Overview

Image Processing

CSE 166
CSE 166: Image Processing

• Today
  – Course overview
  – Logistics
  – Some mathematics
  – MATLAB

• Lectures will be “boardwork” and slides
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
Representing an image
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
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
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)
Examples

- Gamma-ray imaging
- X-ray imaging
- Ultraviolet imaging
- Visible light imaging
- Infrared imaging
- Microwave imaging
- Radio imaging
CSE 166 topics

• Image acquisition
• Image filtering and enhancement
• Image restoration
• Wavelets and other image transforms
• Color image processing
• Image compression and watermarking
• Morphological image processing
• Image segmentation
• Additional topics if time permits
Image acquisition

Sampling and quantization
Image filtering and enhancement

- Intensity transformations
- Spatial filtering

Low-pass filter

Gamma correction
Image filtering and enhancement

- Filtering in the frequency domain
Image restoration

• Noise models
• Noise reduction
Wavelets and other transforms

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Wavelet and Haar transform
Color image processing

• Color models
• Color transformations
Image compression and watermarking

• Lossless vs lossy compression
Morphological image processing

• Dilation and erosion
• Opening and closing
Image segmentation

• Thresholding
Syllabus

• Instructor: Ben Ochoa
• TA: Abhilash Kasarla
• Course is on Canvas
• Course website
  – https://cseweb.ucsd.edu/classes/sp20/cse166-a/
• 19 lecture meetings (recorded)
  – 1 university holiday (Monday, May 25)
• Weekly discussion section (recorded)
• Class discussion
  – Piazza
Syllabus

• Grading
  – Homework assignments (50% of grade)
    • By hand and programming using MATLAB
    • Late policy: 15% grade reduction for each 12 hours late
      – Will not be accepted 72 hours after the due date
  – Midterm exam (20% of grade)
    • Take-home exam during week 6
  – Final exam (30% of grade)
    • Take-home exam during finals week
  – Piazza
    • Ask (and answer) questions using Piazza, not email
    • Good participation could raise your grade (e.g., raise a B+ to an A-)
Textbook

• Digital Image Processing, 4th edition
  – Rafael C. Gonzalez and Richard E. Woods

• See book website
  – Corrections and clarifications
  – Review material
    • Linear systems
    • Matrices and vectors
    • Probability
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.
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.
Academic Integrity Violation

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. In accordance with the CSE department academic integrity guidelines, students found committing an academic integrity violation will receive an F in the course.
Wait list

• Number of enrolled students is limited by
  – Size of room
  – Number of instructional assistants (TAs and tutors)

• General advice
  – Wait for as long as you can

• UCSD policy: concurrent enrollment (Extension) students have lowest priority
Some mathematics
Set operations

A
B
U
A ∪ B
A ∩ B
A^c
A - B
Logical operations

- **NOT(A)**: Invert the truth value of A.
- **(A) AND (B)**: The result is true only if both A and B are true.
- **(A) OR (B)**: The result is true if either A or B or both are true.
- **(A) AND [NOT (B)]**: The result is true only if A is true and B is false.
- **(A) XOR (B)**: The result is true if A and B have different truth values.
Basic linear algebra

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

\[
\begin{bmatrix}
  a_{11} & a_{12} \\
  a_{21} & a_{22}
\end{bmatrix}
\quad \text{and} \quad
\begin{bmatrix}
  b_{11} & b_{12} \\
  b_{21} & b_{22}
\end{bmatrix}
\]

Elementwise product

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

Matrix product

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

In MATLAB, elementwise operations are proceeded by a ‘dot’
For example, A .* B and A ./ B
Getting started with MATLAB
Images in MATLAB

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

```matlab
>> I = imread('cameraman.tif');
>> whos
    Name      Size      Bytes  Class  Attributes
    I     256x256   65536  uint8   

>> imshow(I,[0 255])
>> colorbar
>> axis on
```
MATLAB documentation

• Browse all documentation
MATLAB toolboxes

• Unless specified in the assignment, you may not use MATLAB functions contained in the toolboxes

• If you are unsure about using a specific function, then ask the instructor for clarification
MATLAB documentation

- Documentation for a specific command
MATLAB help

• To view in command window, use help

```matlab
>> help imshow
imshow Display image in Handle Graphics figure.
imshow(I) displays the grayscale image I.

imshow(I,[LOW HIGH]) displays the grayscale image I, specifying the display range for I in [LOW HIGH]. The value LOW (and any value less than LOW) displays as black, the value HIGH (and any value greater than HIGH) displays as white. Values in between are displayed as intermediate shades of gray, using the default number of gray levels.

imshow(I,[]) displays the grayscale image I scaling the display based on the range of pixel values in I. imshow uses [min(I(:)) max(I(:))] as the display range, that is, the minimum value in I is displayed as black, and the maximum value is displayed as white.

imshow(RGB) displays the truecolor image RGB.
imshow(BW) displays the binary image BW. imshow displays pixels with the
```
Get MATLAB for your computer

MATLAB for University of California San Diego Students

University of California San Diego has a Total Academic Headcount (TAH) license for MATLAB, Simulink, and add-on products. Students may use these products for educational and instructional purposes. The license allows individuals to install the products on university-owned equipment, as well as personally owned computers.
Other ways to use MATLAB

Matlab

Find out how Matlab is available for faculty, staff, and students.

Platforms: Windows Macintosh and Linux

MATLAB is a programming platform designed specifically for engineers and scientists. The heart of MATLAB is the MATLAB language, a matrix-based language allowing the most natural expression of computational mathematics.

University of California San Diego has a Total Academic Headcount (TAH) license for MATLAB, Simulink, and add-on products. Please visit UCSD Matlab Portal.

Students may use these products for educational and instructional purposes.

Faculty, researchers, and staff may use these products for teaching, instructional, and research.

The license allows individuals to install the products on university-owned equipment, as well as
Next Lecture

• Image acquisition, geometric transformations, and image interpolation

• Reading
  – Chapter 2: Digital Image Fundamentals