Digital Image Processing
ELEN E4830

Professors:
Shahram Ebadollahi
Lexing Xie
General Information

Spring 2007
Mondays 6:50~9:20pm
Classroom: Mudd 337
Credits: 3

6:50~8:00 part 1
8:00~8:10 break
8:10~9:20 part 2

Target audience:
First year Graduate and Senior level students

ARE YOU IN THE RIGHT CLASS?!
Outline

- **Part I** [Shahram Ebadollahi]
  - Course protocol, policy, and all that
  - Introduction to DIP and examples of applications
  - Course outline
  - Brief review of signals and systems

- **Break**

- **Part II** [Lexing Xie]
  - Image processing tools & software
  - Introduction to MATLAB
Course Protocols & Policies
Pre-requisites

- Signals & Systems
- Probability

- If you haven’t taken these courses please see us after the class TODAY!
Staff

- Lecturers:
  - Shahram Ebadollahi
    Research Staff Member, IBM T.J. Watson Research
    PhD from Columbia U. EE dept., 2005
  - Lexing Xie
    Research Staff Member, IBM T.J. Watson Research
    PhD from Columbia U. EE dept., 2005

- TA:
  - Junfeng He
How to reach us?

Course webpage: http://www.ee.columbia.edu/~xlx/ee4830

- Shahram Ebadollahi
  - E-mail: shahram@ee.columbia.edu
  - Office hours: Mondays 5:30~6:30pm
  - Office: 1312 Mudd

- Lexing Xie
  - E-mail: xlx@ee.columbia.edu
  - Office hours: Mondays 5:30~6:30pm
  - Office: 1312 Mudd

- Junfeng He
  - E-mail: jh2700@columbia.edu
  - Office hours:TBD
  - Office: 711 CEPSR
  - Mailbox:TBD

Please contact the lecturer of the week for problems/question related to each lecture!
Our research

- Shahram Ebadollahi
  - Image/Video content understanding
  - Medical imaging informatics

- Lexing Xie
  - multimedia content analysis, data mining
  - statistical learning and signal processing in multimedia
Course textbook

- **Digital Image Processing, 2nd Edition**

- Very well written book
- Right balance of verbal explanation, math, and image examples
- Broad coverage of the subject
- Accessible by wide audience
Assignments

- 12 assignments

- Due at: END OF DAY OF CLASS IN TA’s MAILBOX OR EMAIL INBOX! (NO EXCEPTIONS)
- Solutions and graded homeworks will be handed out the week after you hand in your assignments.

- Assignment types:
  - **Analytical**
    - 2 to 3 questions/problems.
  - **Experimental**
    - A problem which require some programming and experimentation.
      e.g.
      1) change parameters of an image processing algorithm, observe the effect, comment on your findings
      2) how do you think this image could be enhanced? Show it! Why this approach?
2 Exams

- Midterm (03/05/2007)
  - 150 minutes
  - Open book

- Final
  - 3 hours
  - Open book
Grading Policy

- Homeworks: 50%
  - Analytical: 25%
  - Experimental: 25%

- Midterm: 20%

- Final: 30%
  - All material will be covered in the final exam
DIP Introduction
Image

- Image = 2d function

\[ f(x, y) \in R \quad x, y \in R \]

\[ f(x, y) = i(x, y) . r(x, y) \]

Illumination \quad reflectance

\[ 0 \leq f(x, y) \leq F \]

\[ 0 \leq x \leq X \]
\[ 0 \leq y \leq Y \]
Digital Image

- Discretization
  - Spatial sampling
  - Quantization

\[ f(m, n) \in \mathbb{Z}, \quad m, n \in \mathbb{Z} \]

\[
0 \leq f(m, n) \leq L - 1 \quad 0 \leq m \leq M - 1 \\
0 \leq n \leq N - 1
\]
Digital Image

\[ f = \begin{bmatrix}
  f(0,0) & f(0,1) & \cdots & f(0,N-1) \\
  f(1,0) & f(1,1) & \cdots & f(1,N-1) \\
  \vdots & \vdots & \ddots & \vdots \\
  f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1)
\end{bmatrix} \]
Color Image
Digital Image Processing

Low level

Mid level

High level

\[ x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_p \end{bmatrix} \]
Digital Image Processing

Low level

Mid level

High level

Communication & Storage

\[ x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_p \end{bmatrix} \]
### What are we going to study?

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<td>SE/LX</td>
<td>Course Mechanics, Introduction to Image Processing, Introduction to MATLAB</td>
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<td>Digital Image Fundamentals (ch2)</td>
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Why study DIP?

- Image & video is a major communication media
  - “An image is worth 1000 words!”
- In all application domains, image and video is becoming indispensable
- WWW, faster computation, more storage, proliferation of image capture and consumption devices → Need for more, better, faster, and more intelligent image and video analysis
- It’s fun!
Application Domains

- Consumer domain
  - Storage, tagging, searching,…
- Remote sensing
  - Agriculture, Urban growth monitoring, …
- Medical
  - CAD, quantification, organization, assisted surgery, …
- Space explorations
  - Image mosaic, image matching, …
- Art
  - Working methods of painters, material used, …
- Security
- Military
- … and many more!
Application Domains

- Consumer domain
  - Storage, tagging, searching,…

mountain, snow, buildings, sky
Application Domains

- Remote sensing
  - Agriculture, Urban growth monitoring, …

[Image courtesy of NASA/LANDSAT]
Application Domains

- Medical
  - CAD, quantification, organization, assisted surgery,
  ...
Application Domains

- Space explorations
  - Image mosaic, image matching, …

Panoramic image built from images taken from mars rover Spirit

[image courtesy of NASA/JPL/Cornell]
Review of Signals & Systems