Instructor: Prof. Janusz Konrad (office: PHO 443, tel: 353-1246, e-mail: jkonrad@bu.edu)
Classes: MW, 10-12 (PHO 201), Office hours: Th 10-11am, Fr 12:30-1:30pm (PHO 442)

Objectives:
The goal of this course is to provide the theoretical and practical basis required for the un-
derstanding 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 convey
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 simul-
taneously acquire in-depth understanding of modern applications of image processing, such as
storage and transmission of visual information, digital photography, image enhancement, etc.

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 com-
plemented 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 repre-
sentation 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 prop-
erties 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 con-
cluded 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 enhance-
ment, 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 segmen-
tation, and basic image recognition. In the final part of the course image compression will be
covered, including JPEG compression standard. The course will be illustrated with numerous
examples and the students will verify various results experimentally using Matlab.

Prerequisites:
EC416 and EC505 or their equivalents; prior experience with Matlab is important

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, representa-
tion of color images, human visual system, 2-D image models, image bases and transforms
• Digital image processing (6): sampling grid conversion, intensity and color transforma-
tion, image smoothing and sharpening, image restoration, edge detection and boundary
extraction, image segmentation

- Digital image compression (6): fundamentals of entropy coding (lossless compression) fun-
damentals of rate-distortion theory (lossy compression) still image compression (including
basics of JPEG and JPEG-2000), elements of video compression

Grading:

25% Assignments 6-7 assignments; penalty for late submission; no assignment
accepted after solutions released.
25% Project Team project involving algorithm development in Matlab or
C/C++; report and presentation required. Details to follow.

Course web site: http://learn.bu.edu will contain wealth of information related to the
course (lecture slides, handouts, papers, demos, etc.) - for registered students only.

Course references: I will not use a formal textbook this year. There is no single textbook
that sufficiently covers the material I will introduce in this course, and the feedback on past
textbooks was very mixed. Therefore, you will need to rely on lectures and supplementary
material that will be uploaded regularly to the course web site such as lecture slides, handouts
(various derivations, proofs, etc.), journal papers, excerpts from books. Below is the list of
books that can prove useful for various parts of this course should you like to explore. Each
book is on reserve at the Science and Engineering Library (max. 24 hour check-out period).


Matlab: Each assignment will involve the use of Matlab in order to illustrate the theoretical
concepts of that very assignment, and the Image Processing Toolbox will be very useful in
accomplishing this. You are encouraged to use workstations in the IMDSP (PHO309), SIGNET
(PHO307) or VLSI (PHO305) laboratories since both tools are available there. If you prefer
to use your own computer with Matlab but without the toolbox, you will need to find ways to
accomplish the same outcome as requested in the assignment but without the toolbox functions;
this is possible however requires more effort.

Academic conduct: Collaboration is essential in course project, 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
tytheirs is as serious an offense as submitting another’s work as your own.” Please see the
student handbook for procedures to be followed should academic misconduct be discovered.