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

Classes: MW, 10-12 (SOC B57), Office hours: TBD (PHO 443)

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 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 simultaneously 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 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, 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, 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 transform-
tion, 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:

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<thead>
<tr>
<th>Percentage</th>
<th>Component</th>
<th>Description</th>
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<tr>
<td>25%</td>
<td>Assignments</td>
<td>6-7 assignments; penalty for late submission; no assignment accepted after solutions released.</td>
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<tr>
<td>25%</td>
<td>Project</td>
<td>Team project involving algorithm development in Matlab or C/C++; report and presentation required. Details to follow.</td>
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Course web site: [http://learn.bu.edu](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 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 theirs 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.