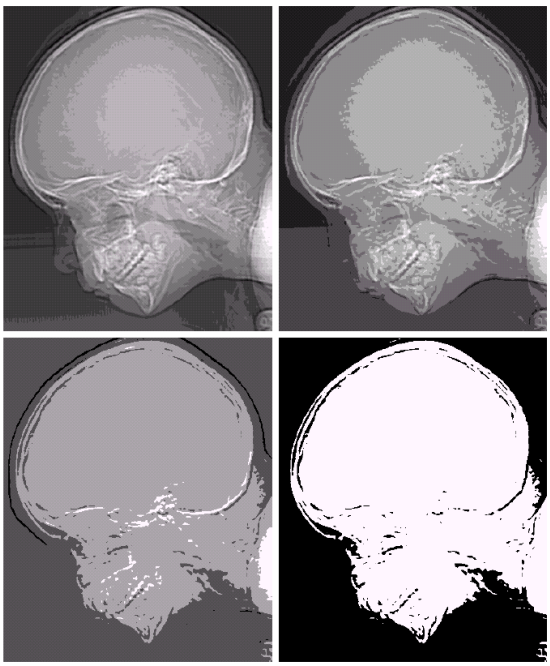
Source: DIP/3e

Intensity Resolution

Number of intensity levels -- usually 8 or 16 bits

e f
g h

FIGURE 2.21 *(Continued)* (e)–(h) Image displayed in 16, 8, 4, and 2 gray levels. (Original courtesy of Dr. David R. Pickens, Department of Radiology & Radiological Sciences, Vanderbilt University Medical Center.)



Source: DIP/3e

Homework 1

due 01/15

Next Class

- MATLAB tutorial
- Image interpolation
- Basic spatial relationships between pixels
- Spatial operations on images
- Intensity transformations