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

Schedule/classroom: M-W 12-2pm/SOC-B65

Objectives: This is an advanced graduate course extending EC520 (“Digital image processing and communication”) to dynamic imagery, i.e., digital video and other types of image sequences. The goal of this course is to provide an understanding of the theory behind various video processing tasks as well as practical experience in accomplishing them. The material covered in the course will extend numerous concepts from still (2-D, i.e., \(x-y\)) images to dynamic imagery (3-D, i.e., \(x-y-t\)), and will also introduce new concepts unique to spatio-temporal data such as timeline, motion, occlusions, etc. The course format will be a combination of regular lectures and homework assignments, compulsory readings followed by in-class discussions, and guest lectures. A very important aspect of the course will be a practical project. Students will select a topic, find suitable literature (with instructor’s guidance) and carry out a simulation in Matlab and/or C/C++. Upon the completion of this course students will have acquired in-depth knowledge to carry out research in image sequence-related areas and also an understanding of modern applications of video processing (e.g., video analytics, streaming video, DVD, HDTV).

Content: The course will start with a review of multi-dimensional signal sampling (lattices) and filtering with a particular focus on three-dimensional (3-D), i.e., spatio-temporal, nature of image sequences. This will be followed by a review of digital representation of image sequences and of human visual system’s properties related to dynamic imagery perception. The distinguishing feature of image sequences is their ability to capture scene dynamics. Therefore, a substantial part of the course will be devoted to motion analysis in image sequences, and in particular to motion detection and motion estimation. A related concept is that of video segmentation, i.e., partitioning video domain into disjoint sets corresponding to certain “events” in the observed scene. Various types of video segmentation will be presented. Although motion in an image sequence is necessarily a space-time concept, its description in the frequency or space/frequency domain has proven beneficial to some analysis and compression tasks, and will be presented as well. This will be followed by a discussion of video enhancement methods (noise reduction, super-resolution, error concealment, mosaics) and by the recent advances in image sequence compression. The most successful approach to video compression to date, namely the motion-compensated hybrid DCT/DPCM coding, will be introduced first. It will be elaborated upon by presenting in some depth its offspring: H.26X and MPEG-X families of video compression standards. Then, very recent approaches to wavelet-based video compression will be discussed. Finally, some error resilience issues (IP, wireless transmission) will be covered.

Prerequisites:
EC520 and EC505, or equivalents, and experience with Matlab
Tentative outline:

- **Introduction:** scope of the course, historic background on moving images, overview of applications, present and future challenges, image definition
- **Review:** 3-D (spatio-temporal) sampling and filtering, digital representation of image sequences (ITU-R 601), human visual system (motion perception), elements of information theory
- **Motion analysis:** motion detection, 2-D motion estimation, 3-D motion estimation
- **Image sequence segmentation:** spatial segmentation (frame-by-frame), temporal segmentation (scene cut detection), spatio-temporal segmentation
- **Spectral analysis of image sequences:** Fourier-, DCT-, and wavelet-domain analysis
- **Video enhancement:** noise reduction, super-resolution, scratch/dust removal
- **Video compression:** motion-compensated hybrid DCT/DPCM coding, H.26X and MPEG-X families of compression standards, error resilience in video coding, introduction to motion-compensated wavelet-domain video compression (MCTF)

Grading:

- 50% Assignments 4-5 theoretical and practical (Matlab) assignments; penalty for each day late, and no assignment accepted after one week.
- 50% Project Project involving experimental work; report and in-class presentation mandatory at the end of the course.

Web page: http://blackboard.bu.edu

Textbook: The course will be based on two textbooks (on reserve at Science/Eng. Library):


Although these are excellent textbooks, some topics are not covered and course notes as well as various handouts will be made available on the course web page.

Other references helpful in the course: