Boston University, College of Engineering
Department of Electrical and Computer Engineering

ENG EC520 A1 – Fall 2008

DIGITAL IMAGE PROCESSING AND COMMUNICATION

Instructor: Prof. Janusz Konrad (office: PHO 443, tel: 353-1246, e-mail: `jkonrad@bu.edu`)

Classes/office hours: Mon-Wed: 10-12am (PHO428) / Mon: 1-3pm, Tue: 11-1pm (PHO443)

Objectives:
The goal of this course is to provide the theoretical and practical basis required for the understanding and design of modern image processing and image communication systems. The material covered in the course will primarily concentrate on still images but will also relate certain concepts from digital video (image sequences). The course will be organized in such a way that students can master background needed for research in image-related areas and simultaneously acquire in-depth understanding of modern applications of image processing, e.g., storage and transmission of images and video (wireless, Internet), digital photography.

Content:
The course will consist of two parts: foundations and applications. In the foundations part, concepts from multidimensional (M-D) signal processing theory will be introduced and complemented with human perception and color representation. This part will start with a brief review of various 1-D signal processing concepts (linearity, shift invariance, filtering) and their extension to multiple dimensions. This will be followed by an introduction to discrete representation of continuous images; M-D sampling theory (generalization of algebraic concepts of 1-D Nyquist theorem to geometric concepts in M-D), and scalar, as well as vector, quantization will be discussed in depth. This will be followed by an overview of human visual system properties since they are heavily exploited at various stages of an image communication system. Subsequently, the notion of color and color spaces will be introduced. This part will be concluded with an introduction to image modeling, including covariance and Markov models, and an overview of unitary transforms. In the second part of the course, various applications of the above concepts to practical image processing tasks will be elucidated. First, image enhancement, such as contrast manipulation, edge sharpening, noise reduction, will be briefly reviewed, followed by image restoration (recovery of original image from noisy/distorted observations). Then, some aspects of image analysis will be covered, such as edge detection, image segmentation (extraction of object boundaries), and basic notions of motion computation. In the final part of the course image compression will be briefly overviewed, including compression standards (JPEG, JPEG-2000, MPEG, H.26X). The course will be illustrated with numerous examples and the students will verify various results experimentally using *Matlab*.

Prerequisites:
SC416 and SC505 or their equivalents; prior experience with *Matlab* will be an asset.

Outline:

- *Introduction (1)*: scope of the course, historic background on the use of images, overview of applications, current and future challenges
- *2-D linear shift-invariant systems (2)*: 2-D signals, 2-D linear shift-invariant systems, 2-D Fourier transform,
- *Discrete representation of images (10)*: image sampling, image quantization, representation of color images, human visual system, 2-D image models, image bases and transforms

- *Digital image processing (6)*: sampling grid conversion, intensity and color transformation, image smoothing and sharpening, image restoration, edge detection and boundary extraction, image segmentation
- *Digital image compression (6):* fundamentals of entropy coding (lossless compression) fundamentals of rate-distortion theory (lossy compression) still image compression (including basics of JPEG and JPEG-2000), elements of video compression

Grading:

30%	Assignments	6 assignments; penalty for late submission; no assignment accepted after solutions released.
20%	Project	Team project involving algorithm development in *Matlab*; report and presentation required. Details to follow.
20%	Mid-term exam.	Closed-book exam.
30%	Final exam.	Closed-book exam.

Course web page: A "Courseinfo" web page (`http://courseinfo.bu.edu`) will contain a wealth of information related to the course, homework assignments, sample images, etc. (only registered students will have access).

Textbook: I will use a recent textbook by J. Woods, but I will supplement it with other material. If you are going to pursue research in images/video, I highly recommend that you buy this text. Slides used in the classroom and other handouts will be available on the course web page. Other references used to complement the textbook are listed below.

References used in the course :

- **J.W. Woods**, *Multidimensional Signal, Image and Video Processing and Coding.* Academic Press, 2006. (**course textbook**, on reserve at the Science and Engineering Library)
- A. Jain, *Fundamentals of Digital Image Processing.* Information and System Sciences Series, Prentice Hall, 1989. (additional text, on reserve at the Science and Engineering Library)
- A. Bovik, *Handbook of Image and Video Processing.* Academic Press, 2000 - 1st edition or 2005 - 2nd edition. (useful reference, on reserve at the Science and Engineering Library)
- E. Dubois, "The sampling and reconstruction of time-varying imagery with application in video systems," *Proc. IEEE*, vol. 73, pp. 502–522, Apr. 1985. (essential apper, available at the Science and Engineering Library and from me)
- A. N. Netravali and B. G. Haskell, *Digital Pictures: Representation and Compression.* Applications of communication Theory, Plenum Press, 1989.

Academic conduct:

Collaboration is permitted on homework, but illegal on exams. If there is collaboration on homework, each collaborator must turn in his/her individual analysis and description of results.

The student handbook defines academic misconduct as follows: *"Academic misconduct occurs when a student intentionally misrepresents his or her academic accomplishments or impedes other students' chances of being judged fairly for their academic work. Knowingly allowing others to represent your work as theirs is as serious an offence as submitting another's work as your own."* Please see the student handbook for procedures to be followed should academic misconduct be discovered.