UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Digital Signal Processing for Inteliigent Systems

2526-3-E3101Q143

Aims

Knowledge and understanding

The student from the theoretical point of view will learn the fundamentals of the transition from analog to digital signal (sampling, quantization, and encoding); will learn the main techniques for processing a digital signal in the time, frequency and time-frequency domains; and will learn techniques for compressing digital signals.
The student will understand these notions referring to audio , image and video signals, and signals acquired with wearable devices (physiological and electrophysiological signals such as heartbeat, skin conductance, respiration, electromyography, electroencephalogram) with special emphasis on their use in human-machine interaction systems.

Applied knowledge and understanding

From a practical point of view, during face-to-face lessons, exercises and laboratory activities the student will learn how to handle and process digital signals, through linear time invariant systems, and also analyzing the signal from the point of view of frequencies.
The student will learn how to process digital signals particularly with respect to their use in human-machine interaction systems.

Making judgements

Students through laboratory activities and required assignments will be able to assess their own preparation and level of understanding of theoretical aspects.

Communication skills

Students will be stimulated to discussion during frontal and laboratory activities. The main focus during these interactions is to increase the ability to clearly, knowledgeably and unambiguously communicate technical content, ideas, problems. These skills fostered in itinere will be assessed through an oral examination test.

Learning skills

The structure of teaching in which theoretical lectures, practical exercises and laboratory experiences alternate in parallel, guides in learning an effective study and learning method.

Contents

The course offers an introduction to multimedia signals (images, video and audio), and signals coming from wearable devices, presenting the main methods of acquisition, digitizing and encoding. The course is divided into two parts: the first part analyzes the analog to digital conversion in particular by introducing the concepts of sampling and quantization, and presents digital signal processing through linear time invariant systems.
The second part focuses on specific aspects: the use of physical and physiological signals coming from werable devices in human machine interaction applications, and intelligent systems, and describes the main methods of lossy and lossless compression, applied in particular to audio, image and video signals.

Detailed program

1. Definition of one-dimensional signals, tw-dimensional signals, N-dimensional signals

- Analog signal
- Digital signal
- Media, variance, energy and power
- Noise

2. Signal in the transformed domain: Fourier Transform

- Fourier series for periodic signals
- Fourier transform for continuous signals
- Fourier transform for discrete time signals
- Discrete Fourier transform for discrete time signals
- Convolution theorem

3. Analog to digital conversion

- sampling theorem
- Filter Anti-Aliasing
- Quantization
- SNR quantization

4 Linear time invariant Systems (LTI)

- Definitions
- input / output equation
- Impulse response
- Equation differences

5. z-transform

- Convergence and convergence region.

- Relationship with the Fourier transform.
- Analysis of LTI systems with z-transform
- diagram poles-zeros, stability and physical feasibility of a LTI system.
- Design FIR and IIR systems through placement of poles and zeros

6. Audio signals, images and video: sampling and quantization, quantization SNR

7. Time-frequency analysis

- spectrogram
- Filter bank
- Wavelet Transform

8.Physical and physiological signals applied in human machine interaction and intelligent system applications

- photopletismography, electroencefalography, respiration, skin conductance, elettromyography
- application in human machine interfaces and intelligent systems: affective computing, ambient assisted living, biometrics, brain computer interfaces.

9. Compression

- Main compression loss-less and lossy algorithms
- Audio Compression
- Image Compression (particularly JPEG)
- Video Compression (in particular MPEG)
- Main image Formats
- Analysis of signal quality

Prerequisites

No prerequisite. The knowledge of some basic concepts of Mathematical Analysis and Programming 1 is useful.

Teaching form

The course consists of 48 hours of lectures and 24 hours of laboratory activities where theoretical concepts will be translated into practical exercises.
Of the 48 face-to-face hours, 36 hours will be of didactic teaching and 12 hours of interactive teaching, with exercises, examples and case studies discussed with the students.

The 24 laboratory hours will all be interactive teaching. During the laboratory activities, some exercises using matlab will be presented and carried out together with the students. Assignments, explained and guided during the laboratory lectures, will be scheduled duringthe course.

Lectures and exercises are given in Italian and in presence.

Textbook and teaching resource

Textbooks:

- Marco Luise, Giorgio Matteo Vitetta, Giacomo Bacci, TEORIA DEI SEGNALI 4/ED 8838613117 · 9788838613111, Mc Graw Hill

Deeping texts:
-R.Gonzalez, R. Woods, Digital Image Processing, Pearson International Edition

- Proakis & Manolakis, Digital Signal Processing.
- Video Processing and Communications, Yao Wang, Jorn Ostermann, Ya-QuinZhang.
- Introduction to Data Compression, K.Sayood

Slides projected during the lectures.

Text of exams and exercises

Semester

primo semester

Assessment method

Examination:
Written and oral exam + practical activities

Evaluation Type:
Final mark out of thirty

Written and oral exam:
The exam consists of two parts. The first part is a written exam. It consists of exercises on digital signal processing, similar to those explained during the course.
The second part (oral) consists of open questions about digitalization and compression and applications of phisical and physiological signals in human machine interaction systems. This part verifies the competencies acquired and it is based on what taught during the lessons, available on the slides and on the indicated text books.
Maximum mark is 30/30.

The assignments carried out during the practical activities will provide further 2 points for the final exam. These points remain valid for the academic year in which the teaching is delivered. **Four assignments are mandatory**.

Final score
The maximum cumulative score of the written and oral parts is 30/30.
The single part is considered passed if it received a score >=15.
The final grade is the average grade when both parts (written and oral) are passed (both >=15) and the exam is passed if the average is >=18.
The final grade is the sum of the grade obtained from the average of written and oral parts plus any points from the lab tests.

Two partial tests are scheduled
The first partial test is scheduled at about half of the lessons, the second at the end of the course.

The first test is about exercises on digital signal processing and it has a maximum mark of 30/30
The second one is oral, and it consists of open questions about digitalization and compression of multimedia signals, and applications of physiological and physical signals and it has a maximum mark of 30/30.

The single test is considered passed if it has received a score >=15. The final mark is the average of the two parts (both of them >=15). This part of the exam is passed if this average is >=18.

The final mark is the average of the marks of the written and oral exam plus the eventual extra points for the practical activities.
If one of the two parts is not carried out (absent or withdrawn student) or if it is not sufficient it coud be pass during the scheduled exams.

Office hours

Friday from 11.00 to 12.00.

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE