Universidad de Navarra

Signal Processing (Ing.Gr.)
Teaching guide 2026-27

INTRODUCTION

Course description:

Digital signal processing is ubiqutous in biomedicine because by extracting meaningful information we can learn about the health of a patient from the many signals that can be acquired non-invasively from the human body, e.g. electroencephalogram (EEG) to assess neural activity, electrocardiogram (ECG) to estimate cardiac rhythm and detect possible pathologies, electromyography (EMG) that is related to muscle movement, and other physiological activities. This course covers representation of signals and systems in time and frequency domain to allow for 1) efficient removal of interferences through filtering and 2) extraction of useful information about patient's state. The course also covers techniques commonly used in biomedical image analysis and processing with application to images acquired through Computed Tomography (CT) and Magnetic Resonance Imaging (MRI).

Degree (Módulo/Materia):

- Biomedical Engineering (Fundamentos de Ingeniería/Electrónica y Señal)

Module in the Degree Program:

- **Number of credits**: 6 ECTS
- **Year**: Third, 1st semester
- **Type of course**: Required
- **Language**: English

Instructors:

- Podhorski, Adam / Profesor Contratado Doctor

LEARNING OUTCOMES (Competencies)

BIOMEDICAL ENGINEERING

CG3 - This course will provide graduate students with the necessary technological knowledge that allows them to address problems in the field of Biomedical Engineering.

CG4 - Graduate students will be trained to carry out a unified scientific treatment in matters related to biology and medicine.

CG5 - This course is to train professionals capable of applying the concepts of engineering to the fields of biology and health.

CE4 - Students will learn to identify the engineering concepts that can be applied in the field of biology and health.

CE11 - Students will study the particularities of biomedical images and data with respect to processing and treatment.

PROGRAM

Universidad de Navarra

Part I: Signal processing

Topic 1. Introduction

Topic 2. Signals

Topic 3. Linear time-invariant systems, convolution

Topic 4. Systems represented by linear constant-coefficient difference equations

Topic 5. Frequency-domain representation of signals and systems

Topic 6. Sampling and quantisation

Topic 7. Filtering

Topic 8. Analysis and processing of signals in the frequency domain

Part II: Image processing

Topic 9. Image representation

Topic 10. Image enhancement

Topic 11. Image filtering

Topic 12. Image registration

Topic 13. Image segmentation

EDUCATIONAL ACTIVITIES

The theoretical developments are accompanied by a number of labs in which specific signal processing tasks are performed to put the theoretical concepts into practice with Matlab, Signal and Image Processing Toolboxes as the tools.

The workload of 150-180h (6 ECTS) is divided into the following educational activities:

- Lectures
- Preparation of the labs
- Labs in Computer Rooms
    - Personal study
- Exams

ASSESSMENT

FIRST CALL

The assessment is based on the activity in class, lab reports, and in-term written exams. There is no final exam.

- In-class activity: 10%
- 5 labs: 60% in total
- 3 in-term exams (1h15m each): 30% in total,10% each

- The 3rd exam is during the exam period

SECOND CALL

The assessment is based on:

- Exam: covering the entire course material, including classes and labs. Both, theoretical and practical problems are included (5 hrs), 100% of the final grade.

OFFICE HOURS

Dr. Adam Podhorski (apodhorski@unav.es)

- Office D20. Building Ibaeta. Floor 1.
- By appointment.

BIBLIOGRAPHY AND RESOURCES

Part I: Biomedical signal processing

Basic bibliography:

- Alan V. Oppenheim, Alan S. Wilsky with S. Hamid Nawab, *Signals and Systems*, 2nd ed., Prentice Hall, 1997. Find the book in the library

Oppenheim-Willsky---Signals-and-Systems---book-cover.jpg

Part II: Biomedical image processing

Basic bibliography:

- R. C. González, R. E. Woods, “Digital Image Processing”, Addison-Wesley, 2002. Find the book in the library

R. C. González, R. E. Woods, “Digital Image Processing”, Addison-Wesley, 2002.jpg

Additional bibliography:

- A. K. Jain, “Fundamentals of Digital Image Processing,” Prentice Hall, 1989. Find the book in the library
- M. Sonka, V. Hlavac, R. Boyle, “Image Processing, Analysis and Machine Vision,” 3rd ed., Thomson-Engineering.
- R. M. Rangayyan, “Biomedical Image Analysis,” CRC Press, 2004. Find the book in the library