Course guide 295623 – 295MB022 – Digital biomarkers and artificial intelligence in healthcare

Responsible unit:	295 – Barcelona East School of Engineering (EEBE)		
Department:	707 – Automatic Control Department (ESAII)		
Degree	Master in Advanced Biomedical Technologies		
Academic year	2025	**ECTS credits**	6
Languages	Spanish	**Type**	Mandatory

FACULTY

Responsible faculty:	Lozano García, Manuel
Other:	Torres Cebrián, Abel

COURSE PRESENTATION

This course presents a set of fundamental concepts to introduce students to the world of digital biomarkers and artificial intelligence (AI) in healthcare. It will provide an overview of the technical and ethical aspects of AI projects in the health sector and will provide basic knowledge of programming and data processing for the extraction of digital biomarkers and the development of AI models and their application in the diagnosis and monitoring of several pathologies.

PREVIOUS SKILLS

Prior knowledge of:

- Fundamentals of physiology and biology
- Biomedical signal processing and analysis

It is recommended to have passed the subject Biomedical Signal Analysis in the first semester.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

- C1 - Integrate in work teams, participate and assume responsibilities in production management, either as a regular member or carrying out management or leadership tasks.
- C2 - Apply the appropriate methodologies for managing projects and biomedical equipment, products and technologies, depending on the type of project.
- C3 - Identify and analyse problems that require autonomous, informed and argued decision-making, in order to act with social responsibility, following ethical values and principles.
- C4 - Solvent use of information resources, managing the acquisition, structuring, analysis and visualisation of data and information in the field of their speciality and critically assessing the results of this management.
- C5 - Use scientific-technical information to respond to any demand for modification, innovation or improvement of devices, products and processes linked to biomedical engineering for new scientific or technological applications.
- C6 - Integrate the values of sustainability, understanding the complexity of systems, in order to undertake or promote actions that establish and maintain the health of ecosystems and improve justice, thus generating visions for sustainable futures.

LEARNING OBJECTIVES

- Acquire and apply advanced knowledge in digital biomarkers and IA techniques in health technologies.
- Identify and propose digital biomarkers through advanced biomedical signal analysis and IA techniques.

TEACHING METHODOLOGIES

The course uses the following methodologies:

- Participative lectures
- Laboratory sessions
- Independent work
- Cooperative group work
- Debates
- Case studies and discussion of scientific articles
- Project-based learning

OVERALL STUDENT DEDICATION HOURS

Type	Hours	Percentage
Large group hours	30	20 %
Small group hours	30	20 %
Autonomous learning hours	90	60 %
Overall dedication:	150 h	

CONTENTS

Theme 1: Introduction to digital biomarkers

Description:

- Definition of digital biomarker
- Conventional biomarkers VS digital biomarkers
- Types of digital biomarkers

- Biomedical data acquisition. Wired devices and wireless/wearable devices
- Examples of digital biomarkers in healthcare

Related activities:
Case studies and discussion of scientific articles
Final exam

Dedication:
Large group/Theory: 3h
Guided activities: 3h
Autonomous learning: 4h

Theme 2:	Digital biomarkers and biomedical signals

Description:
- Biomedical signals: electrocardiogram, electromyogram, electroencephalogram, etc.
- Noise and pre-processing of biomedical signals.
- Characterisation of biomedical signals: feature engineering and parameter extraction. Temporal, frequency, time-frequency and statistical parameters. Principal component analysis (PCA) for the characterisation of biomedical signals.

Related activities:
Collaborative project
Laboratory sessions
Case studies and discussion of scientific articles
Final exam

Dedication:
Large group/Theory: 6h
Guided activities: 6h
Autonomous learning: 20h

Theme 3:	Data preparation

Description:
- Data exploration and visualisation: distribution, histograms, boxplots, scatter plots, etc.
- Data transformation
- Feature selection: variance, correlation, information, PCA for feature selection

Related activities:
Collaborative project
Laboratory sessions
Case studies and discussion of scientific articles
Final exam

Dedication:
Large group/Theory: 6h
Guided activities: 6h
Autonomous learning: 20h

Theme 4:	Introduction to AI in healthcare

Description:
- Big data in health and AI
- Types of AI models
- Applications of AI in health
- Ethical and legal aspects of AI in healthcare
- AI in Python

Related activities:
Laboratory sessions
Case studies and discussion of scientific articles
Final exam

Dedication:
Large group/Theory: 3h
Guided activities: 3h
Autonomous learning: 6h

Theme 5:	Machine Learning models

Description:
- Supervised models: logistic regression, Support Vector Machine (SVM), k-Nearest Neighbour (kNN), decision tree, random forest, XGBoost, artificial neural networks (ANN)
- Unsupervised models: k-means clustering
- AI in Python

Related activities:
Collaborative project
Laboratory sessions
Case studies and discussion of scientific articles
Final exam

Dedication:
Large group/Theory: 6h

Guided activities: 6h
Autonomous learning: 20h

Theme 6:	Deep Learning models

Description:
- Convolutional neural networks
- Recurrent neural networks
- AI in Python

Related activities:
Collaborative project
Laboratory sessions
Case studies and discussion of scientific articles
Final exam

Dedication:
Large group/Theory: 6h
Guided activities: 6h
Autonomous learning: 20h

ACTIVITIES

- Collaborative project:
  - To be carried out in groups of 3 people
  - It will be defended by means of an oral presentation at the end of the course
  - A technical report in the form of a scientific article of between 4 and 7 pages will also be handed in, together with the code files that have been generated
- Laboratory sessions:
  - Sessions of 2 hours/week
  - Sessions will be carried out in groups of 2 persons
  - Practices will cover 2 or 3 consecutive sessions; a report per pair will be handed in at the end of these sessions, detailing the objectives, activities and results achieved
  - The different theoretical concepts presented in the theoretical classes will be put into practice
- Case studies and discussion of scientific articles:
  - The critical analysis of scientific articles will be considered and will be assessed by means of one of the following activities:
    - Written tests carried out in class
    - An oral presentation in which the main findings, conclusions and proposals for application are presented
- Final exam

RATING SYSTEM

Collaborative project = 30%
Laboratory reports = 30%
Discussion of scientific articles = 15%
Final exam = 25%

Details
There will be no re-evaluation exam in this course, by virtue of the continuous evaluation system and the formative monitoring established in the academic regulations.

BIBLIOGRAPHY

- Jyotismita Talukdar, Thipendra P. Singh, Basanta Barman. Artificial Intelligence in Healthcare Industry. Series: Advanced Technologies and Societal Change. Springer Singapore. 1st edition. DOI: 10.1007/978-981-99-3157-6
- Adam Bohr, Kaveh Memarzadeh. Artificial Intelligence in Healthcare. Academic Press. ISBN: 978-0-12-818438-7
- Walid Zgallai. Biomedical Signal Processing and Artificial Intelligence in Healthcare. Academic Press. ISBN: 978-0-12-818946-7
- Maria Deprez, Emma C. Robinson. Machine Learning for Biomedical Applications. With Scikit-Learn and PyTorch. Academic Press. 1st edition. ISBN: 9780128229057

RESOURCES

Other resources:
Learning resources available in ATENEA (digital campus of the Universitat Politècnica de Catalunya - UPC)
Software: Matlab, Python
Biomedical databases
Biomedical Engineering Laboratory (A8.2)