EC516 (Fall 2020) Digital Signal Processing (DSP)

Lecturer: Prof. S. Hamid Nawab Office: PHO 433

Narrative Lectures: These weekly lectures will be pre-recorded lectures (approximately 90 minutes/week) that you will have to watch as part of your weekly homework assignment. These lectures will be equally accessible to students whether on campus or not. You can watch them at whatever time is convenient to you. They will be posted on the EC516 Blackboard Learn site (this site will become available to you by this coming weekend). A new narrative lecture will be posted each Monday of the semester and you will be expected to have watched that particular narrative lecture by Monday of the following week.

Problem-Solving lectures: Each student in the class is expected to attend one problemsolving lecture (50 minutes) per week. The Problem-Solving lecture for any particular week can be attended in-person or through Zoom. The in-person version of each Problem-Solving lecture will be delivered four times a week:

Group A: Monday 10:10-11:00am *Group B*: Monday 11:05-11:55am *Group C*: Wednesday 10:10-11:00am *Group D*: Wednesday 11:05-11:55am

Group A: students whose last names begin with letters in the range *A through C. Group B:* students whose last names begin with letters in the range *D through J. Group C:* students whose last names begin with letters in the range *K through R. Group D:* students whose last names begin with letters in the range *S through Z.*

The in-person lectures will be held in PHO 203 (the lecture room assigned to EC516), which according to social distancing rules of the university can accommodate up to 14 students at a time. The weekly Problem Solving Lecture will also be repeated live on Zoom (Wednesdays at 8pm).

Please note that Prof. Nawab will deliver the narrative lectures as well as the problem solving lectures.

SPECIAL NOTE FOR FIRST TWO WEEKS: There are no classes being held at BU on Monday Aug 31 and on Monday September 7. The very first lecture in EC516 this semester will be LIVE on Zoom from 10:10am to 11:55am on Wednesday September 2nd. In the second week of the semester, there will also be a LIVE Zoom lecture from 10:10am to 11:55am on Wednesday September 9. Attendance (via Zoom) of these LIVE Zoom lectures is encouraged for all students registered in EC516.

Graduate Teaching Assistant:

The Graduate Teaching Assistant for the course this semester is Timur Zirtiloglu. Timur will hold office hours (starting the week of September 14) on **Zoom.** These hours will be posted in a later announcement.

The purpose of Timur's office hours is (1) for you to discuss with him any difficulties you are having on the current homework and (2) for you to discuss any MATLAB issues that may arise in the Course Project or in the Problem Sets.

Course Description:

In this course, we will explore the foundational depths and structural breadth of digital signal processing (DSP) from a data patternization perspective. In this perspective, we view DSP as a *computational* means for transforming raw patterns of *receive-only sensor* and sensor array data into alternative patternizations for use in domains such as pattern recognition, pattern authentication, machine learning, machine/robot perception, and enhancement of human perception. The goal of such a patternization capability is to enable the practical implementation of application use cases such as speech-to-text conversion by a smartphone, efficient video communication for HD television, directional voice enhancement in a digital hearing aid, ultrasound imaging of the heart, or accelerometer-based physical activity monitoring on a smartphone. The job of the DSP engineer is to come up with an appropriate patternization alternative for any given use-case application. As we shall discuss, the vast majority of patternization frameworks available to present-day DSP engineers have a *convolutional* basis in time, space, frequency, or wavenumber domains. In this course, we shall examine the variety of such patternization frameworks available to the DSP engineer and the type of expertise it takes to develop the right patternization for a given application. In EC516, we will also study how selection among patternization alternatives often involves considerations of resolution tradeoffs, information blindness tradeoffs, representational efficiency and inferential efficiency. In particular, we will examine these issues in the context of specific patternization frameworks such as decimation and interpolation, discrete Fourier transforms, time-dependent and space-dependent Fourier transforms, digital adaptive filters, homomorphic deconvolution, and parametric signal modeling.

Learning Outcomes:

This course is designed to achieve certain learning outcomes. As such, you may expect that as a result of taking this course you would be able to:

- Understand and describe the major classes of **patternization design options** available in modern DSP
- Understand and describe a diverse set of application **use cases** for which modern DSP is called upon to provide appropriate patternization capabilities.
- Understand and describe the underlying **convolutional themes** in many patternization capabilities provided by DSP.

- Understand and describe the generalization of basic Signals and Systems concepts to **multidimensional and multichannel frameworks**.
- Understand and describe the importance of **resolution tradeoffs** in the context of data patternization use cases.
- Understand and describe the importance of **blindness tradeoffs** in the context of data patternization use cases.
- Design, implement, and analyze **sampling**, **decimation** and **interpolation** in the context of data patternization use cases
- Design, implement, and analyze **Discrete Fourier Transforms** in the context of data patternization use cases
- Design, implement, and analyze **Time-Dependent** (or space-dependent) **Discrete Fourier Transforms** in the context of data patternization use cases.
- Design/implement/analyze **Homomorphic Deconvolution** in the context of data patternization use cases.
- Design/implement/analyze **Parametric Signal Modeling** in the context of data patternization use cases.
- Design/implement/analyze Adaptive Digital Filtering in the context of data patternization use cases.

Grading:

Test 1: 30% (Closed Book, Performance Based)

Test 2: 30% (Closed Book, Performance Based)

Final Exam: 30% (Closed Book, Performance Based)

Homework: 20% (Open Book, Participation Based)

Homework Policy:

Homework will consist of two components, watching a pre-recorded narrative lecture and doing a Problem Set each eeek. Each problem set will consist of **4 drill problems**, and **2 challenge problems**. Homework will be posted online by *Wednesday* of the week that it

is assigned. Your homework solution will be due on *Wednesday on Blackboard Learn* in the week following the week in which it is assigned. Homework will be graded on the basis of *seriousness of attempt* rather than the accuracy of the answers. While collaboration is encouraged, copying of others' homework is considered cheating in this course. *Three lowest homework scores will be dropped* when calculating the average of all the homework scores for the course.

Test Dates:

Test1: Wednesday, October 14 via Zoom Test2: Monday, November 23 via Zoom Final: TBA (Between December 16 and December 20) via Zoom

Special Dates:

No EC516 on Monday, October 12 (Columbus Day).

Tuesday October 13 at BU will follow *Monday schedule*. A special live Zoom Review Lecture (for Test 1 on the following day) will be held for the entire class from 10:10am to 11:55am.

No EC516 lecture on Wednesday, November 25 (Thanksgiving Recess).

Thanksgiving Recess is Wednesday, November 25 to Sunday, November 29.

Last Class Meets: Wednesday, December 9.

Academic Misconduct:

BU takes academic integrity very seriously. Academic misconduct is conduct by which a student misrepresents his or her academic accomplishments, or impedes other students' opportunities of being judged fairly for their academic work. Knowingly allowing others to represent your work as their own is as serious an offense as submitting another's work as your own. More information on BU's Academic Conduct Code, with examples, may be found at http://www.bu.edu/academics/policies/academic-conduct-code .

Collaboration Policy:

In this class you may use any textbooks or web sources when completing your homework, and/or any number of human collaborators (from class) per homework, subject to the following strictly enforced conditions:

• You must clearly acknowledge all your sources (including your

collaborators) on the top of your homework.

- You must write all homework answers in your own words.
- You must be able to fully explain your answers upon demand.
- You may not use any human resource outside of class (including webbased help services, outside tutors, etc.) in doing your homeworks.

The two tests and the final exam in this course are closed book and the use of any electronics is strictly forbidden during each exam. Collaboration with others during any of these three exams is also strictly forbidden. The course instructor (Prof. Nawab or his representative) will provide you a detailed formula sheet during each exam. You are not to bring any other written material (such as "cheat sheets") to any of the three exams.

Failure to meet any of the above conditions would constitute plagiarism and will be considered cheating in this class. If you are not sure whether something is permitted by the course policy, please ask Prof. Nawab.

Extra Reference:

A.V. Oppenheim and R.W. Schafer, *Discrete-Time Signal Processing* (3rd Edition), 2010, Pearson, Prentice Hall Signal Processing Series, ISBN: 860-1419506941. This reference is **neither required nor recommended to buy**. It is Prof. Nawab's opinion that the reference material posted on the EC516 Blackboard Learn site along with (1) serious attempts on the assigned homeworks, (2) attendance of lectures, (3) attendance of office hours when needed should be *sufficient* to achieve the learning outcomes of EC516.