

Overview

Image Processing
CSE 166

CSE 166: Image Processing

- Today
 - Course overview
 - Logistics
 - Some mathematics
 - MATLAB
- Lectures will be boardwork and slides
 - Take written notes or take pictures of the board

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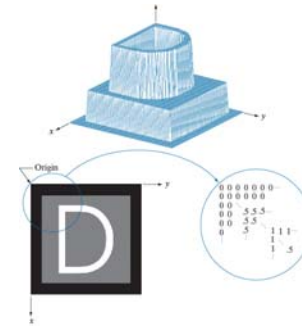
What is an image?

- 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

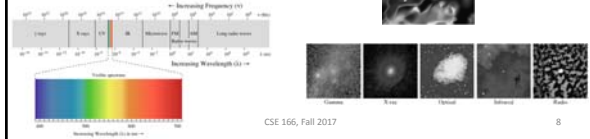
- 1940s: Modern digital computers
- 1950s: High-level programming languages and the integrated circuit
- 1960s: Operating systems
- 1964: Computer-based digital image processing
- 1970s: Microprocessor
- 1980s: Personal computers (PCs)

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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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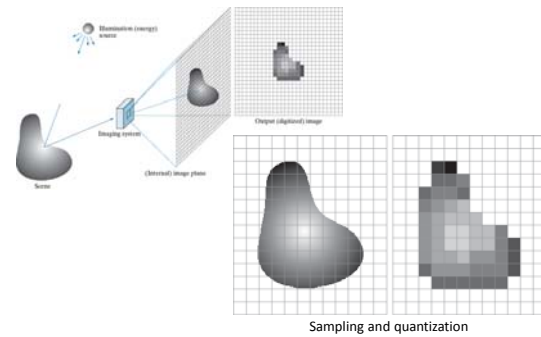
Topics

- 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

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Image acquisition



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Image filtering and enhancement

- Intensity transformations
- Spatial filtering



Low-pass filter

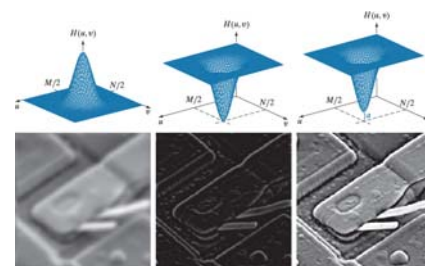
Gamma correction

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Image filtering and enhancement

- Filtering in the frequency domain

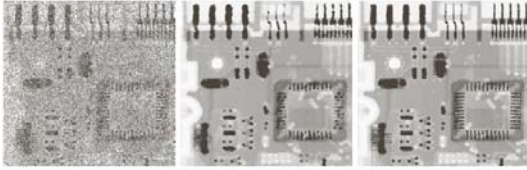


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Image restoration

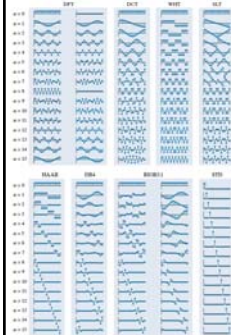
- Noise models
- Noise reduction



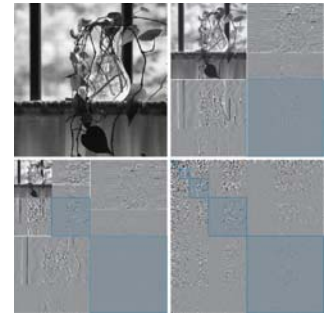
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Wavelets and other transforms



Basis vectors



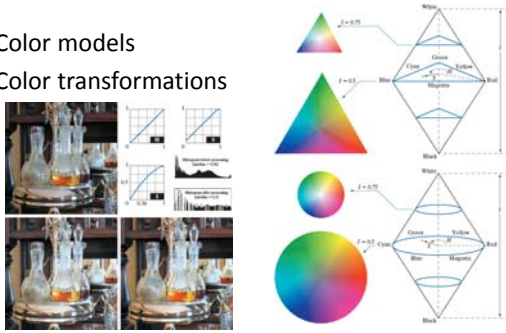
Wavelet and Haar transform

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Color image processing

- Color models
- Color transformations



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Image compression and watermarking

- Lossless vs lossy compression



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Morphological image processing

- Dilation and erosion
- Opening and closing

Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1000 rather than the year 2000.



1 1 1
1 1 1
1 1 1

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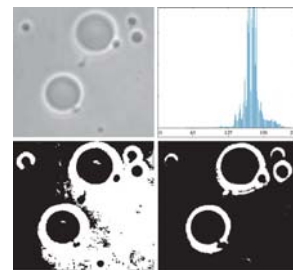
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Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.



Image segmentation

- Thresholding



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Syllabus

- Instructor: Ben Ochoa
- TA: Rithwik Kollipara
- Tutor: Ashwin Srikant
- Course website
 - <https://cseweb.ucsd.edu/classes/fa17/cse166-a/>
- 19 lecture meetings
 - No university holidays for MW classes, but no meeting on day before Thanksgiving (Wednesday, November 22)
- Weekly discussion section
- Class discussion
 - Piazza

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Syllabus

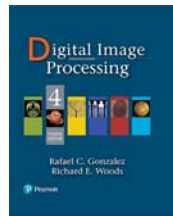
- Grading
 - Homework assignments (50% of grade)
 - By hand and programming using MATLAB
 - Late policy: 15% grade reduction for each 12 hours late
 - Midterm exam (20% of grade)
 - Final exam (30% of grade)
 - Piazza
 - Ask (and answer) questions using Piazza, not email
 - Good participation could raise your grade (e.g., raise a B+ to an A-)

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Textbook

- Digital Image Processing, 4th edition
 - Rafael C. Gonzalez and Richard E. Woods
- See book website
 - Corrections and clarifications
 - Review material
 - Linear systems
 - Matrices and vectors
 - Probability



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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

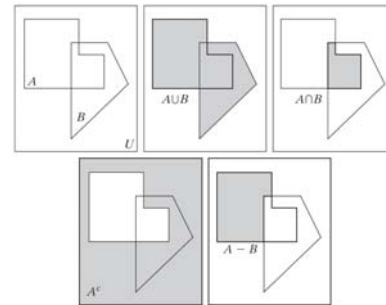
- Number of enrolled students is limited by
 - Size of room
 - Number of TAs and tutors
- General advice
 - Wait for as long as you can
- Concurrent enrollment (Extension) students have lowest priority

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Some mathematics

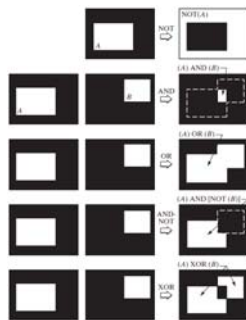
Set operations



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Logical operations



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Basic linear algebra

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

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Elementwise vs matrix operations

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

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 preceded by a 'dot'
For example, $A .* B$ and $A ./ B$

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Getting started with MATLAB

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Images in MATLAB

```
>> A = imread('logo643a.jpg');
>> whos
Name      Size      Bytes  Class  Attributes
-----
A         650x650x3  1170000 uint8
```

A → 650x650x3
 Number of rows (height) ← 650
 Number of columns (width) ← 650
 Number of channels ← 3

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

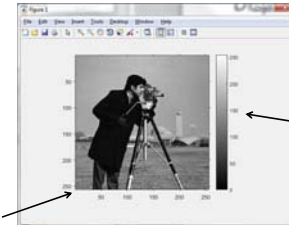
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Displaying images in MATLAB

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

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

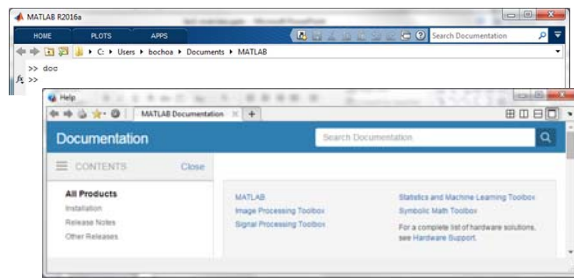


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MATLAB documentation

- Browse all documentation



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MATLAB toolboxes

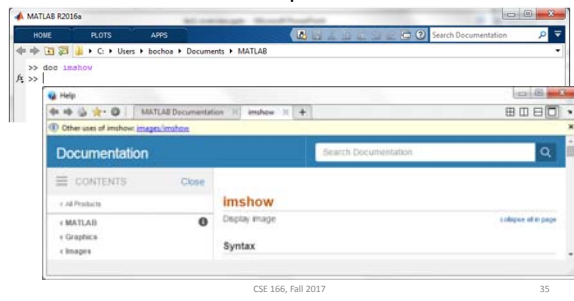
- Unless specified in the assignment, you may not use MATLAB functions contained in the toolboxes
- If you are unsure about using a specific function, then ask the instructor for clarification

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MATLAB documentation

- Documentation for a specific command

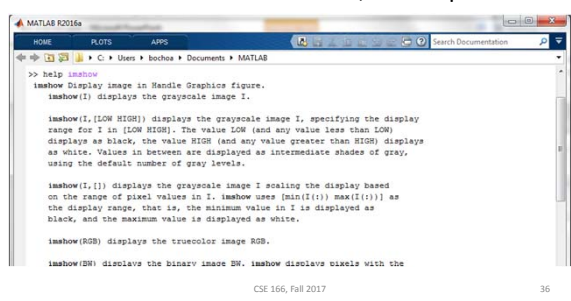


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MATLAB help

- To view in command window, use help



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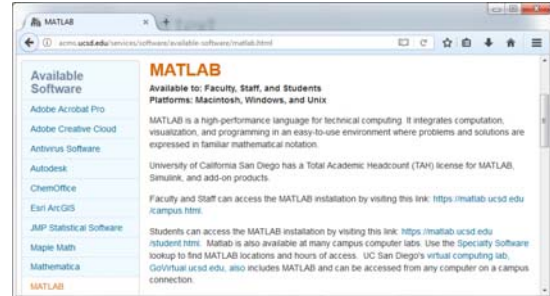
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Get MATLAB for your computer



The screenshot shows a web browser window with the URL <https://matlab.ucsd.edu/student.html>. The page features the UC San Diego logo in the top right corner. The main heading is "MATLAB for University of California San Diego Students". Below the heading, a paragraph states: "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." At the bottom of the page, the text "CSE 166, Fall 2017" and the number "37" are visible.

Other ways to use MATLAB



The screenshot shows a web browser window with the URL <https://matlab.ucsd.edu/services/software/available-software/matlab.html>. The page is titled "MATLAB" and lists "Available Software" on the left side, including Adobe Acrobat Pro, Adobe Creative Cloud, Antivirus Software, Autodesk, ChemOffice, ERI ArcGIS, JMP Statistical Software, Maple Math, and Mathematica. The main content area is titled "MATLAB" and contains the following text: "Available to: Faculty, Staff, and Students", "Platforms: Macintosh, Windows, and Unix", "MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.", "University of California San Diego has a Total Academic Headcount (TAH) license for MATLAB, Simulink, and add-on products.", "Faculty and Staff can access the MATLAB installation by visiting this link: <https://matlab.ucsd.edu/icmpus.html>", and "Students can access the MATLAB installation by visiting this link: <https://matlab.ucsd.edu/student.html>. Matlab is also available at many campus computer labs. Use the Specialty Software lookup to find MATLAB locations and hours of access. UC San Diego's virtual computing lab, GoVirtual.ucsd.edu, also includes MATLAB and can be accessed from any computer on a campus connection." At the bottom of the page, the text "CSE 166, Fall 2017" and the number "38" are visible.