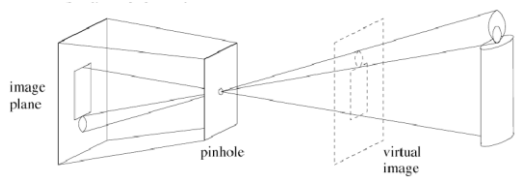
CPE 428 Computer Vision: Basics

- Geometry of image formation
- Imaging devices
- Digital image representation
- Effects of sampling and quantization
- Digital image types

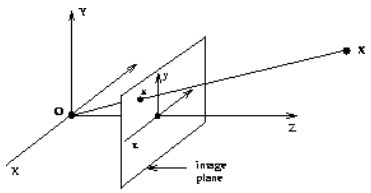
1

Pinhole Camera



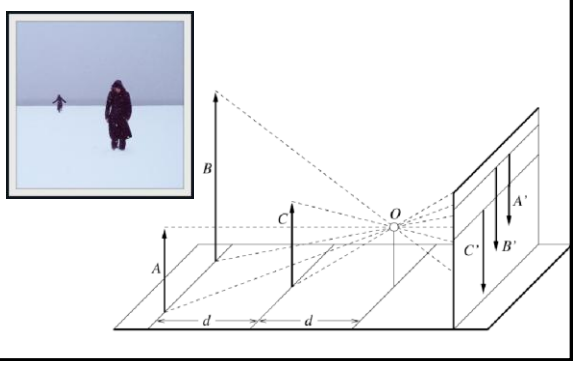
2

Imaging geometry

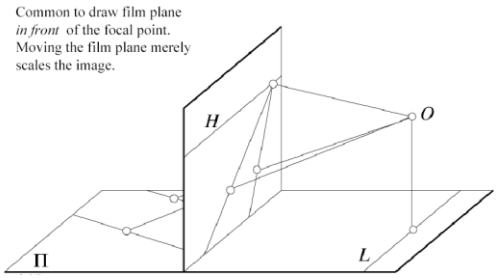


3

Perspective Projection



Perspective Projection



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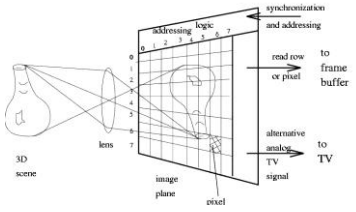
CCD Camera

- CCD sensor array is constructed of physically discrete units.
- The discrete cells convert light energy into electrical charge
- The image is read out of the CCD one row at a time
- Color cameras use 3 CCD arrays packed together, each sensitive to different wavelengths of light



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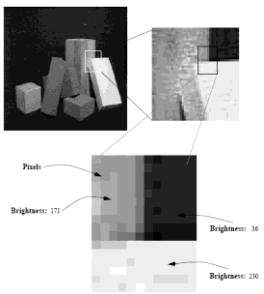
Digital Images



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Mathematical Representation of Digital Images

- Digital images are 2D arrays (matrices) of numbers
- Depending on the type, the numbers represent:
  - light intensities,
  - distances, or
  - other physical quantities.

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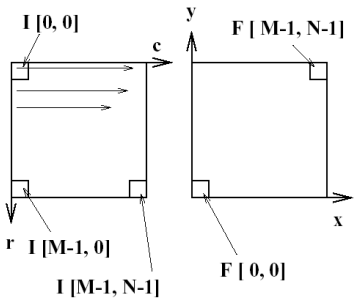
Coordinate systems



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Coordinate systems

- Raster coordinate system
  - Derives from printing an array on a line printer
  - Origin (0,0) is at upper left
  - Row (r) increases downward; Column (c) increase to right
- Cartesian coordinate system
  - Typical system used in mathematics
  - Origin (0,0) is at lower left
  - x increases to the right; y increases upward

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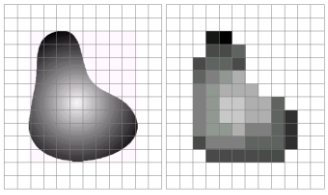
Sampling and Quantization



a b
FIGURE 2.17 (a) Continuos image projected onto a sensor array. (b) Result of image sampling and quantization.

Sampling: digitizing spatial coordinate values
Quantization: digitizing the amplitude values

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Effects of Sampling

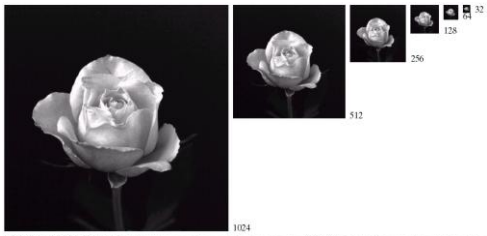

FIGURE 2.19 A 1024 × 1024, 8-bit image subsampled down to size 32 × 32 pixels. The number of allowable gray levels was kept at 256.

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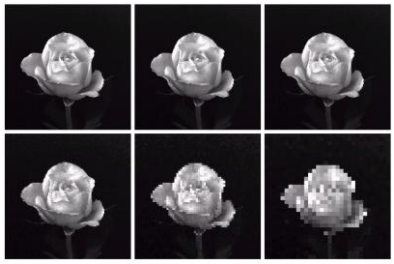
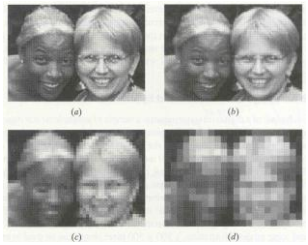
Effects of Sampling



a b c
d e f

FIGURE 2.20 (a) 1024 × 1024, 8-bit image. (b) 512 × 512 image resampled into 1024 × 1024 pixels by row and column duplication. (c) through (f) 256 × 256, 128 × 128, 64 × 64, and 32 × 32 images resampled into 1024 × 1024 pixels.

Resolution Examples



- Resolution decreases by one half in cases at left
- Human faces can be recognized at 64 x 64 pixels per face

Effects of Quantization

From 8-bit (256 gray levels) to 1-bit (2 gray levels)

Type of Digital Images

- **Digital image** - a discrete array I[r,c], f(x,y) with limited precision (rows, columns, max I)
  - A **gray-scale image** is a monochrome image with one intensity value per pixel.
  - A **binary image** is a digital image with all pixels values 0 or 1.
  - A **multispectral image** is a digital image that has a vector of values at each pixel. e.g. (R,G,B)
  - A **labeled image** is a digital image whose pixel is a *symbol* denoting the outcome of a decision, e.g. grass vs. sky vs. house