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

ENG EC720 A1 – Fall 2025

Digital Video Processing

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

Lectures: Tue-Thu 3:30–5:15/Location TBD, **Office hours:** TBD

Objectives: This course extends EC520 ("Digital image processing and communication") to single- and multi-camera time-varying imagery that finds applications in video analytics, video compression/streaming, autonomous navigation, robotics, etc. The goal is to provide in-depth understanding of the theory behind various video processing tasks and the practical experience in implementing them. The material covered will extend numerous concepts from still images (2-D, i.e., $x-y$) to image sequences (3-D, i.e., $x-y-t$) and multi-view sequences (4-D, i.e., $x-y-t-\alpha$), but will also introduce new concepts unique to spatio-temporal data (timeline, motion, motion-induced occlusions, etc.) and spatio-angular data (viewing angle, angle-dependent perspective, angle-induced occlusions, etc.) The course format will be a combination of regular lectures and compulsory readings followed by in-class discussions, plus homework assignments. An important practical element of the course will be a project. Students will select a topic, study literature and implement a solution in *Matlab/Python/C/C++*. Upon the completion of this course students will have acquired in-depth knowledge to carry out research related to video processing and computer vision, and an understanding of their modern applications.

Prerequisites: Ideally, EC520 or EC516, but at the very minimum EC401 (or equivalents); fluency in *Matlab* or *Python*.

Outline: Video processing has been traditionally *model-based*, however effective *learning-based methods* are emerging. Throughout the course, examples of such methods, primarily based on *neural networks*, will be provided and analyzed

- *Introduction and Motivation*:
  - scope of the course, historic background, sample applications, challenges
- *Review of EC520 Material*:
  - sampling and filtering of 3-D signals ($x-y-t$)
  - digital representation of image sequences
  - human visual system (motion perception)
- *Motion Analysis*:
  - motion detection, 2-D and 3-D motion estimation; learning-based methods
- *Image Sequence Segmentation*:
  - spatial, temporal and spatio-temporal segmentation; video instance segmentation
- *Spectral Analysis of Image Sequences*:
  - video analysis in Fourier, DCT, and wavelet domains

- *Video Enhancement*:
  - noise reduction, super-resolution, error concealment; learning-based methods
- *Video Compression*:
  - motion-compensated hybrid DCT/DPCM coding
  - H.26X and MPEG-X families of compression standards
  - error resilience in video coding
  - motion-compensated wavelet-domain video compression (MCTF)
  - learning-based video compression

Grading:

50%	Assignments	5 assignments covering theory and practice (*Matlab/Python*); penalty for late submission; no assignment accepted after one week.
50%	Project	Project involving experimental work; report and in-class presentation at the end of the course.

On-line resources:

- Blackboard: lecture slides, handouts, papers, demos, etc.
- Gradescope – homework submission, re-grade requests
- Piazza – discussion forum

Course material: The course is primarily based on my lecture notes and handouts. I will also use the book by M. Tekalp, *Digital Video Processing*. Signal Processing Series, Prentice Hall, 2015 (2nd edition only) and post reading material (journal and conference papers) on Blackboard. Other helpful references (availble at the Science and Engineering Library):

- J.W. Woods, *Multidimensional Signal, Image and Video Processing and Coding*. Academic Press, 2nd edition - 2012 (alternatively, 1st edition - 2006).
- Y. Wang, J. Ostermann and Y.-Q. Zhang, *Video Processing and Communications*. Signal Proc. Series, Prentice Hall, 2002.
- A. Bovik (Ed.), *The Essential Guide to Video Processing*. Academic Press, 2009 (available on-lineat https://ebookcentral.proquest.com /lib/bu/detail.action?docID=328547)
- E. Dubois, "The sampling and reconstruction of time-varying imagery with application in video systems," *Proc. IEEE*, vol. 73, pp. 502–522, Apr. 1985.

Project: The course project is a key element of learning in EC720. Depending on the final class size, the projects may be individual or team-based. Projects may be theoretical, practical or combination thereof. I will offer a list of topics, but students are encouraged to propose their own projects. Projects will be executed over about 2-1/2 months with a final report and in-class presentation at the end of the course.

Programming: Homeworks will involve programming to map theory onto practice. *Matlab* Image Processing and Computer Vision Toolboxes are essential for accomplishing this. Computers in the SIGNET Lab (PHO307) have all *Matlab* toolboxes installed. You can use *Matlab* on your own computer, or run a remote session on SCC or other BU servers. Running video-processing tasks through *Matlab Online* in your browser is discouraged due to computational load. You can use *Python* instead, but no *Python*-specific programming hints will be provided.

Collaboration Policy: You may collaborate with fellow EC720 students on homeworks subject to the following strictly-enforced conditions:

- You must acknowledge all your collaborators at the top of your homework.
- You must write all homework answers in your own words (solutions, source code, analysis).
- You must be able to fully explain your answers upon demand.
- **You may not use human resources from outside of class**, including outside tutors, web-based help services, etc.

Generative AI: Since generative AI is part of our lives, ***you may use it in the development of homework solutions or project, but you must clearly acknowledge where you used it and how, and you must hand-write all the solutions yourself (no Latex/Word homework submissions)***. I may award extra credit for particularly effective use of AI, but I will consider AI use without acknowledgment as academic misconduct with all its consequences.

Academic conduct: BU takes academic integrity very seriously. 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.

Accommodations for Students with Documented Disabilities: If you are a student with a disability or believe you might have a disability that requires accommodations, requests for accommodations must be made in a timely fashion to Disability & Access Services, 25 Buick St, Suite 300, Boston, MA 02215; 617-353-3658 (Voice/TTY). Students seeking academic accommodations must submit appropriate medical documentation and comply with the established policies and procedures `http://www.bu.edu/disability/accommodations`