

Overview

Image Processing
CSE 166

CSE 166: Image Processing

- Today
 - Course overview
 - Logistics
 - Some mathematics
- Lectures will be boardwork and slides

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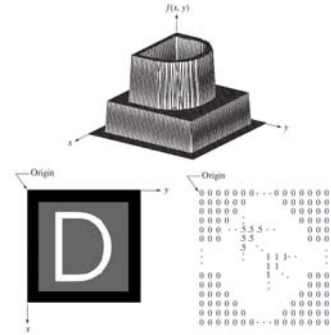
What is an image?

- A two-dimensional function $f(x,y)$, where x and y are spatial coordinates
- The amplitude of f at the coordinates (x,y) is called the intensity or gray level at that point
- A *digital* image is composed of a finite number of elements at discrete points
 - The elements are called picture elements (pixels, pels) or image elements

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Representing an image



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What is image processing?

- A discipline in which both the input and output of a process are images
 - Some believe this to be limiting, including the authors of the textbook
 - There are usually other input parameters to the process
- Related disciplines
 - Image analysis, machine vision, computer vision

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History

- In the early 1920s, newspapers transmitted and received digital pictures by cable across the Atlantic (without computers)
 - Reduced transport time from over a week to less than three hours



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History

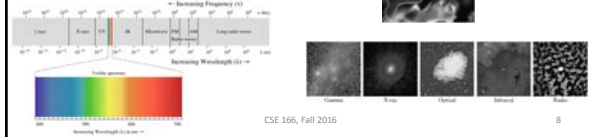
- 1940s: Modern digital computers
- 1950s: High-level programming languages and the integrated circuit
- 1960s: Operating systems
- **1964: Computer-based digital image processing**
- 1970s: Microprocessor
- 1980s: Personal computers (PCs)

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Examples

- Gamma-ray imaging
- X-ray imaging
- Ultraviolet imaging
- Visible light imaging
- Infrared imaging
- Microwave imaging
- Radio imaging



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Topics (tentative)

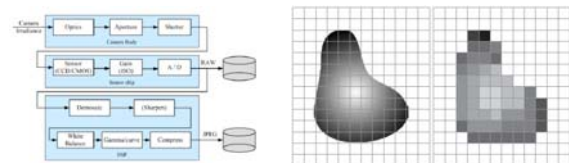
- Image acquisition
- Image filtering and enhancement
- Image restoration
- Color image processing
- Wavelets and multiresolution processing
- Morphological image processing
- Image segmentation

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Image acquisition

- Sensing and acquisition
- Sampling and Quantization

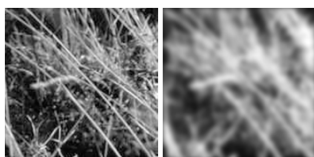


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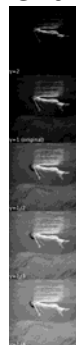
Image filtering and enhancement

- Intensity transformations
- Spatial filtering
- Filtering in the frequency domain



Low-pass filter

Gamma correction



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Image restoration

- Noise models
- Noise reduction



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Color image processing

- Color models
- Color transformations
- Color mapping
- Color transfer





Source



Target

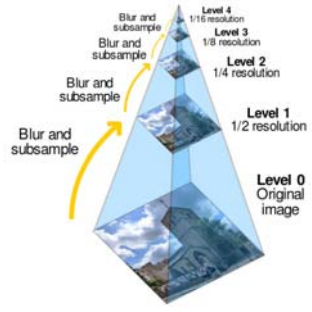


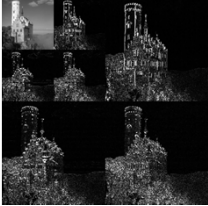
Source mapped to target

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Wavelets and multiresolution processing

- Image pyramids
- Scale space
- Wavelets





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Image compression

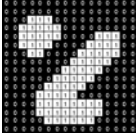
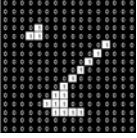
- Lossless vs lossy compression

