ECE 468: Digital Image Processing

Lecture 1

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OSU Oregon State University

ECE 468: Digital Image Processing

- Instructor:

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- Office:

  2107 Kelley Engineering Center

- Office Hours:

  Tuesday 1-2pm, or by appointment

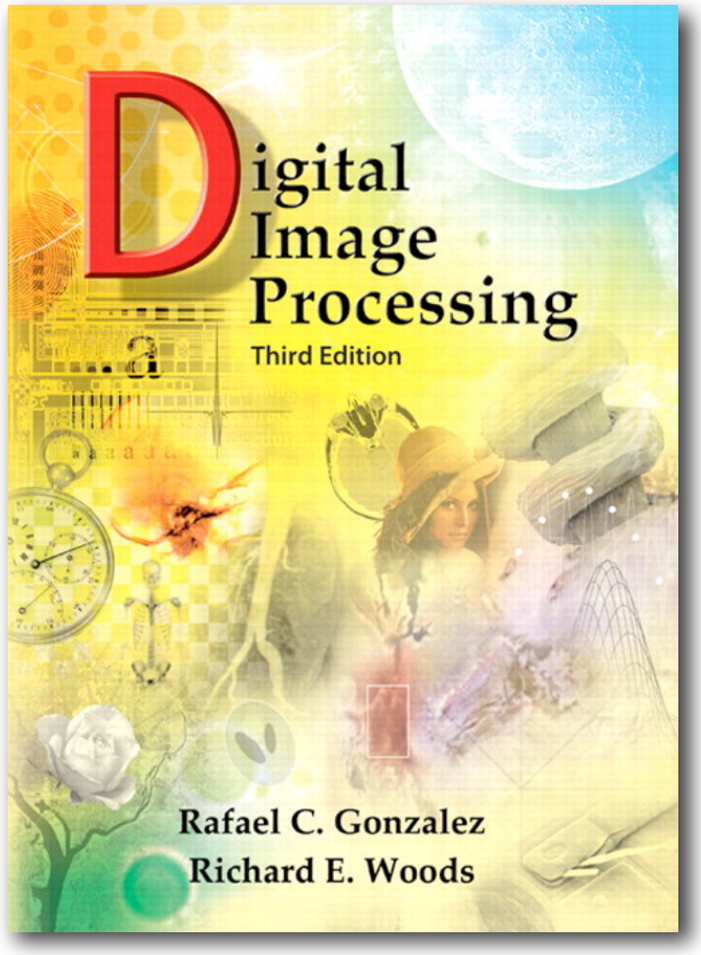
- Classes:

  MWF 3-3:50pm, STAG 329

- 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

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- Weekly homework assignments due on Mondays 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

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- Exam 1 on October 26, 3-3:50pm, STAG 1001

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- Exam 2 on November 11, 3-3:50pm, STAG 1001

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- Final exam on December 7, 12:00pm, STAG 329

Grading Policy

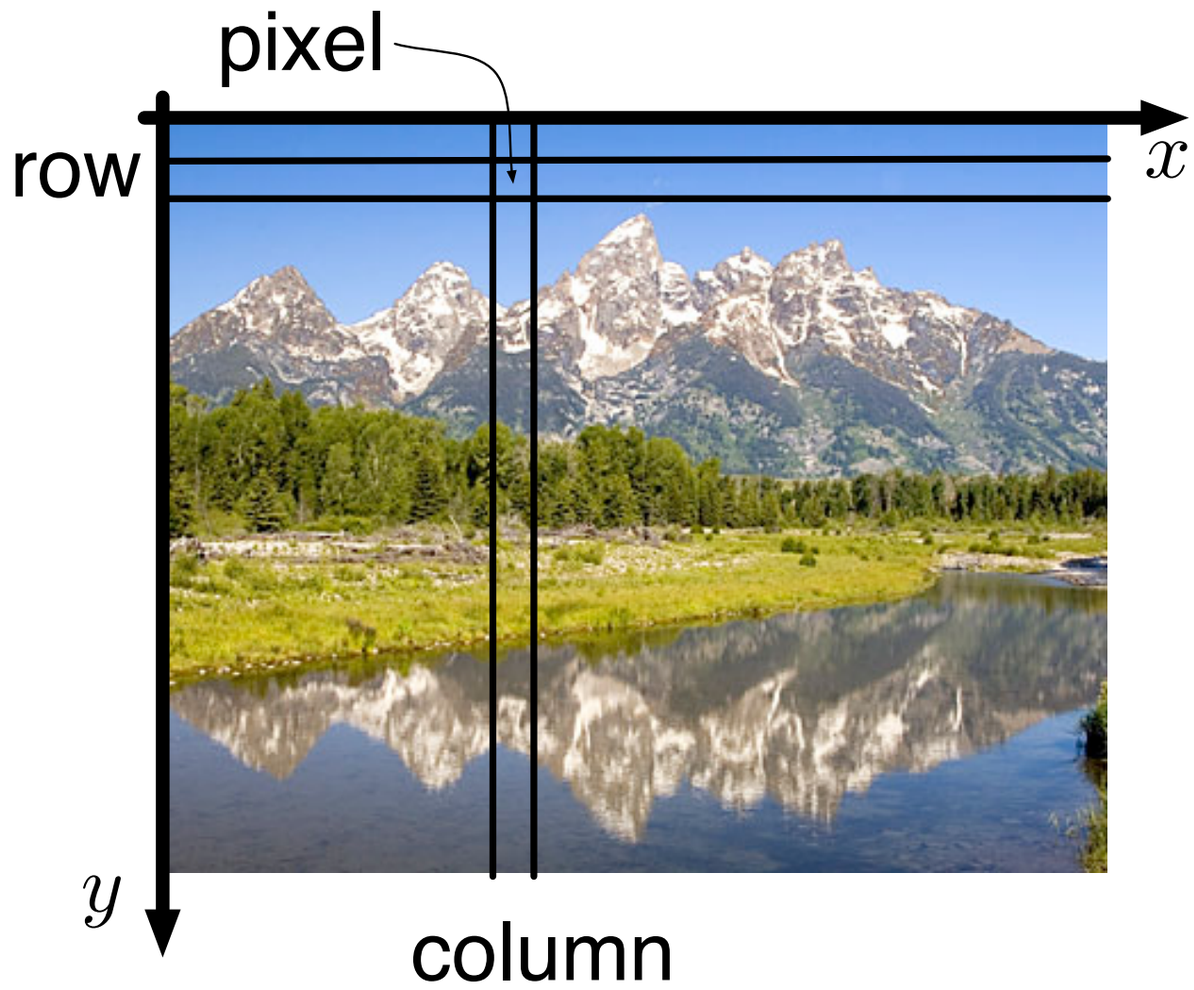
- Homework = 20%
- Exam 1 = 25%
- Exam 2 = 25%
- Final exam = 30%

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

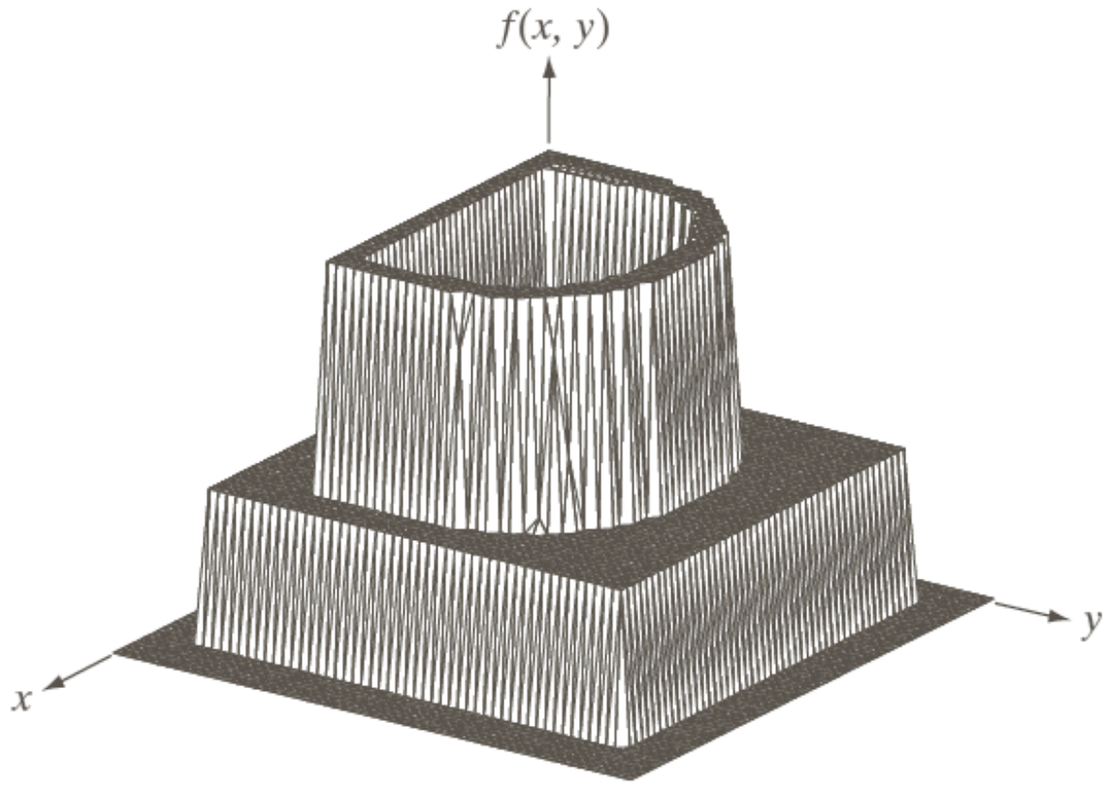
What is a Digital Image?

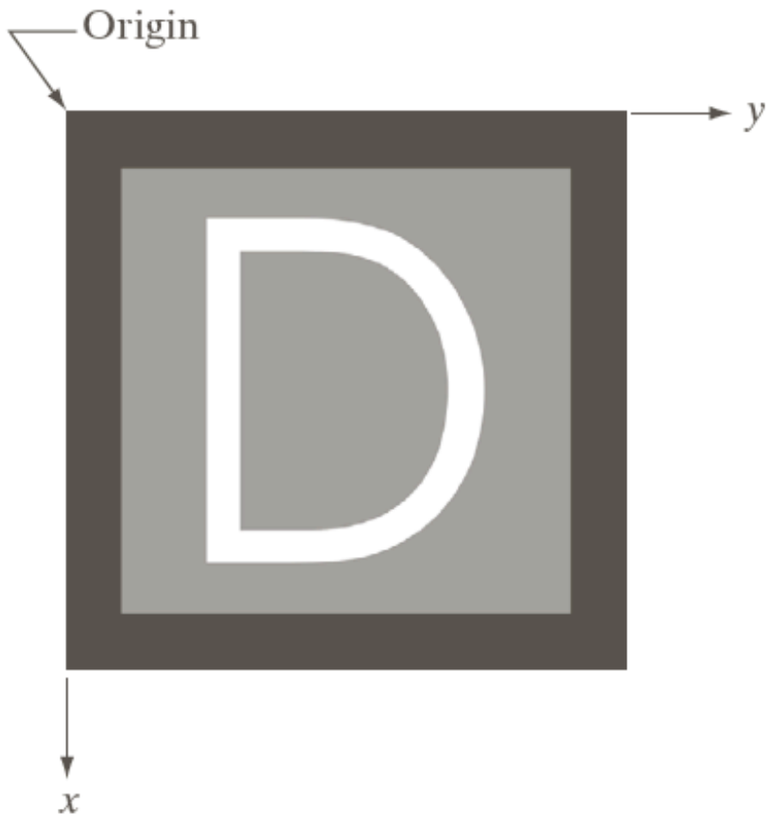
What is a Digital Image?



