Master's Department of Engineering Sciences

Name of the unit: Digital signal processing

Lecturer: Olivier BETHOUX (olivier.bethoux@sorbonne-universite.fr)
Course code: UM4RBT14
Student workload: 12h of lectures, 10h of tutorial sessions, 6h of lab sessions@
Credits: 3 ECTS

Specialization tracks:	- **E3A** :	☐ CIMES	☐ Syscom	☒ IPS
	- **AR** :	☒ ROBOT	☐ SI	☒ MeDH
	- **MECA** :	☐ MS2	☐ MF2A	☐ CompMech
		☐ ACOU	☐ EE	☐ EE APP

Semester offered: ☒ S1 ☐ S2 ☐ S3 ☐ S4
Language of instruction: ☒ French ☐ English
Targeted audience: ☒ Engineering Sciences students ☐ Other (specify):
Localization : ☒ PMC Campus ☐ Other (specify):

Course Overview

This course aims to train students in the analysis of digital data and their processing. The teaching focuses on discrete frequency analysis on the one hand, and on the synthesis of digital filters on the other.
Keywords: Signal processing, sampling, discrete Fourier and FFT analysis, discrete systems and digital filter analysis, digital filter synthesis.

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Analog signal processing: convolution, series and continuous-time Fourier transform;
- Continuous-time systems: Laplace transform, frequency response, transfer function, analog filter synthesis.

Intended Learning Outcomes

By the end of this course, students will be able to:

1. Define the Fourier transform of a 1D signal to be used according to the continuous or discrete nature of the signal;
2. Explain the effects of sampling an analog signal (Shannon's theorem);
3. To know the definition and properties of the Fourier transform of a discrete signal, and the effects of its different parameters (number of points, windowing, etc.) on the resolution/accuracy of the frequency analysis;
4. Analyze the result of a Fourier transform calculation (e.g., associating the temporal and frequency properties of signals, identifying the frequency support of information, etc.)
5. Determine the Z transform of any discrete signal;
6. Calculate the input/output relationship of a linear and invariant discrete system, in the time and frequency domain;
7. Recognize a discrete system such as FIR or IIR;
8. Use these relationships to characterize the properties of a linear and invariant discrete system (stability, velocity, filtering, etc.);

9. Synthesize a digital filter on the basis of specifications;
10. Write a a Matlab or a Python program to display and analyze the spectrum of a signal;
11. Write a Matlab or a Python Python program to design and use a numerical filter based on the software tools provided.

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1	Reminders about continuous time		AAV1
S2	C2	Sampling		AAV2
S3	C3 / TD1	Frequency analysis	Preparatory video for TD1	AAV1, AAV3-4
S4	TD2	Windowing	Preparatory video for TD2	AAV3-4
S5	TP1	FFT and windowing	Review FFT and its properties	AAV4, AAV10
S6	C4	Z-Transform		AAV5
S7	C5 / TD3	Discrete Time Systems / Discrete Systems Analysis	Preparatory video for TD3	AAV6-8
S8	C6	Synthesis of digital filters		AAV8-9
S9	TD4	Synthesis of digital filters	Preparation for TD4	AAV9
S10	TP2	Using a synthesis tool in Python	Review FFT and FIR/IIR synthesis	AAV10-11
S11	TD5	Last year final exam		AAV1-11

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Sequence of the unit:
The UE takes place in 3 successive sequences:
- Sequence 1: recalls, sampling and frequency analysis of discrete signals (C1/2/3 + TD1/2 + TP1 + Quiz1)
- Sequence 2: mathematical tools and discrete time systems (C4/5 + TD3 + Quiz 2)
- Sequence 3: synthesis of digital filters (C6 + TD4/5 + TP2)

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
S11	Individual	In-person	Practical	AAV 10-11	30 %
S12	Individual	In-person	Written	AAV 1-9	70 %

2nde session of exam

Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
2	Individual	In-person	Written	AAV 1-11	70 %
1	Individual	In-person	Practical	AAV 10-11	30 %

Bibliographic references

- A.W.M. Van Den Henden, N.A.M Verhoeckx, Traitement numérique du signal : une introduction. Masson.
- M. Bellanger, Traitement numérique du signal. Dunod.
- Etienne Tisserand, Jean-François Pautex, Patrick Schweitzer, "Analyse et traitement des signaux - Méthodes et applications au son et à l'image", Dunod, EAN 9782100524372

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