האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

The Hebrew University of Jerusalem

Syllabus

Introduction to Signal Processing - 52419

Last update 12-11-2024

HU Credits: *3*

Degree/Cycle: *1st degree (Bachelor)*

Responsible Department: *Statistics*

Academic year: *0*

Semester: *1st Semester*

Teaching Languages: *Hebrew*

Campus: *Mt. Scopus*

Course/Module Coordinator: *Barak Sober*

Coordinator Email: *barak.sober@mail.huji.ac.il*

Coordinator Office Hours:

Teaching Staff:

Dr. Barak Sober

Course/Module description:

Despite its name, this is not an ordinary course in Digital Signal Processing as it is being taught in Electrical Engineering (where there is an emphasis on communication signals), but the course is focused on Data Science students. The course aims to present central ideas from Signal Processing and Harmonic Analysis, which are relevant to Data Analysis and Machine Learning (Image Processing, Sound Processing).
The course will go through classical topics in Signal Processing, such as Fourier Analysis, Convolutions, Wavelets, and the gap between continuous (or even smooth) signals and their digitized representations. At the end of the course, we will try to connect some of the concepts to their utilizations in modern Machine Learning and Neural Networks.

Course/Module aims:

We will survey the mathematical tools and knowledge that accumulated over the course of half a century of research in the field of Signal Processing and the gap created by representing continuous signals in a discrete manner. In addition, the course aims to connect some of these concepts to modern approaches in Signal Processing, which are often based on Machine Learning and Deep Neural Networks.

Learning outcomes - On successful completion of this module, students should be able to:

At the end of this course, students will be able to:
- Explain basic principles in signal processing
- Use Fourier-based and Wavelets-based methods to manipulate signals.
- Understand the ideas behind convolution and how it is implemented in practice.
- Connect pivotal ideas in Signal Processing to their utilizations in Neural Networks.

Attendance requirements(%):

80

Teaching arrangement and method of instruction: The course will be frontal in the classroom (a few lessons will be given through Zoom).
Attendance is mandatory.
The lessons will be recorded but will become available only to students that will show a legitimate reason for their absence.

Course/Module Content:

The list below is just a tentative list of topics. The actual topics may differ (some may be omitted while others are added).

1. Introduction and applications of Signal Processing (RF, Image, Sound)
2. Introduction to Hilbert spaces and classical bases to the L2 space (Fourier, Windowed Fourier, Wavletes), the concept of Frames.
3. Convolution and filtering
4. Discrete Fourier Transform and Fast Fourier Transform
5. Discrete representations of signals, Shannon-Nyquist Sampling Theorem, Theoretical bounds for approximation and estimation of sampled signals in the presence of stochastic noise.
6. Convolutional Neural Networks and their relations to Signal Processing.

Required Reading:

None

Additional Reading Material:

"Digital Signal Processing: Principles, Algorithms, and Applications" by John G. Proakis and Dimitris G. Manolakis.
"Wavelet Methods in Statistics with R" by Guy Nason.
"Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
“Ten Lectures on Wavelets” by Ingird Daubechies.

Grading Scheme:

Essay / Project / Final Assignment / Home Exam / Referat 80 %
Submission assignments during the semester: Exercises / Essays / Audits / Reports / Forum / Simulation / others 20 %

Additional information: