

FICHA TÉCNICA DE LA ASIGNATURA

Datos de la asignatura	
Nombre completo	Optativa Complementaria. Machine Learning for Engineers
Código	DOI-OPT-614
Impartido en	Máster Universitario en Ingeniería Industrial + Máster en Medioambien. y Gest. Intel. de la Energía [Segundo Curso] Máster Universitario en Ingeniería Industrial y Máster Universitario en Administración de Empresas [Segundo Curso] Máster Universitario en Ingeniería Industrial [Segundo Curso] Máster Universitario en Ingeniería Industrial y Máster Universitario en Administración de Empresas [Segundo Curso]
Nivel	Postgrado Oficial Master
Cuatrimestre	Semestral
Créditos	6,0 ECTS
Carácter	Optativa
Departamento / Área	Departamento de Organización Industrial
Responsable	Susana Ortiz Marcos
Horario de tutorías	Solicitar cita previa

Datos del profesorado	
Profesor	
Nombre	Pablo Carlos del Saz-Orozco Huang
Departamento / Área	Departamento de Electrónica, Automática y Comunicaciones
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DATOS ESPECÍFICOS DE LA ASIGNATURA

Contextualización de la asignatura
<p>Aportación al perfil profesional de la titulación</p> <p>The purpose of this course is to provide students with a fundamental understanding and an extensive practical experience of how to extract knowledge from an apparently unstructured set of data. By the end of the course, students will:</p> <ul style="list-style-type: none"> Understand the basic principles behind machine learning. Have practical experience with the most relevant machine learning algorithms. Have well-form criteria to choose the most appropriate techniques for a given application.
<p>Prerequisitos</p> <p>Students willing to take this course should be familiar with linear algebra, basic probability and statistics, machine learning, and undergraduate-level programming. Previous experience with python programming language is also desired although not strictly required.</p>

Competencias - Objetivos

Competencias

General Competences

- Have acquired advanced knowledge and demonstrated, in a research and technological or highly specialized context, a detailed and well-founded understanding of the theoretical and practical aspects, as well as of the work methodology in one or more fields of study.
- Know how to apply and integrate their knowledge, understanding, scientific rationale, and problem-solving skills to new and imprecisely defined environments, including highly specialized multidisciplinary research and professional contexts.
- Know how to evaluate and select the appropriate scientific theory and the precise methodology of their fields of study in order to formulate judgements based on incomplete or limited information, including, when necessary and pertinent, a discussion on the social or ethical responsibility linked to the solution proposed in each case.
- Be able to predict and control the evolution of complex situations through the development of new and innovative work methodologies adapted to the scientific/research, technological or specific professional field, in general multidisciplinary, in which they develop their activity.
- Be able to transmit in a clear and unambiguous manner, to specialist and non-specialist audiences, results from scientific and technological research or state-of-the-art innovation, as well as the most relevant foundations that support them.
- Have developed sufficient autonomy to participate in research projects and scientific or technological collaborations within their thematic area, in interdisciplinary contexts and, where appropriate, with a high knowledge transfer component.
- Being able to take responsibility for their own professional development and their specialization in one or more fields of study.

Specific Competences

- Be able to design and train systems that learn automatically, mastering both supervised and unsupervised learning techniques. Understand the potential application of these systems in the improvement of industrial processes, relations with clients, etc.

Resultados de Aprendizaje

By the end of the course students should:

- RA1. Understand the basic principles behind machine learning.
- RA2. Have practical experience with the application of the most relevant machine learning algorithms.
- RA3. Have well-formed criteria to choose the most appropriate techniques for a given application.

BLOQUES TEMÁTICOS Y CONTENIDOS

Contenidos – Bloques Temáticos

Theory and laboratory

Unit 1. Introduction

1. Data mining & machine learning
2. The learning process
3. Smart industry levers and drivers
4. Types of machine learning



Unit 2. Generalities of an end-to-end machine learning project.

1. The big picture of a ML project
2. Performance metrics.
3. Visualize the data for gaining insights.
4. Prepare the data for your project.
5. Select, train and tune your model.

Unit 3. Generalized linear and basic models.

1. Linear Regression.
2. Logistic Regression.
3. Regularization.
4. K-Nearest Neighbors.

Unit 4. Moving beyond linearity.

1. Polynomial regression.
2. Splines.
3. Generalized additive models.
4. Linear discriminant analysis.

Unit 5. Tree based models

1. Theoretical background.
2. Splitting criteria.
3. Estimating probabilities.
4. Hyperparameter implications.

Unit 6. Ensemble methods

1. Bagging vs Boosting.
2. Random Forest.
3. Adaboost.
4. XGboost.

Unit 7. Support vector Machines

1. Linear SVM.
2. Kernelized SVM.

Unit 8. Time series forecasting

1. Stochastic processes
2. Exponential smoothing
3. Decomposition methods
4. ARIMA models
5. Dynamic regression models

Unit 9. Artificial Neural Networks



1. Multilayer perceptrons
2. Recurrent Neural Networks
3. Convolutional Neural Networks

Unit 10. Unsupervised learning

1. Dimensionality reduction methods
2. