Digitalisation, Data Science and Machine Learning in Water Engineering (250MAG001)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA DE L'AIGUA (pla 2025)
Course	2025/26

Main teaching language at each group

- Group 10Q1 English (Q1)

Faculty

Responsible Faculty: Pedro Diez Mejia
Faculty: Pedro Diez Mejia, Alberto Garcia Gonzalez, David Modesto Galende

Objectives of Education

Specialization subject where knowledge in specific skills is intensified. Knowledge at a specialization level that should allow the development and application of advanced techniques and methodologies. Master's level specialization contents related to research or innovation in the field of engineering.

This subject aims to provide an insight into the possibilities offered by machine learning techniques, digitalization and artificial intelligence in disciplines related to water engineering.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	45.0 h	100.00 %
	Medium group	0.0 h	0.00 %
	Laboratory classes	0.0 h	0.00 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

Introduction and reminder of fundamental concepts.

Data sets and basic concepts of probability and statistics.
Functional approximation and linear regression.
Overdetermined linear systems, eigenvalues and singular values

Data complexity. Dimensionality reduction

Large data sets, redundancy and optimal representation. Features that describe the phenomenon optimally.
Linear dimensionality reduction, PCA.

Nonlinear dimensionality reduction.
Stochastic field reduction, Karhunen-Loève
Applications to water engineering

Response Functions and Surrogate Models

Advanced Linear Regression with Statistics
Gaussian Regression: Kriging
Neural Network Approximation
Applications to Water Engineering

Clustering and classification

Unsupervised Learning: k-means clustering
Hierarchical Supervised Learning: Dendogram
Supervised Learning and Linear Discriminants
Support Vector Machines (SVM)
Classification Trees and Random Forests Clustering: k-means, dendogram…
Logistic Regression
Applications in Water Engineering

Teaching Methodology

The course consists of 4 hours per week of classroom activity.
Two hours are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.
Two hours are devoted to problem-solving using specific software with increased interaction with students.
Practical exercises are conducted to consolidate the general and specific learning objectives.

Grading Rules

(*) The evaluation calendar and grading rules will be approved before the start of the course.

Practical exercises proposed and solved in class (30% of the grade)
Final exam to evaluate the knowledge obtained (70%)

Office Hours

To be agreed with the student. You must make an appointment in advance.

Bibliography

Basic

- Bishop, Christopher M. Pattern recognition and machine learning. New York: Springer, cop. 2006. ISBN 0387310738.
- Brunton, Steven L; Kutz, Jose Nathan. Data-driven science and engineering : machine learning, dynamical systems, and control. 2nd ed. Cambridge: Cambridge University Press, 2022. ISBN 9781009098489.