- 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)* ∈ [0, 255]

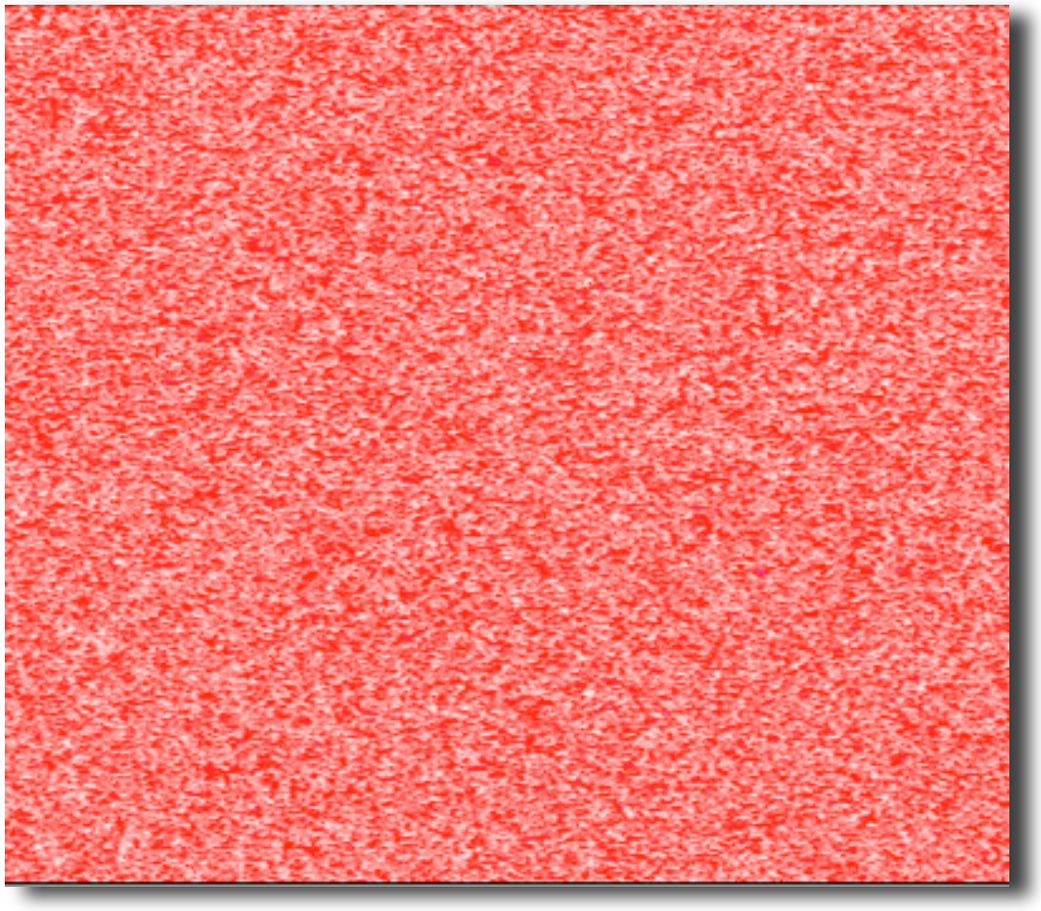
Pixel Values





Source: DIP/3e

Images are not Collections of Random Pixels



A Typical Digital Image Processing System

3D world

camera

input image

algorithms
representations

processed image

irrelevant interaction for this course

users

problem understanding
trade offs
training data
expert systems
knowledge base

Sources of Energy for Image Formation

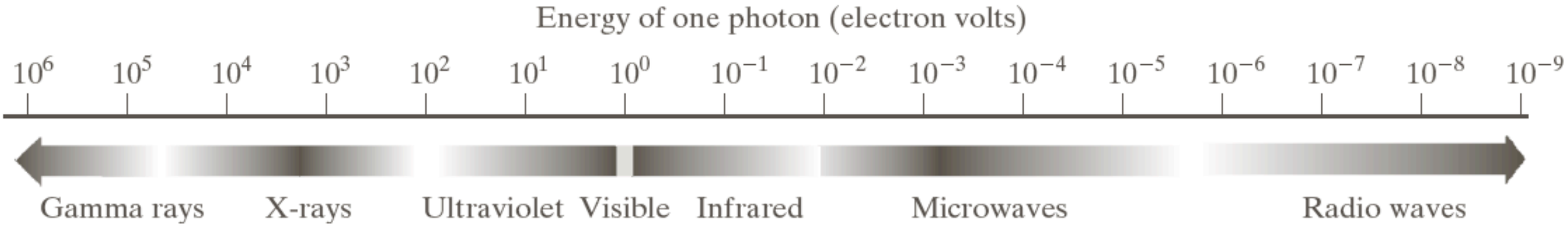
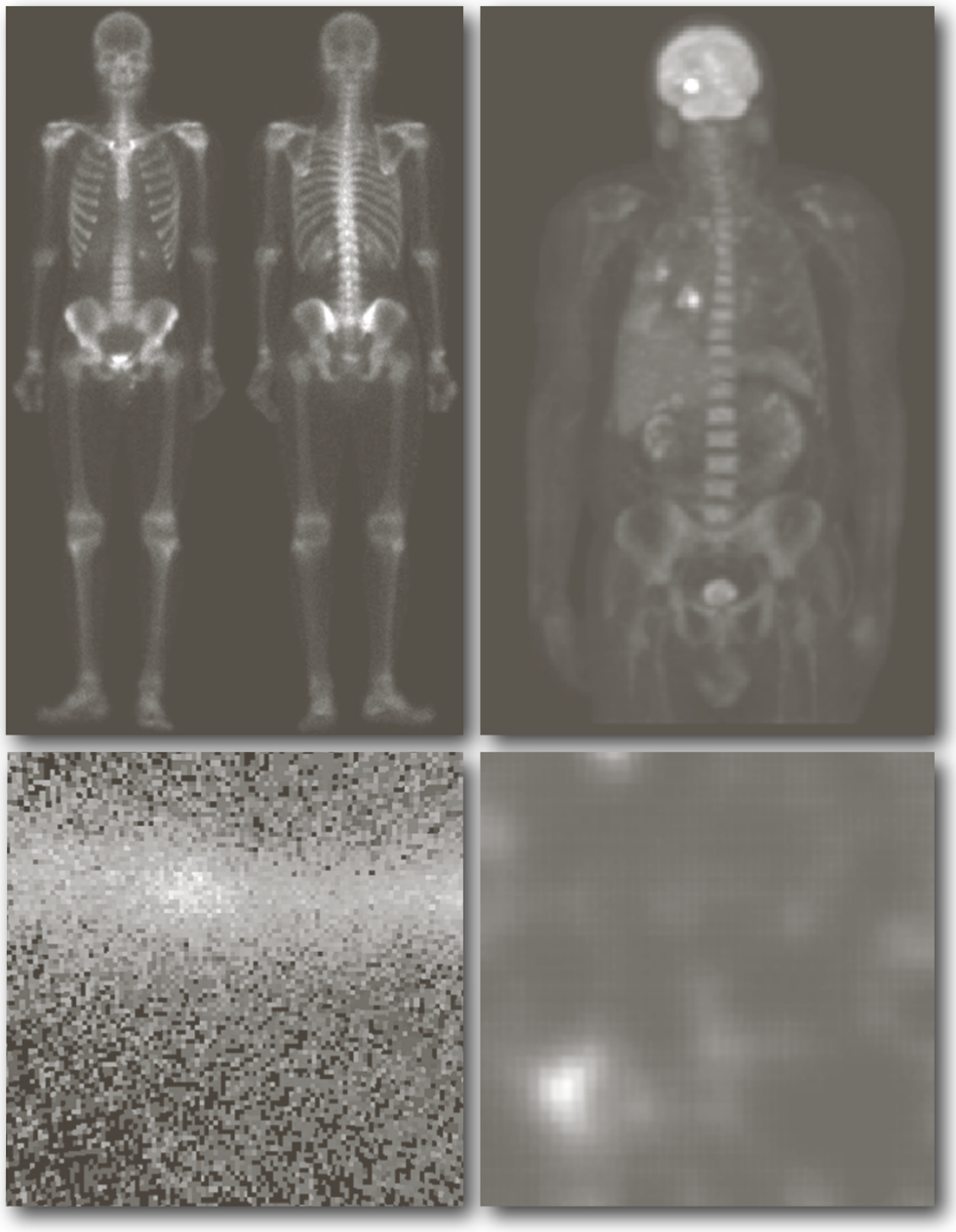


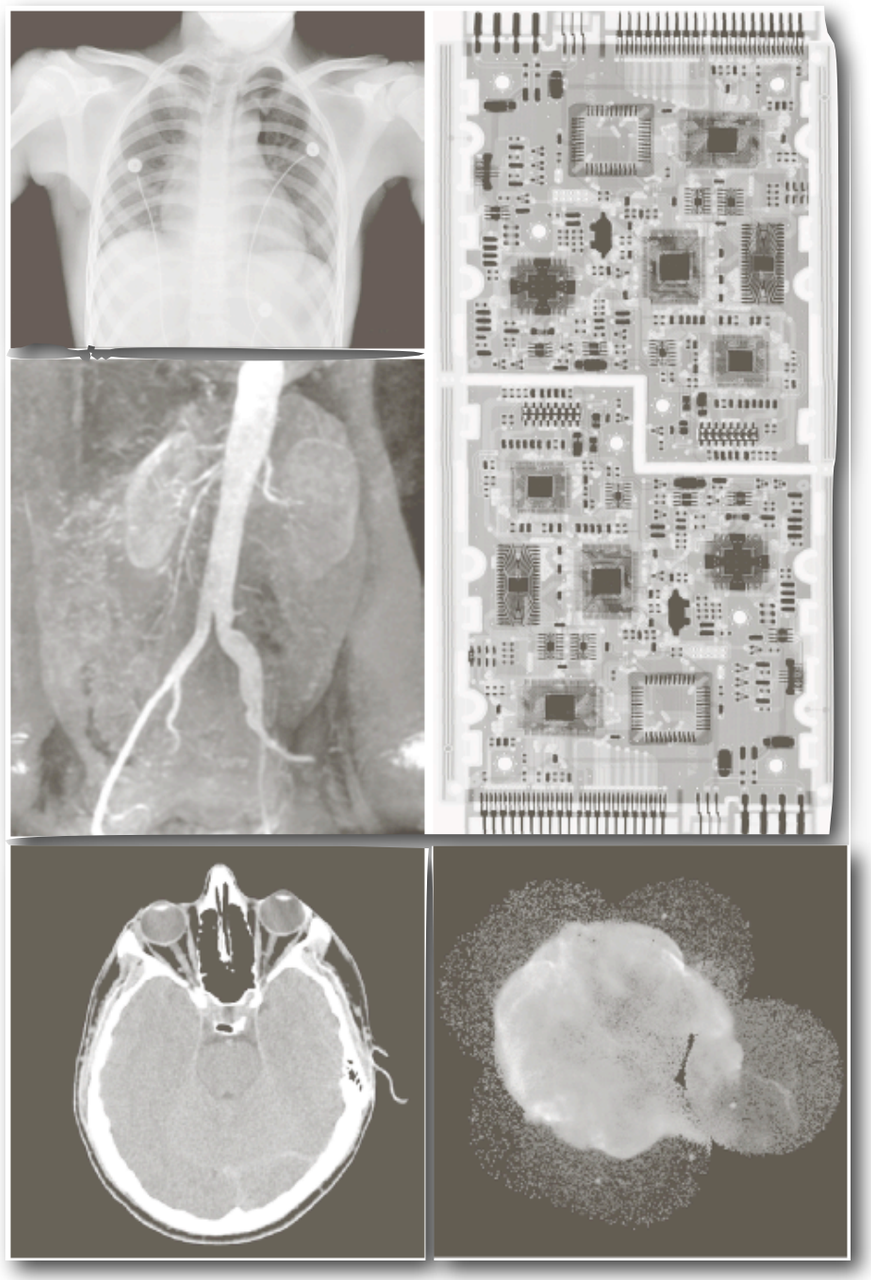
FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

Source: DIP/3e

Some Applications -- Medical Diagnostics



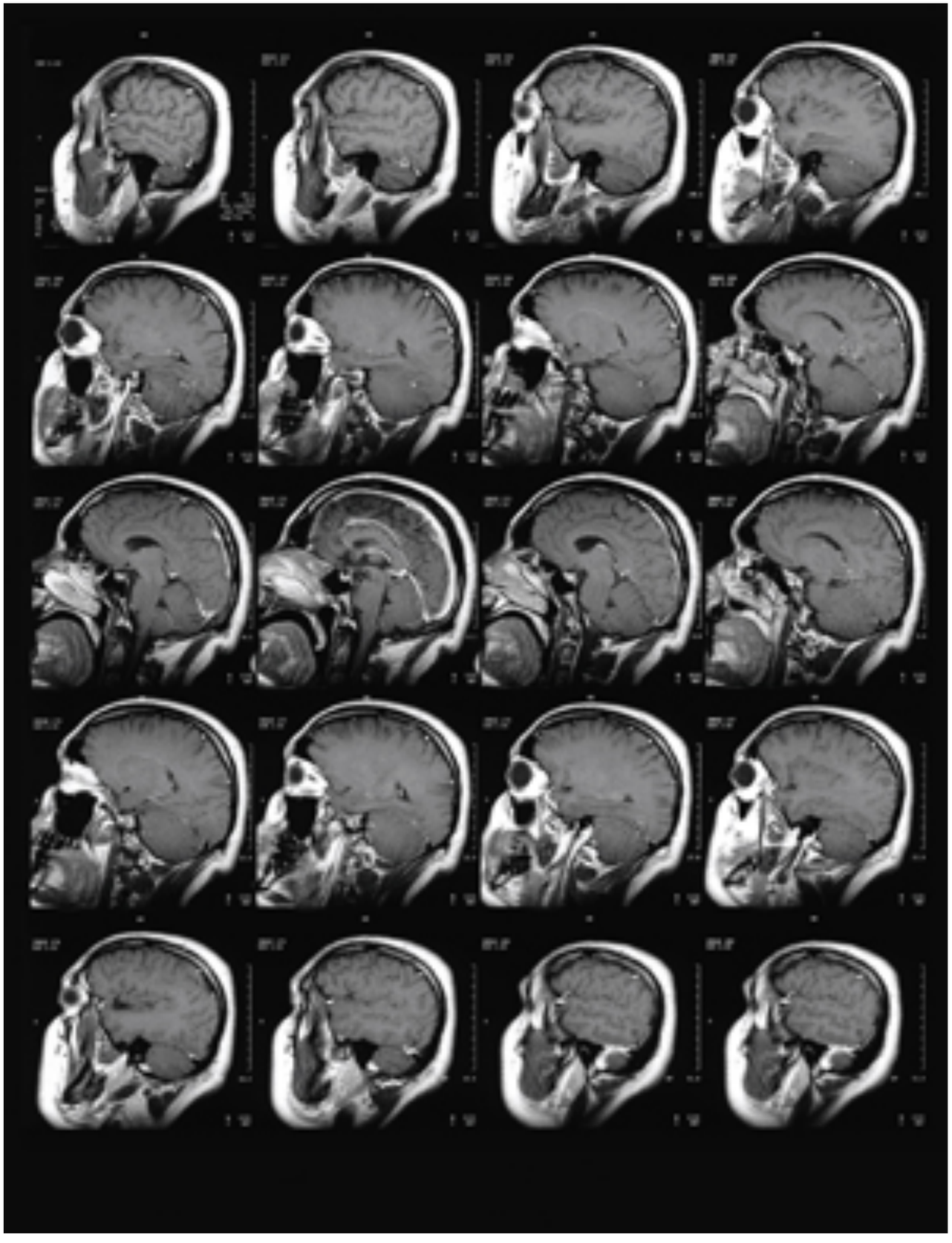
Gamma-ray imaging



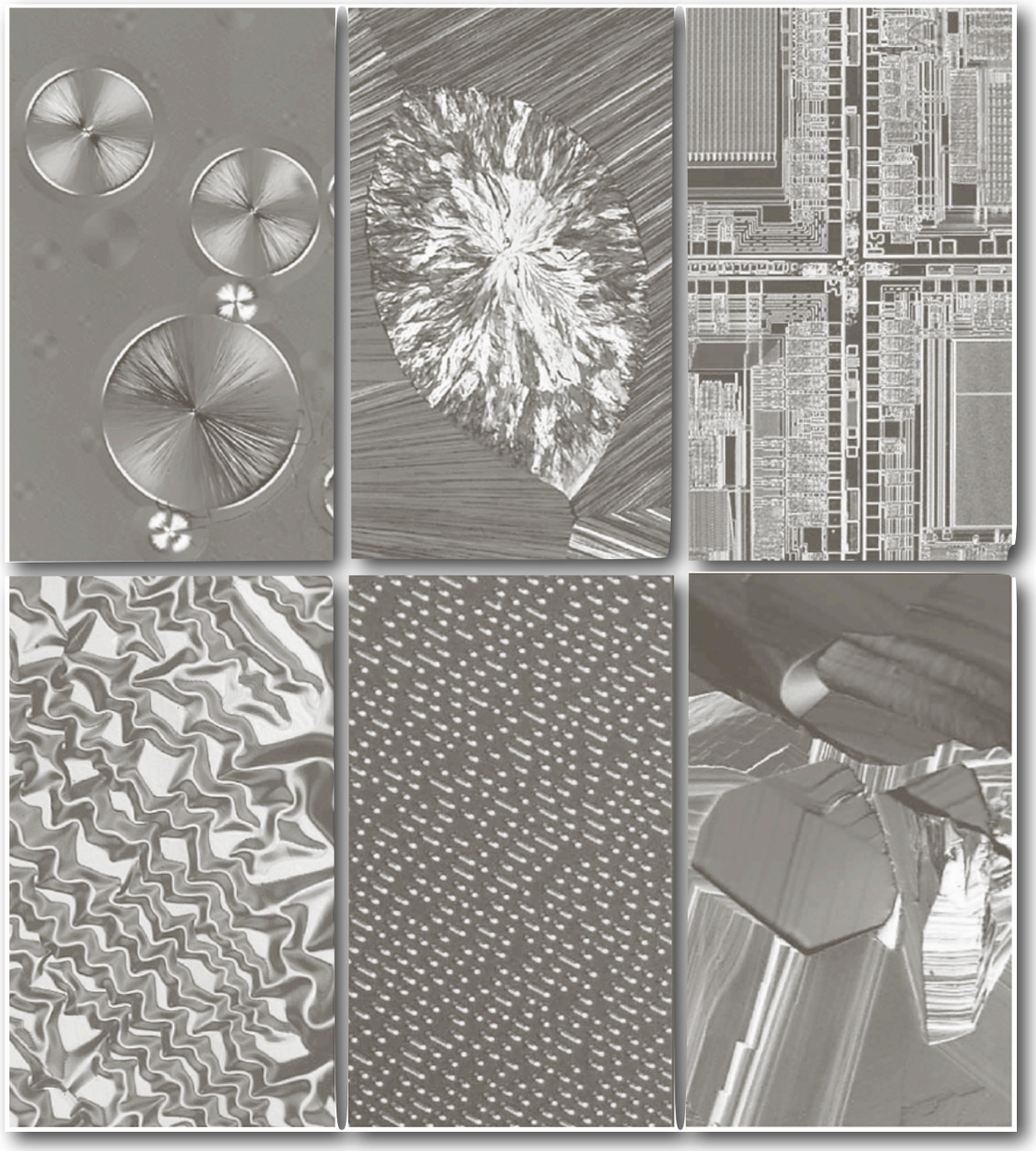
X-ray imaging

Source: DIP/3e

Some Applications -- Magnetic Resonance Imaging



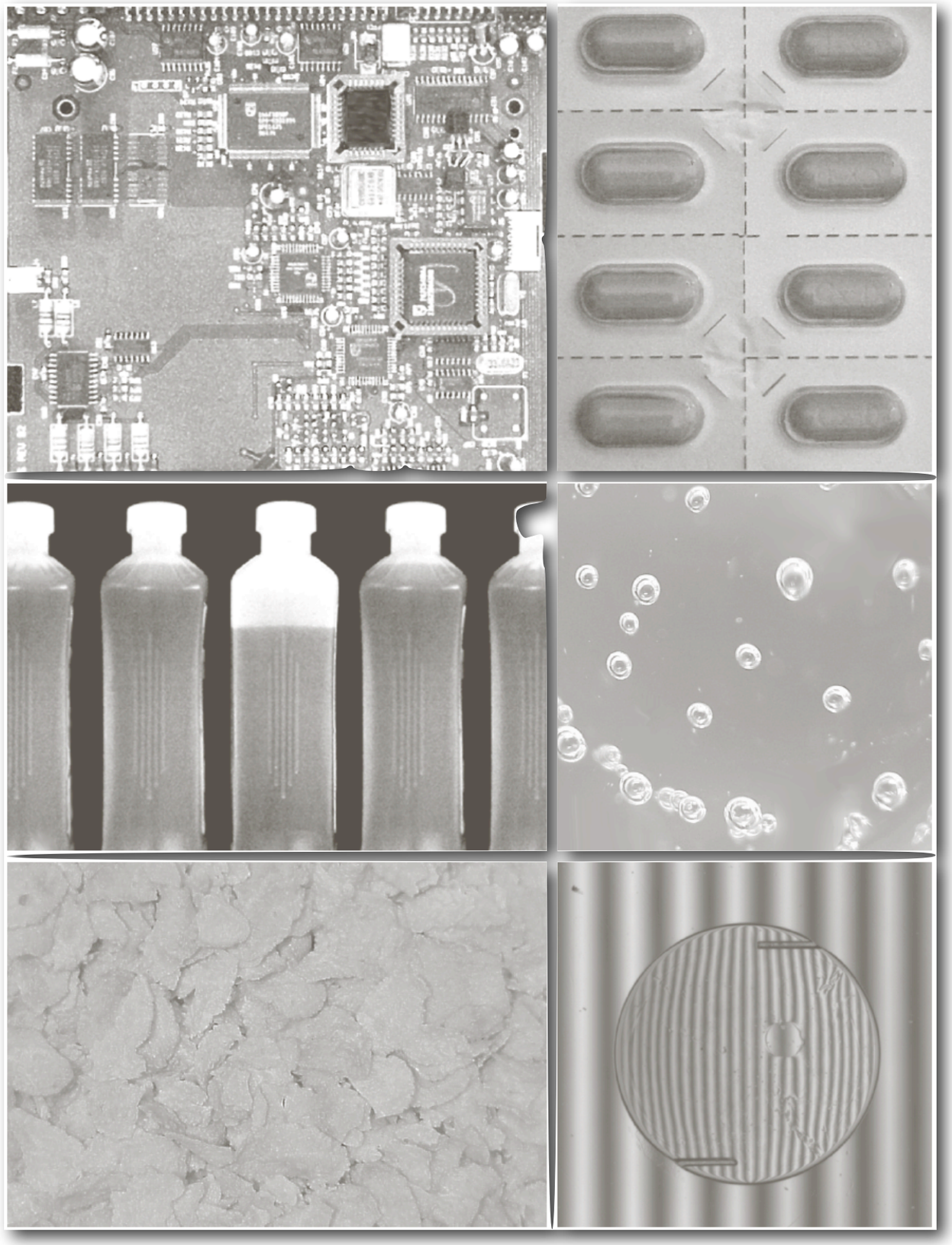
Some Applications -- Microscopy



Visible-light microscopy imaging

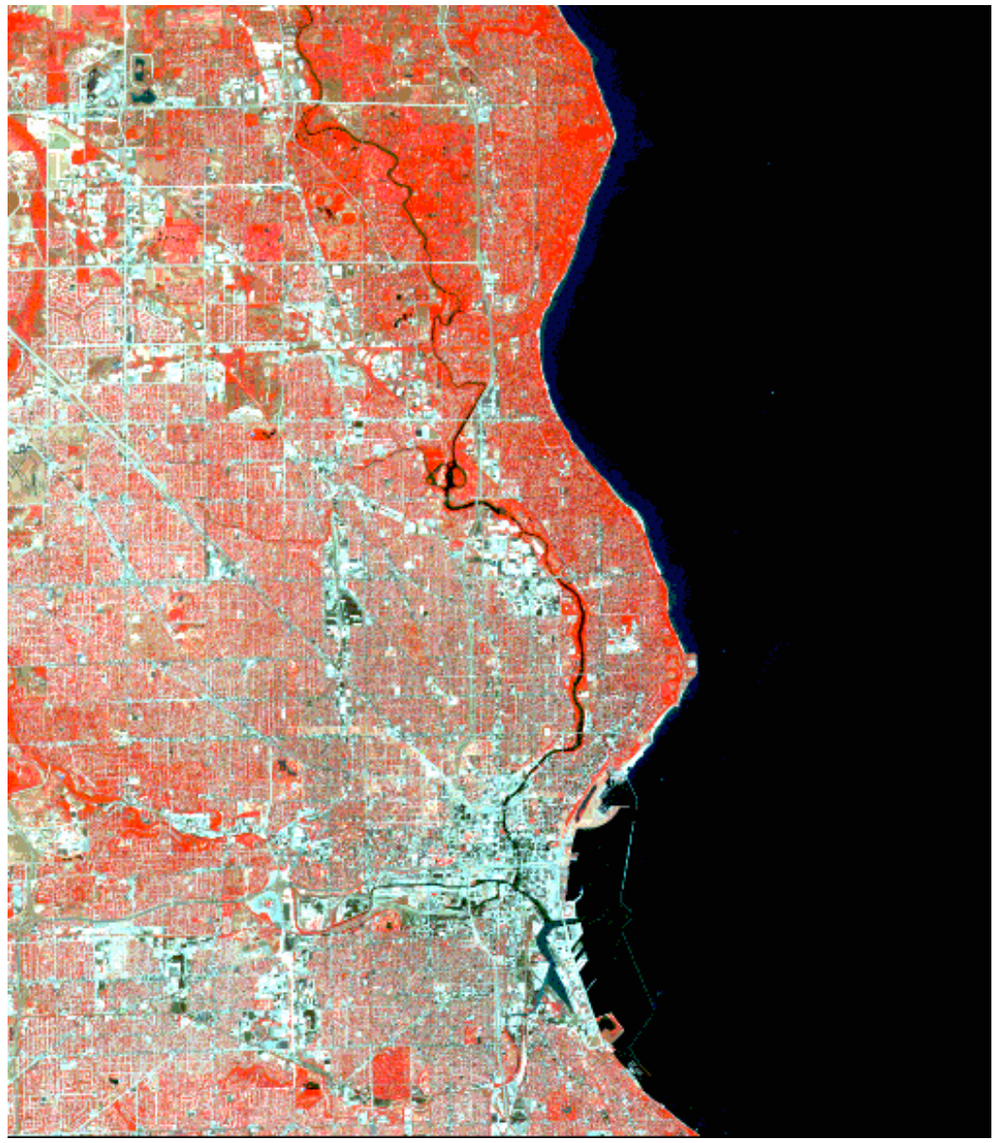
Source: DIP/3e

Some Applications -- Industrial Inspection



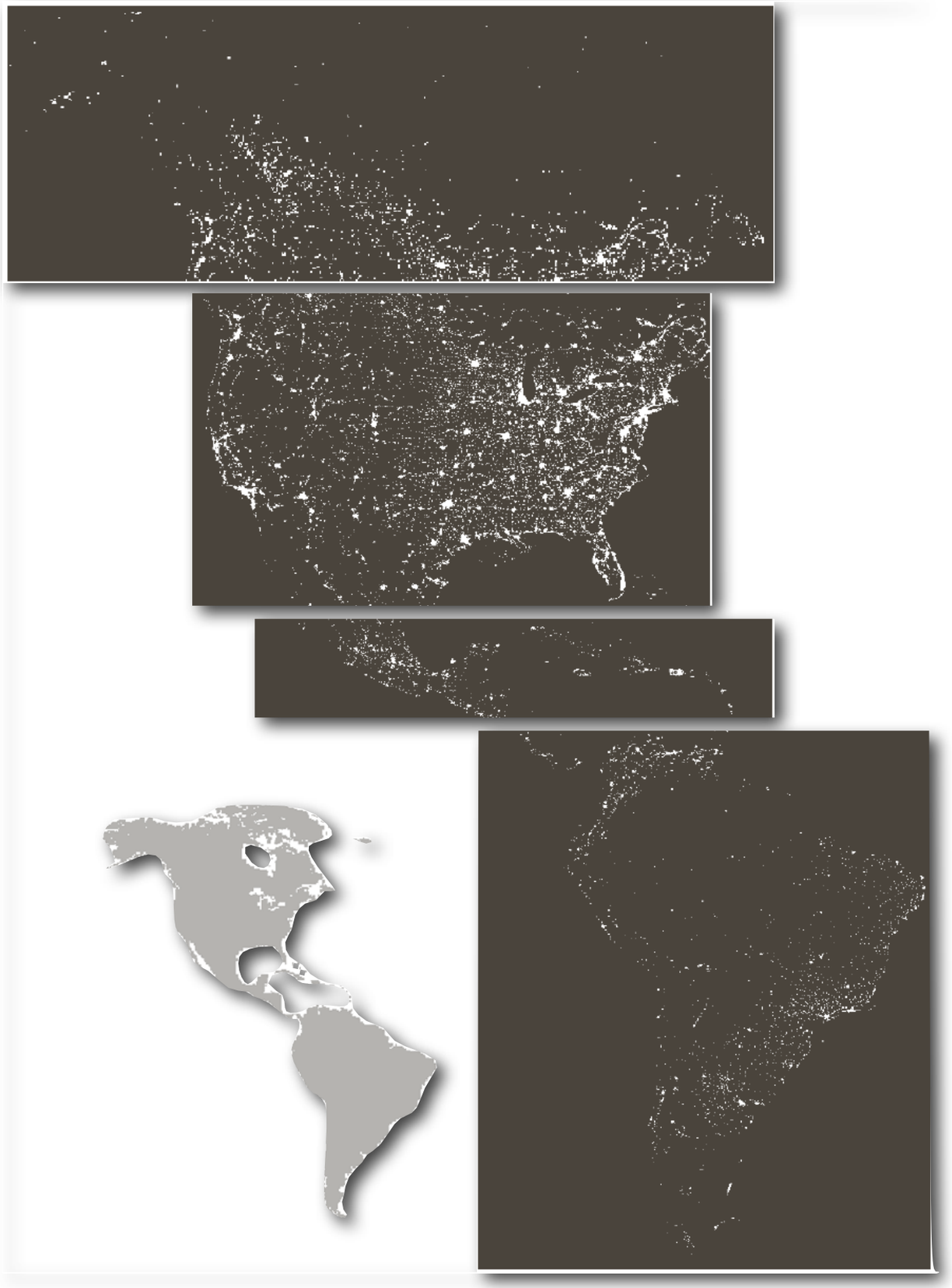
Some Applications -- Remote Sensing

Aerial images



Satellite images

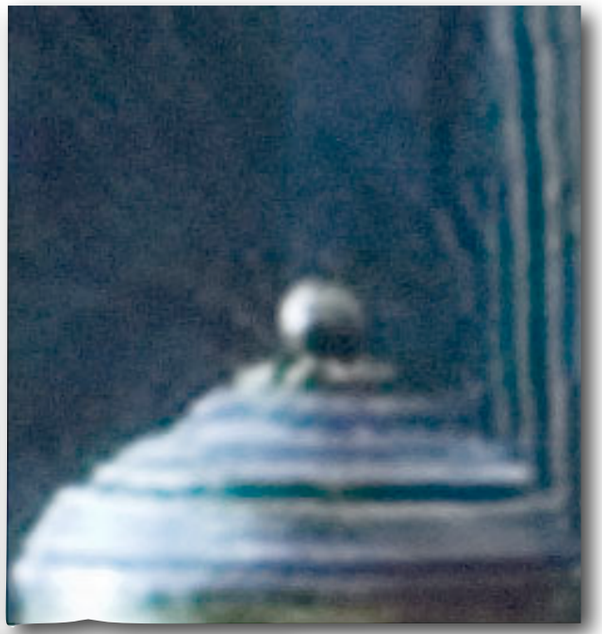
Some Applications -- Infrared Satellite Images

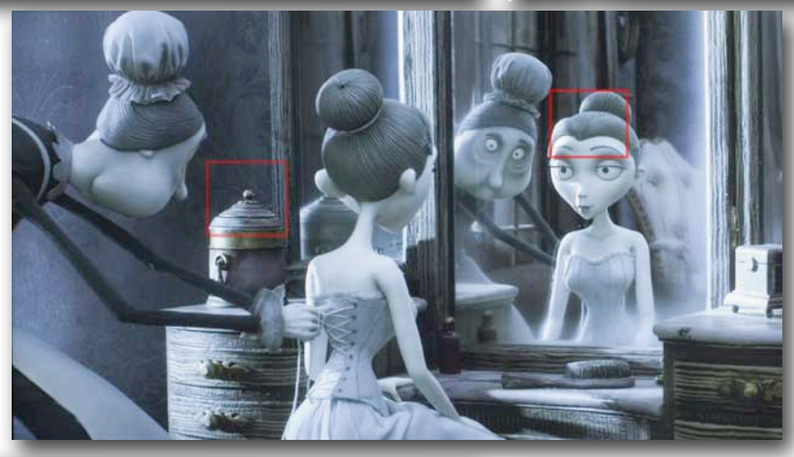


Source: DIP/3e

Some Applications -- Storing Images

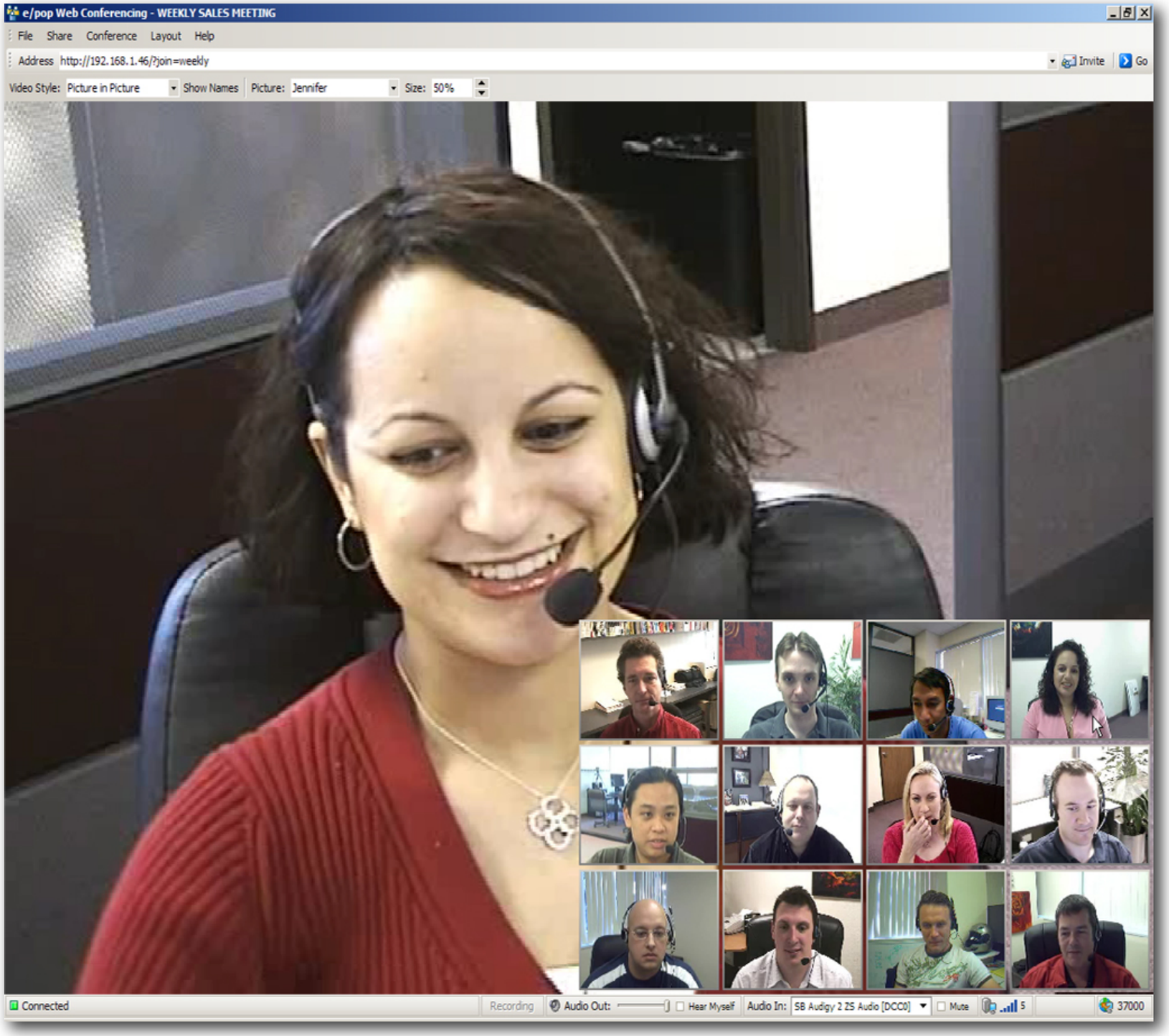
Standard DVD





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

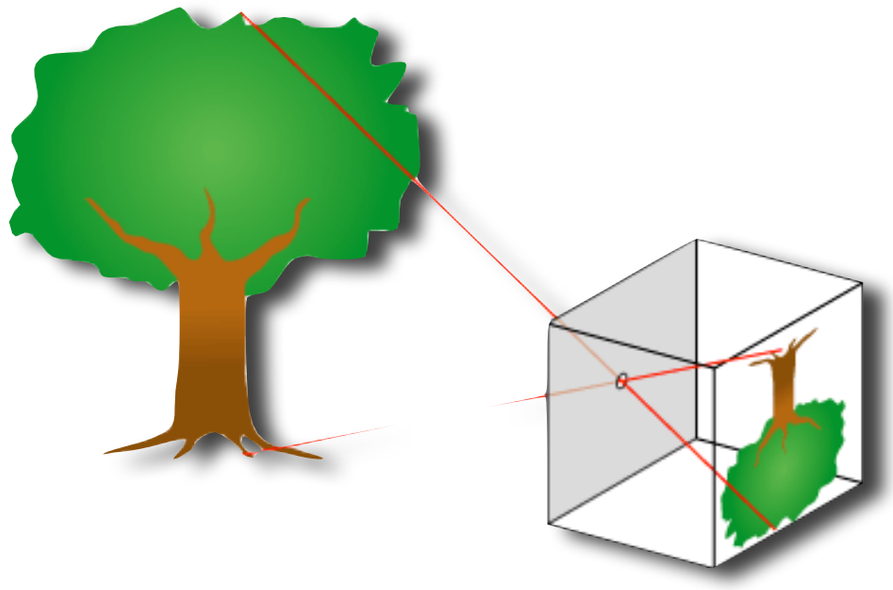
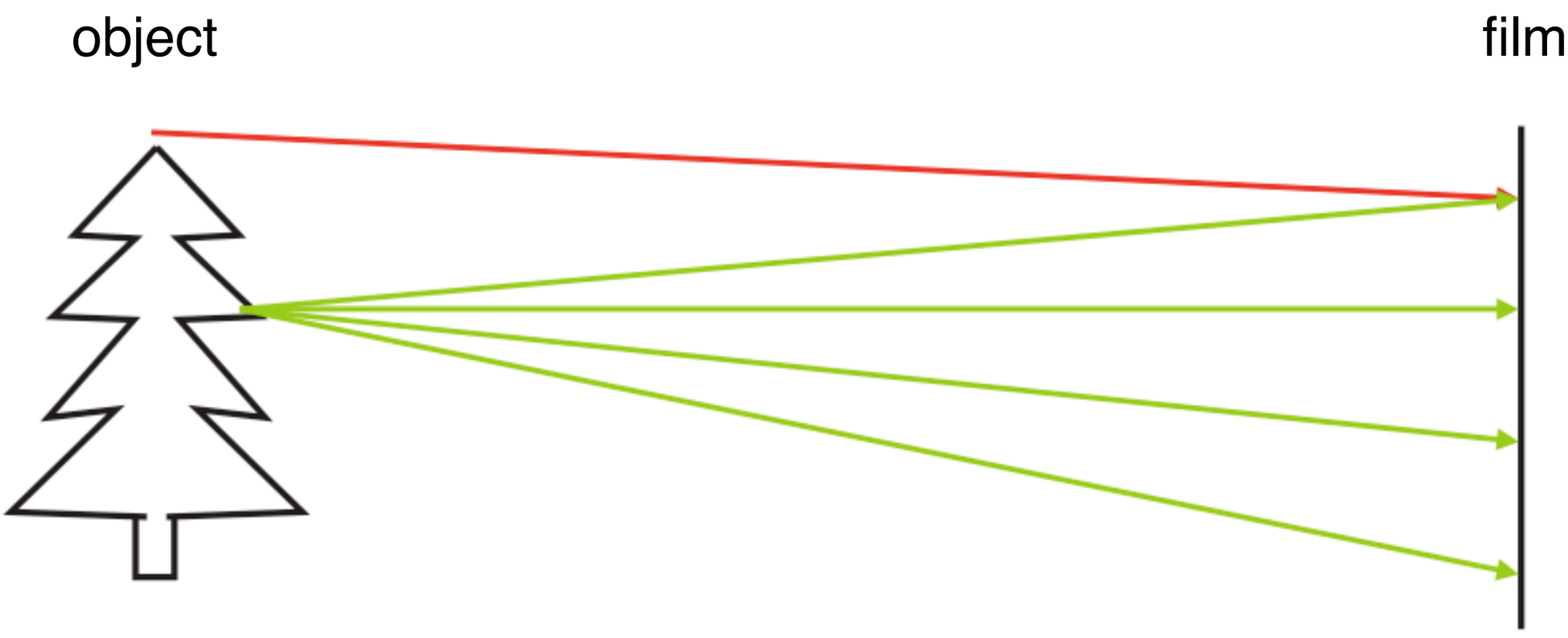


Image properties depend on:

- 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

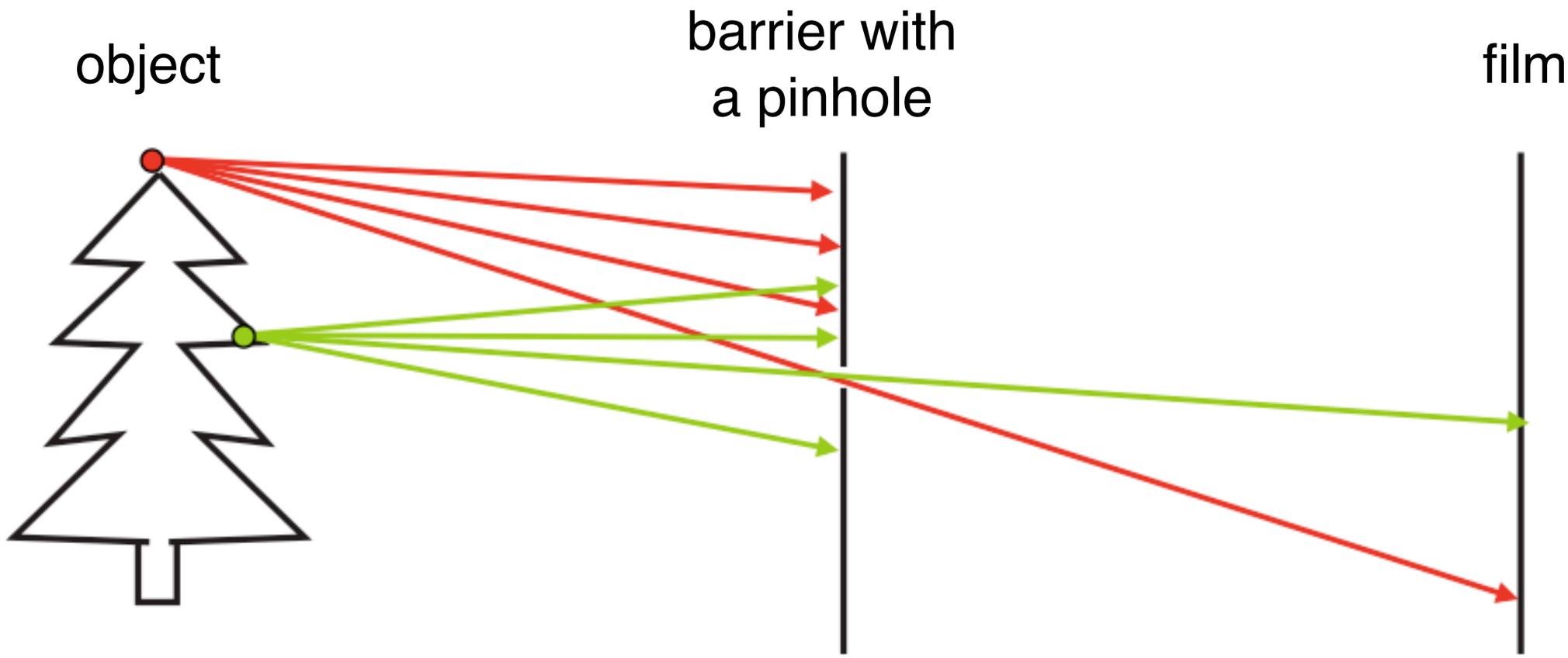
How to Design a Camera?



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

source: S. Savarese

Pinhole Camera

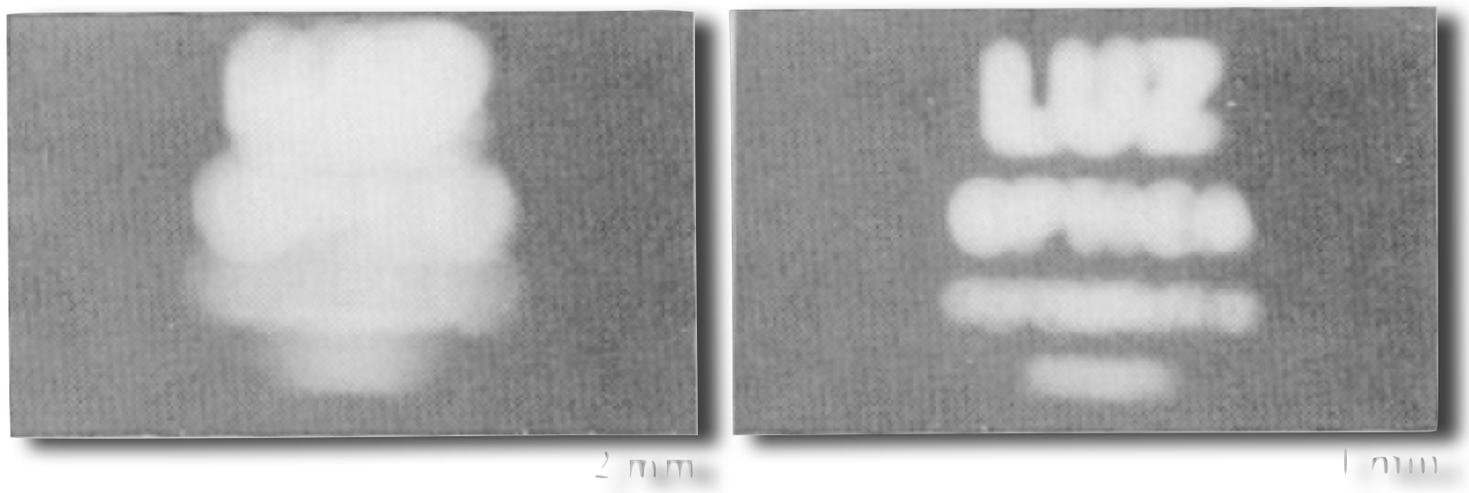


- The barrier block off most of the rays
- This reduces blurring
- Aperture = Opening of the pinhole

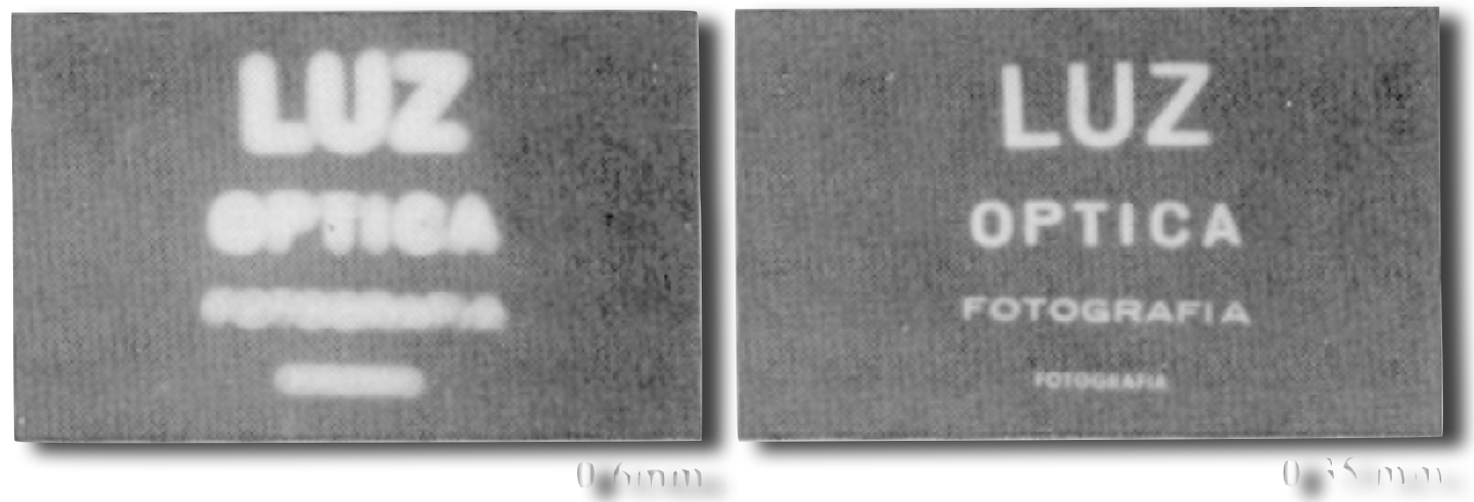
source: S. Savarese

Shrinking the Aperture...

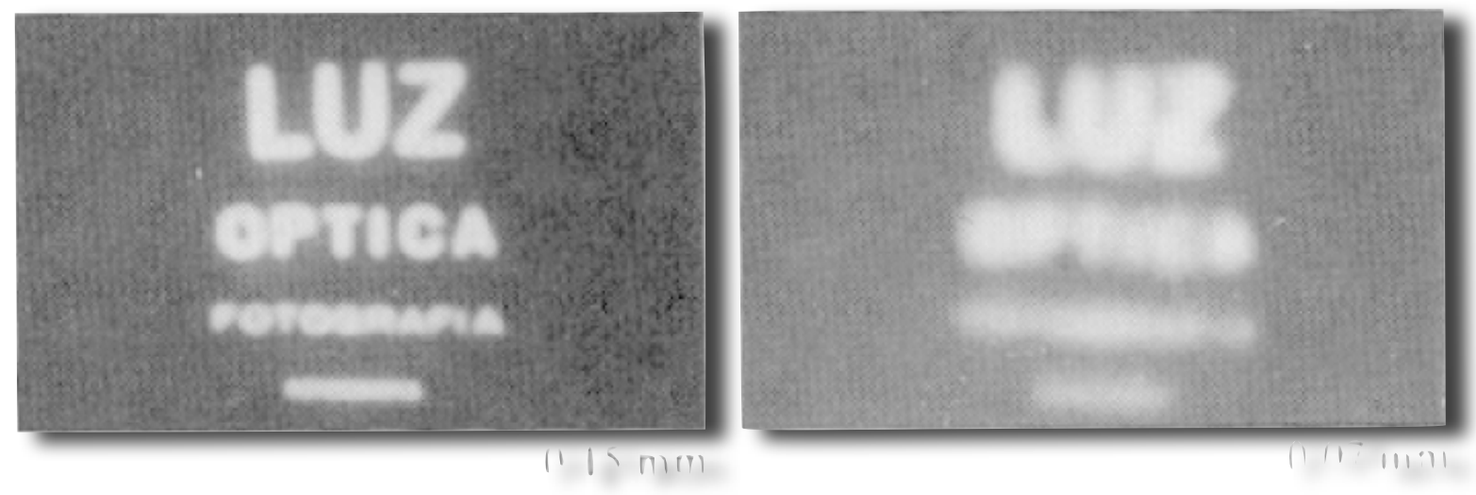
pinhole too big:
bright and blurred



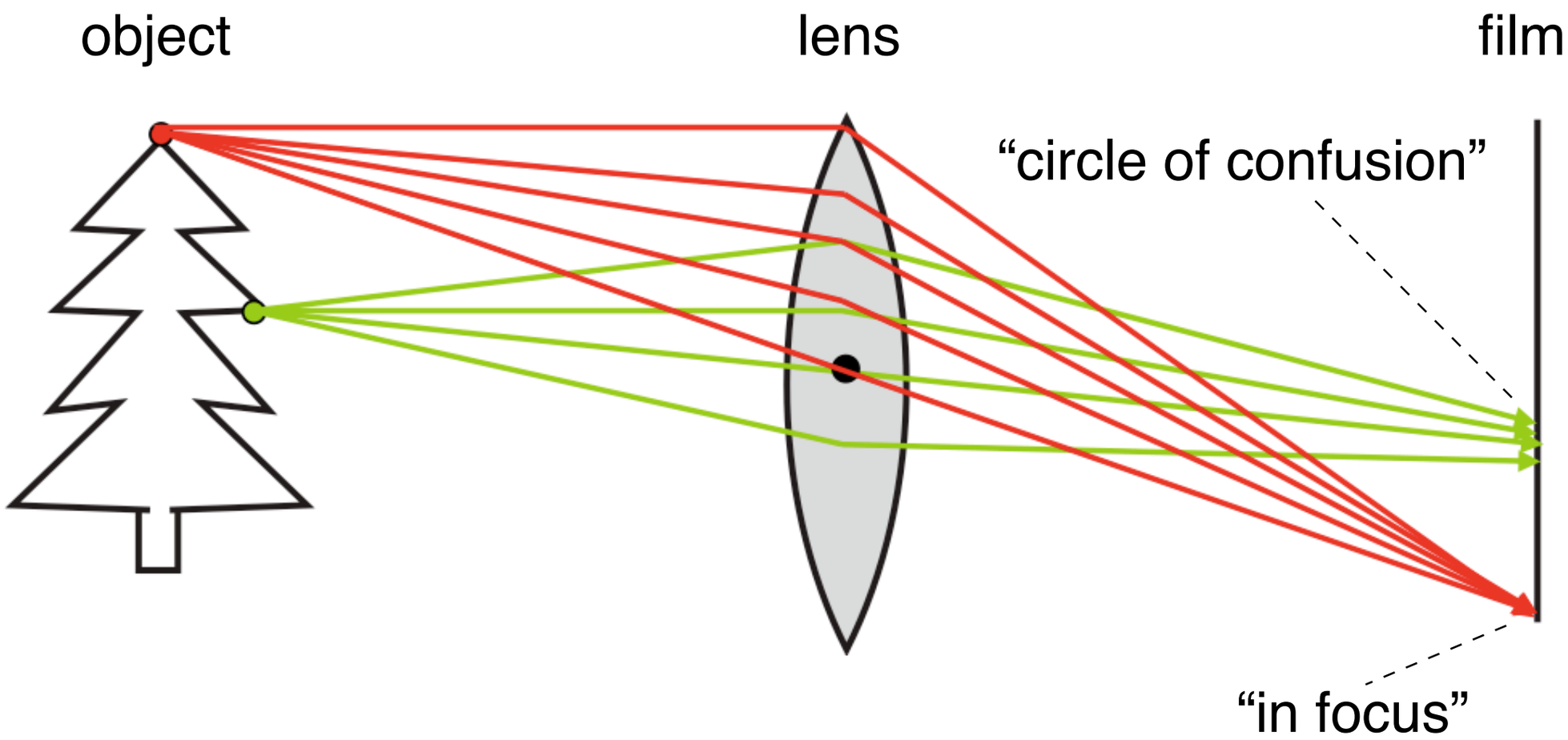
pinhole right size:
dark and crisp



pinhole too small:
dark and diffraction blur



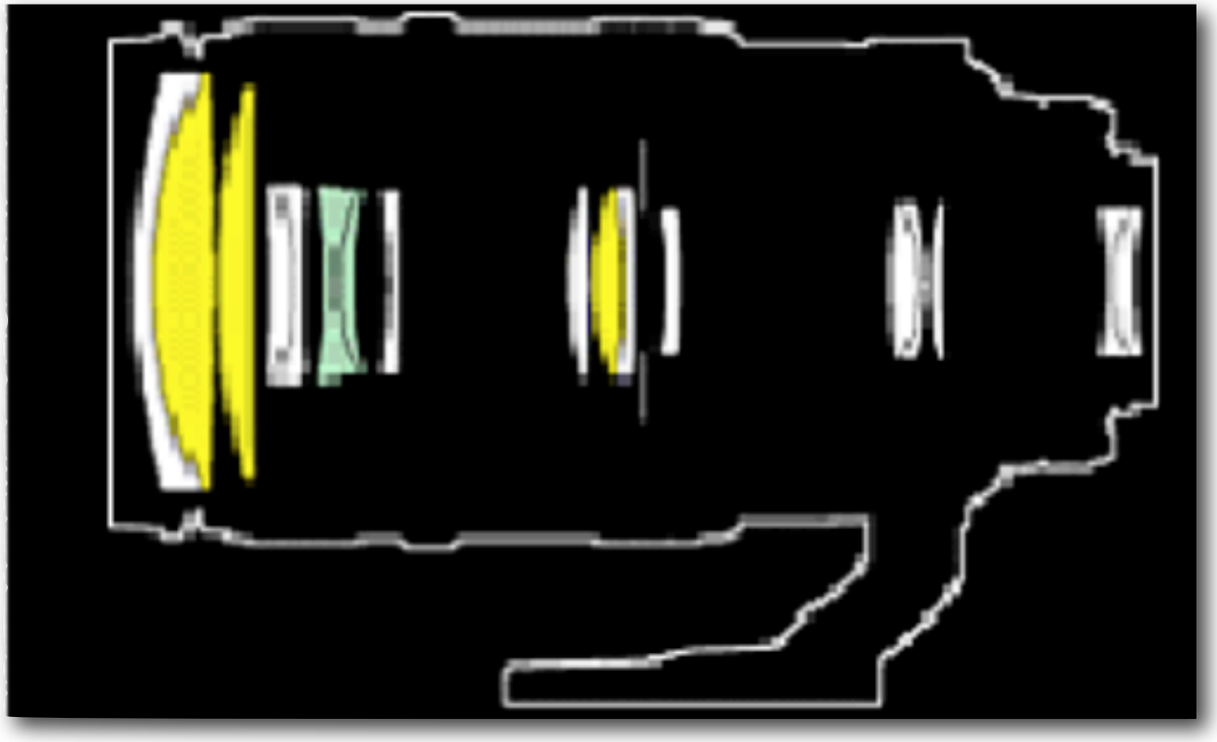
Adding Lens...



The lens focuses light onto the film

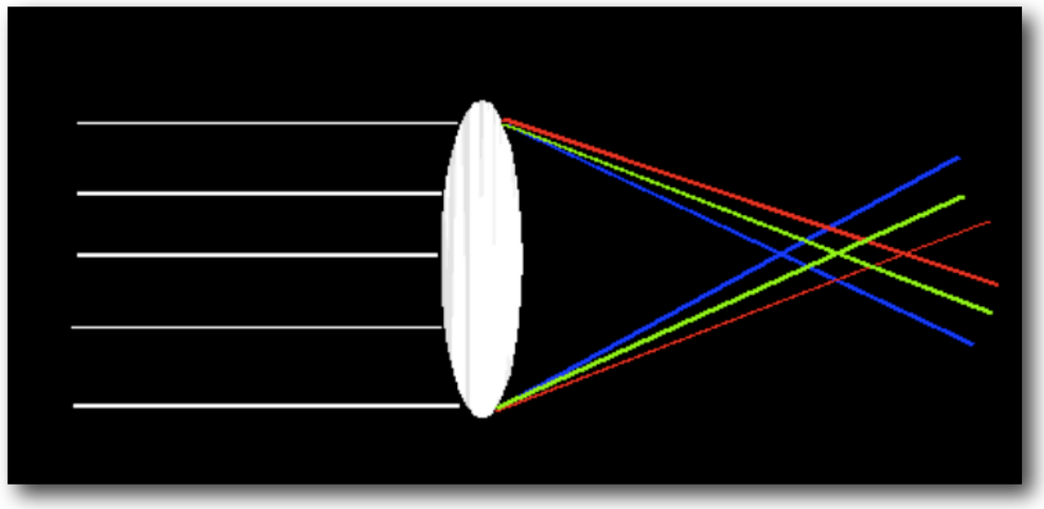
source: S. Savarese

Combining Lenses...



source: S. Savarese

Issues with Lenses: Chromatic Aberration



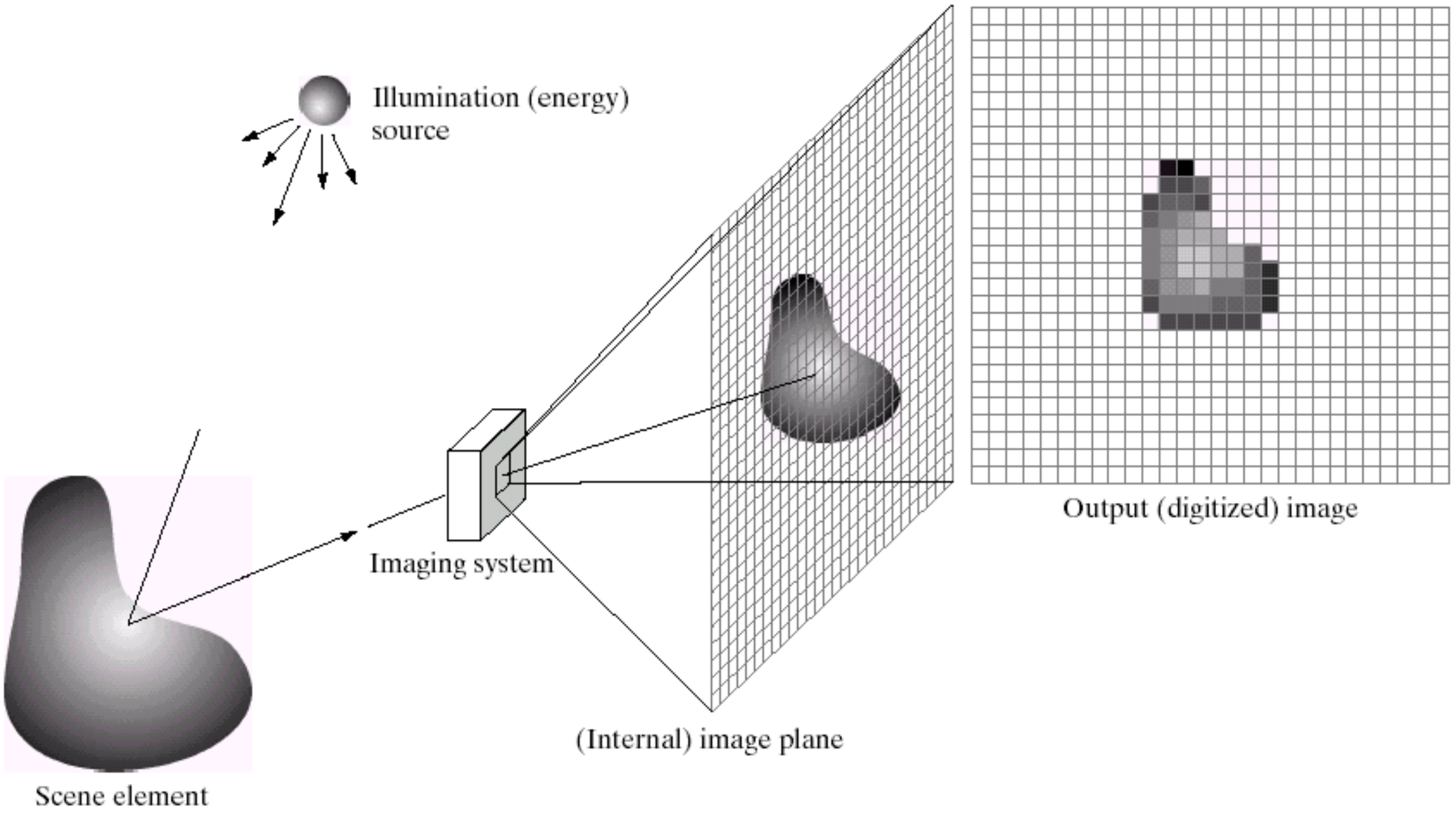
different refractive indices for different light wavelengths

source: S. Savarese

Issues with Lenses: Radial Distortion

source: S. Savarese

Image Sampling and Quantization

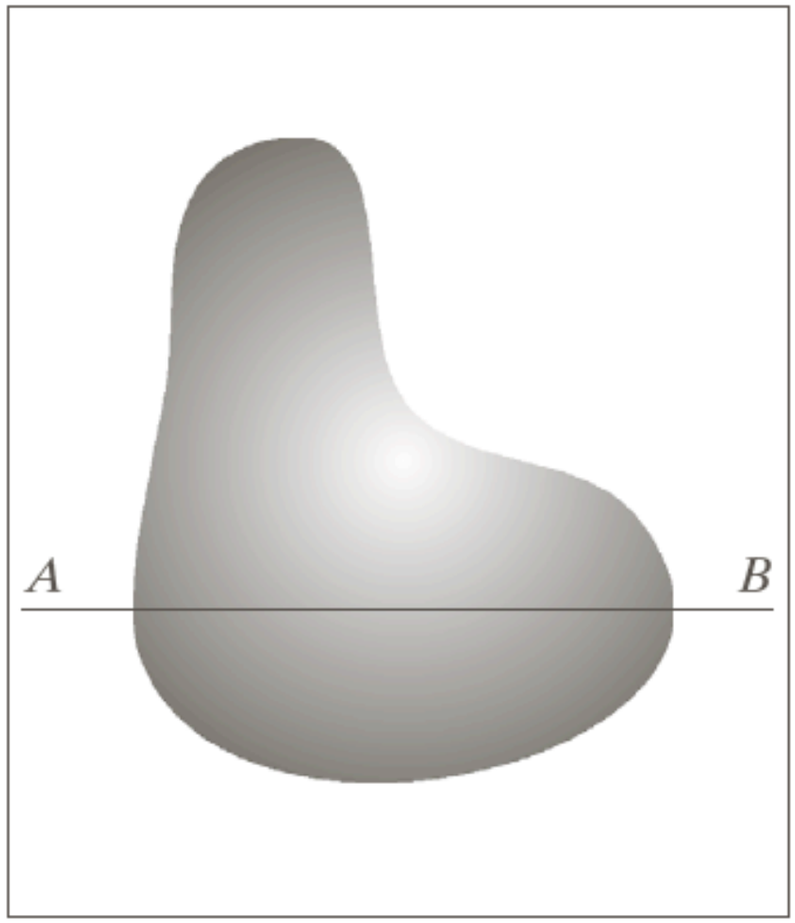


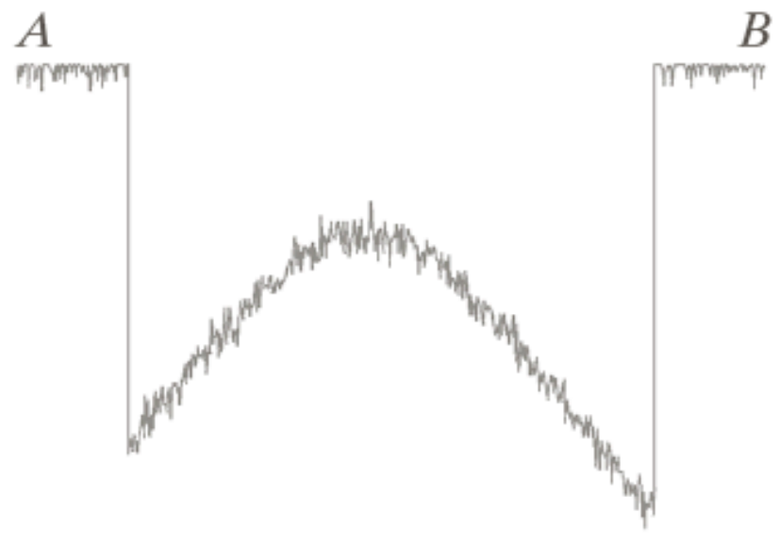
a
b c d e

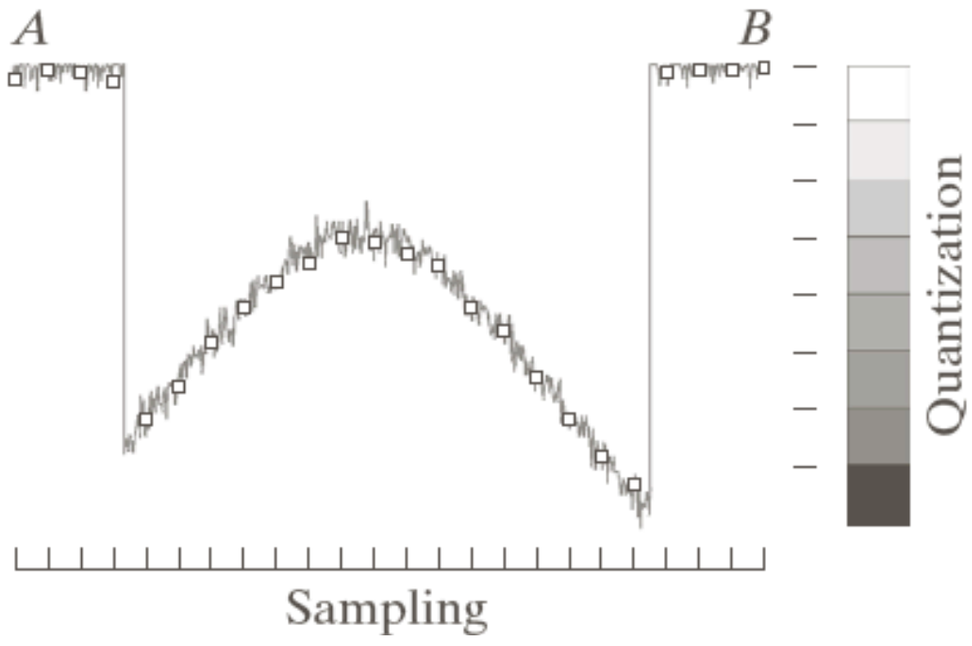
FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

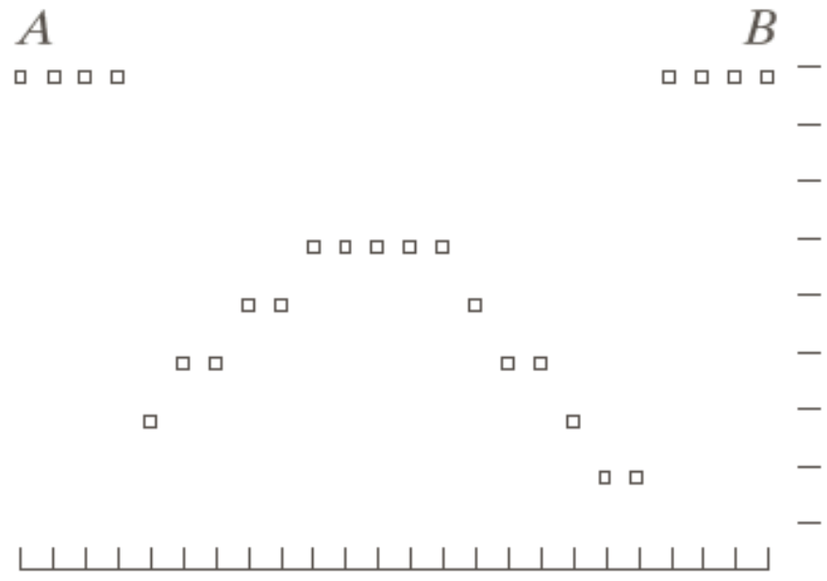
Source: DIP/3e

Image Sampling and Quantization



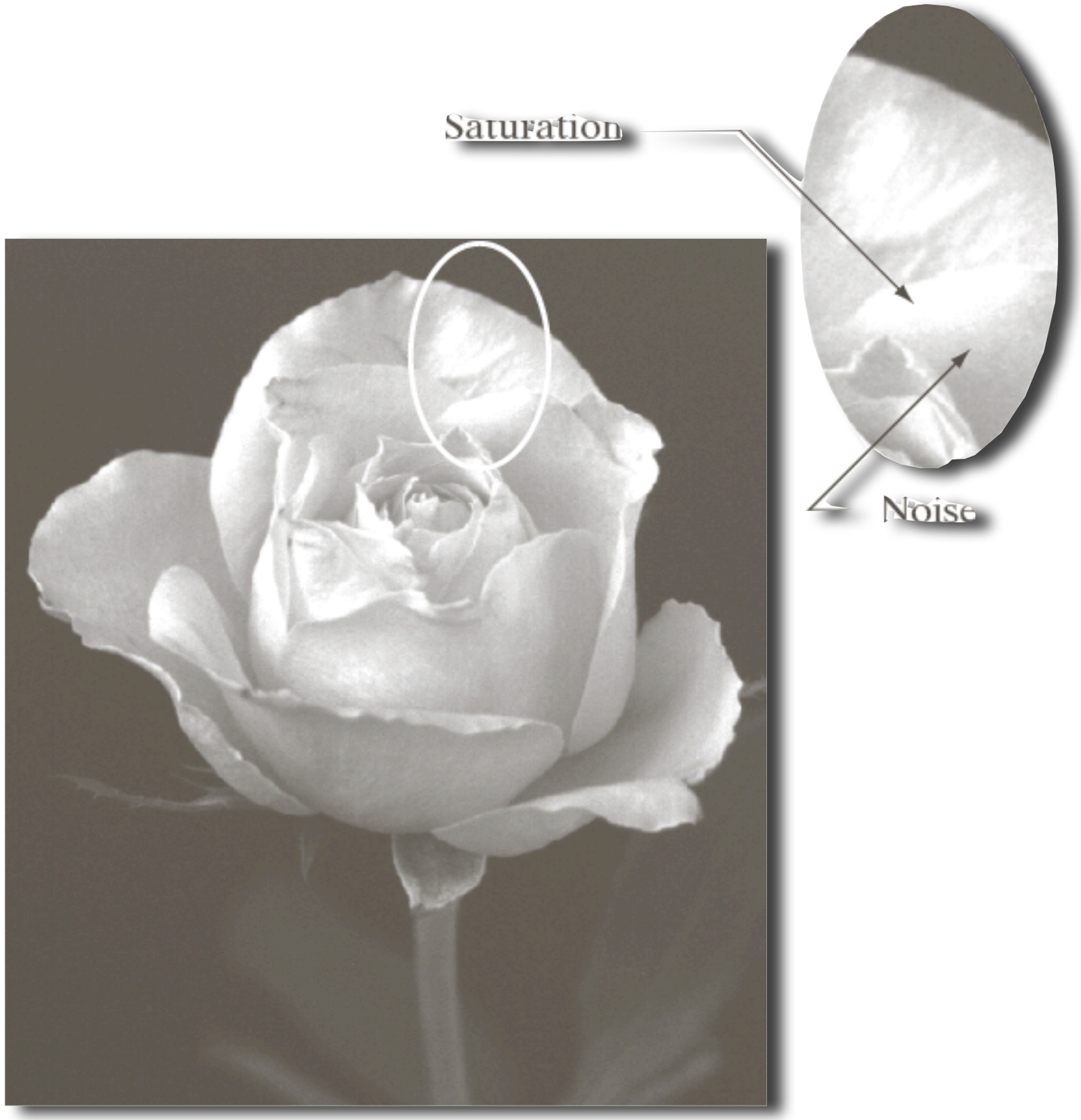






Source: DIP/3e

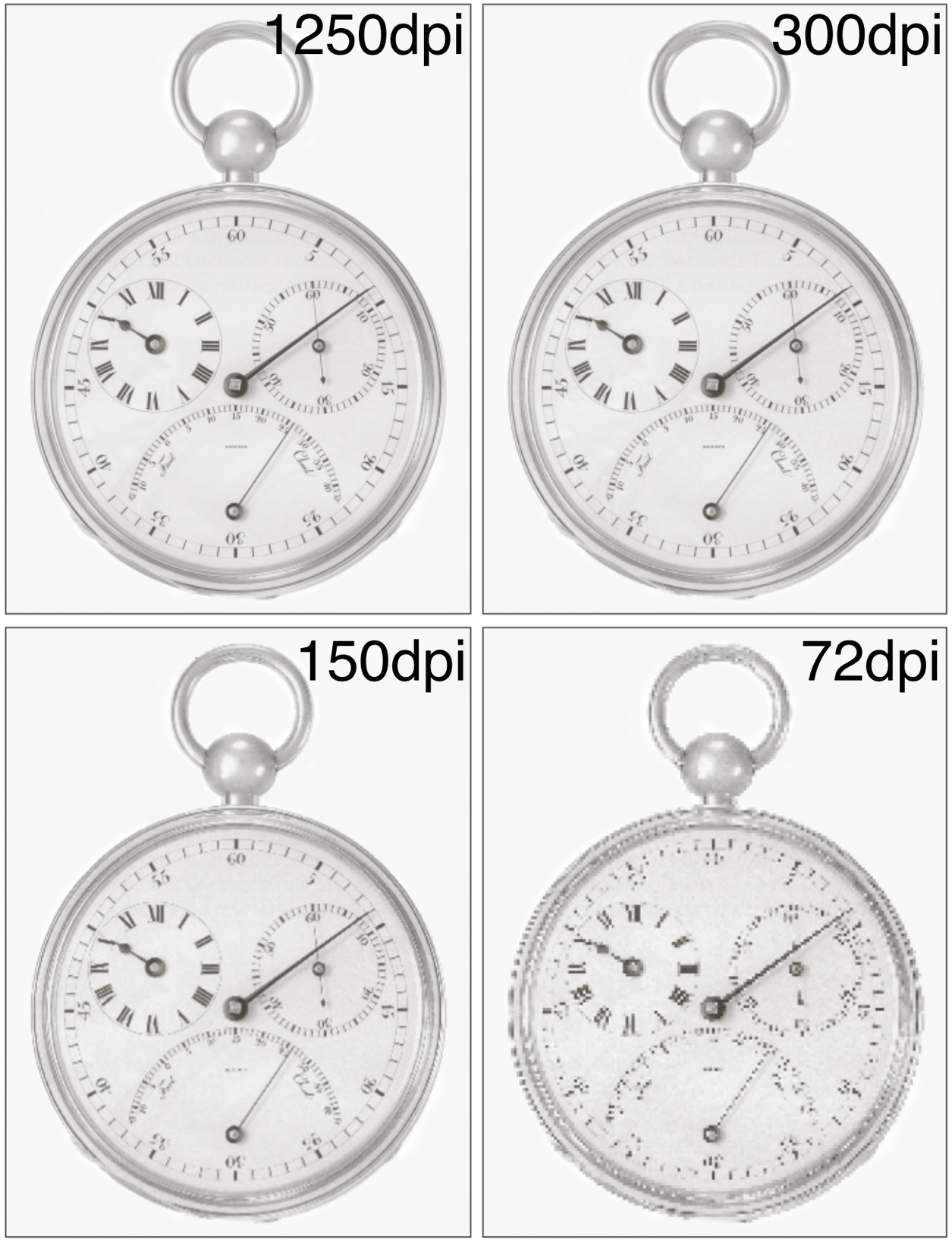
Saturation



Source: DIP/3e

Spatial Resolution

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



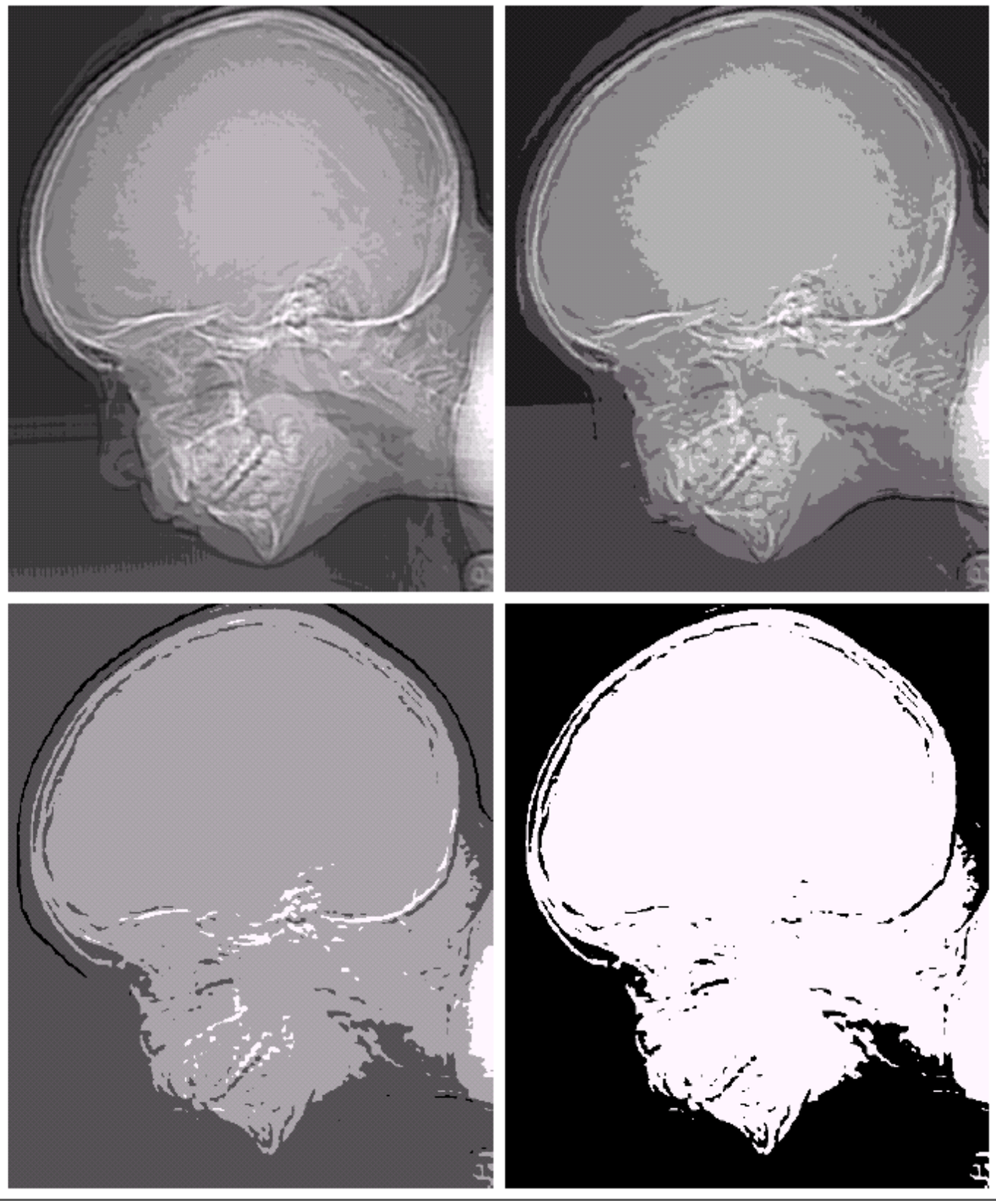
Source: DIP/3e

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

Next Class

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