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

**ENG EC520 A1 – Spring 2018**

**DIGITAL IMAGE PROCESSING AND COMMUNICATION**

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

**Teaching assistant:** M. Ozan Tezcan (e-mail: mtezcan@bu.edu)

**Grader:** Charles Saunders (e-mail: cs13@bu.edu)

**Classes:** Monday-Wednesday, 2:30–4:15pm (MET B02B)

**Discussion hours with TA:** Thursday, 11am-1pm (PHO 442); Friday, TBD

**Office hours with instructor:** Friday, 11am-12pm (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 concentrate on still images but will also convey concepts from digital video. The students will first learn the theory of image acquisition and representation followed by algorithms used in various image processing and compression tasks. Those interested in image-related research will build a necessary foundation, while those interested in practical use will gain insight into modern applications such as image enhancement (HDR), object recognition (faces, people), image coding (JPEG) and transmission (FaceTime), etc.

**Content:**
The course will consist of two parts: **foundations** and **applications**. The **foundations** part will start with a brief review of various 1-D signal processing concepts (linearity, shift invariance, causality, stability, 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 1-D Nyquist theorem to M-D), and amplitude quantization. Then, an overview of human visual system properties, extensively used in image compression, will be presented. Subsequently, the notion of color and color spaces will be introduced. This part will conclude with an introduction to image modeling, including covariance and Markov models, and an overview of unitary transforms. The **applications** part of the course will cover various uses of the above concepts in practical image processing tasks. First, image enhancement, such as contrast manipulation, edge sharpening, noise reduction, will be reviewed, followed by image restoration (recovery of original image from noisy/distorted observations). Then, elements of image analysis will be introduced, such as edge detection, image segmentation, and image recognition. Image compression will be covered at the end, including JPEG. While lectures will include lots of visual examples, the students will verify many results experimentally in homeworks.

**Prerequisites:**
EC381 and EC416 (or equivalents); prior experience with Matlab or Python is essential.

**Outline:**

- *Introduction*: scope of the course, historic background, some applications, challenges
- *2-D signals and systems*: 2-D signals, linear shift-invariant systems, Fourier transform
- *Discrete representation of images*: image sampling, image quantization, human visual system, representation of color, image models, image bases and transforms
• **Digital image processing**: sampling grid conversion, color transformation, image enhancement and restoration, boundary extraction, image segmentation, image recognition

• **Digital image compression**: fundamentals of entropy coding (lossless compression), fundamentals of rate-distortion theory (lossy compression), still-image compression (JPEG and foundations of JPEG-2000), elements of video compression

**Grading:**

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<thead>
<tr>
<th>Percentage</th>
<th>Component</th>
<th>Details</th>
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<tbody>
<tr>
<td>25%</td>
<td>Homeworks</td>
<td>About 10 homeworks (≈1 per week); <strong>the lowest grade discarded</strong> from final grade calculation; penalty for late submission; no assignment accepted after solutions released.</td>
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<td>25%</td>
<td>Project</td>
<td>Team project involving algorithm development in Matlab, Python, or C/C++/C#; report and in-class presentation.</td>
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**Web site:** [http://learn.bu.edu](http://learn.bu.edu) will contain lecture slides, handouts, papers, demos, etc.

**References:** I will not use a formal textbook; there is no single textbook covering all the material in this course, and the feedback on past textbooks was very mixed. **Therefore, attendance at lectures is essential.** Supplementary material will be regularly uploaded to the course web site (lecture slides, handouts with derivations and proofs, journal papers, excerpts from books, etc.) 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 for a limited-time check-out.


**Programming:** Each assignment will involve the use of Matlab in order to illustrate the theoretical concepts of that 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 a student edition of Matlab (no 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. You may use Python, but you need to be comfortable enough to develop the code on your own since I will be providing hints only for Matlab.

**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.