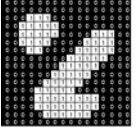
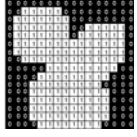



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Morphological image processing

- Erosion and dilation
- Opening and closing




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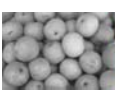


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Image segmentation

- Thresholding
- Region-based segmentation

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Syllabus

- Instructor: Ben Ochoa
- TA: Vrinda Gupta
- Tutor: Dhanesh Pradhan
- Course website
 - <http://cseweb.ucsd.edu/classes/fa16/cse166-a/>
- 19 lecture meetings
 - No university holidays for MW classes, but no meeting on day before Thanksgiving (Wednesday, November 23)
- Weekly discussion section
- Class discussion
 - Piazza

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Syllabus

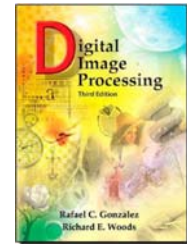
- Grading
 - Homework assignments (50% of grade)
 - By hand and programming using MATLAB
 - Midterm exam (20% of grade)
 - Final exam (30% of grade)
 - Piazza
 - Ask (and answer) questions using Piazza, not email
 - Good participation could raise your grade (e.g., raise a B+ to an A-)

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Textbook

- Digital Image Processing, 3rd edition
 - Rafael C. Gonzalez and Richard E. Woods
- Download the corrections and clarifications



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Academic Integrity Policy

Integrity of scholarship is essential for an academic community. The University expects that both faculty and students will honor this principle and in so doing protect the validity of University intellectual work. For students, this means that all academic work will be done by the individual to whom it is assigned, without unauthorized aid of any kind.

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Collaboration Policy

It is expected that you complete your academic assignments on your own and in your own words and code. The assignments have been developed by the instructor to facilitate your learning and to provide a method for fairly evaluating your knowledge and abilities (not the knowledge and abilities of others). So, to facilitate learning, you are authorized to discuss assignments with others; however, to ensure fair evaluations, you are not authorized to use the answers developed by another, copy the work completed by others in the past or present, or write your academic assignments in collaboration with another person. If the work you submit is determined to be other than your own, you will be reported to the Academic Integrity Office for violating UCSD's Policy on Integrity of Scholarship.

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Wait List

- Number of enrolled students is limited by
 - Size of room
 - Number of TAs and tutors
- General advice
 - Wait for as long as you can
- Concurrent enrollment (Extension) students have lowest priority

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Some Mathematics

Basic linear algebra

- Vectors and matrices
- Vector and matrix transpose
- Vector-vector dot or inner product
- Matrix-vector multiplication
- Matrix-matrix multiplication

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Array vs matrix operations

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \text{ and } \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

The array product of these two images is

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} & a_{11}b_{12} \\ a_{21}b_{11} & a_{21}b_{12} \end{bmatrix}$$

On the other hand, the matrix product is given by

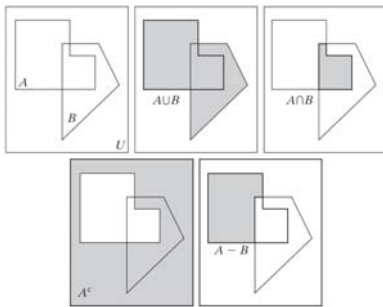
$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

In MATLAB, array operations are preceded by a 'dot'
For example, $A.*B$ and $A./B$
These are called element-wise operations

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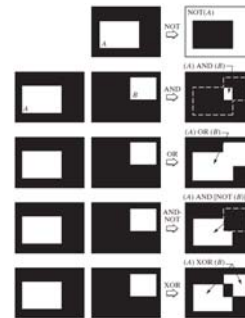
Set operations



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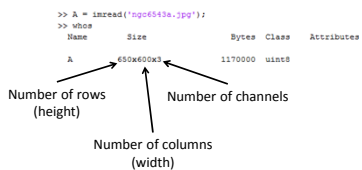
Logical operations



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Images in MATLAB



- Warning: MATLAB uses 1-based index, not 0-based
- $A(100, 200, 2)$ is row 100, column 200, and channel 2

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