UNIVERSITÀ DI PAVIA

Anno Accademico 2021/2022

BIOSIGNALS AND BIOIMAGES PROCESSING

Enrollment year	2019/2020
Academic year	2021/2022
Regulations	DM270
Academic discipline	ING-INF/06 (ELECTRONIC AND INFORMATION BIOENGINEERING)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	BIOENGINEERING
Curriculum	PERCORSO COMUNE
Year of study	3°
Period	1st semester (27/09/2021 - 21/01/2022)
ECTS	12
Lesson hours	110 lesson hours
Language	Italian
Activity type	WRITTEN TEST
Teacher	MAGENES GIOVANNI (titolare) - 10 ECTS MATRONE GIULIA - 2 ECTS
Prerequisites	Basics of Calculus, Physics, Control Theory and Electronics
Learning outcomes	The course aims at providing students with the basic methodological tools to face problems of signal and image processing, with particular reference to those related to clinical diagnosis. The course is mainly methodological, so it is necessary that the student is able to manage with friendlyness mathematical and physical basics in order to address the topics. There is also a technological part on signal conditioning by means of operational amplifiers and on technologies for biomedical image acquisition and reconstruction. In the methodological part the student will acquire the knowledge for basic processing of more general use: the relationship between dynamic models in continuous time (analog) and discrete-time

	numerical calculations in environment (digital), the basics of the frequency description of signal and image processing in this domain (filtering), both analog and digital design methods of linear digital filters; image reconstruction (2D, tomographic, 3D), image processing methods (filtering, analysis, segmentation, edge detection, etc.) In the technological part the student will acquire the knowledge to condition analog electrical signals by means of operational amplifiers and filters; to understand the physical principles and methods of image formation by means of ionizing electromagnetic radiations, magnetic resonance, ultrasounds, radioisotopes, etc .. ; to buid up a basic knowledge of the fundamental components for instrumentation dedicated to bioimaging.
Course contents	1. Introduction to biosignals and biomedical images with examples. 2. Analog signals and systems: summary of the Fourier transform and the Laplace transform; frequency response and Bode plots; conditioning and analog filtering using operational amplifiers. 3. Signals and discrete systems: sampling of signals, Sampling theorem (Shannon), reconstruction of a sampled signal, A / D conversion and quantization; discrete time signals and sequences, signals originating from invariant linear systems; Discrete Time Fourier Transform; Z-transform for sampled signals; inverse Z-transform. 4. Digital signal conditioning: non-recursive digital filters (FIR); synthesis of derivative filters; frequency response and design of FIR filters (time windows, frequency sampling, zero placement) ; recursive filters (IIR); synthesis of IIR filters from analog filters; elimination of network interference, notch filter; notes on the accuracy of the FIR and IIR filters; optimization of digital filters (laboratory). 5. Spectral analysis: introduction to autoregressive models; power spectra and energy spectra; spectrum estimation by numerical methods. 6. Bioimaging: historical introduction to biomedical images; classification of biomedical images; Psychophysocs and image perception; characterization of imaging systems; sampling of an image 7. Treatment of digital images: image enhancement, punctual operators, local and global operators, contrast enhancement; binary images and contour tracking, mathematical morphology operators. automatic image analysis. Hough transform and generalized HT. 8. Current diagnostic technology: ionizing radiation and X-ray images, CT images, nuclear medicine images, ultrasound, magnetic resonance imaging, functional images. Interpretation of the images for diagnostic and therapeutic purposes. 9. Reconstructive methods, compression and storage: sampling on grids, reconstruction, interpolation, projection theorem and Radon transform; encoding and transmission of images, PACS, DICOM.
Teaching methods	Lectures with exercises in computer rooms for the use of specific software
Reccomended or required readings	1. Willis J. Tompkins “Biomedical Digital Signal Processing”, Prentice Hall, 1993. 2. A.V. Oppenheim & R.W.Schaefer “Elaborazione numerica dei segnali” , Franco Angeli, 3. Valli G., Coppini G., “Bioimmagini”, Patron, 2002

	4. Webb A., “Introduction to Biomedical imaging”, IEEE Press, 2003 5. Semmlow J.L., “Biosignal and Medical Image Processing”, CRC Press, 2009.
Assessment methods	The exam will consist of a test to be carried out in a computer classroom (B2, C2-C3 or D8). The test will include written exercises, computer exercises using the specific software used in the course and theory questions.
Further information	
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile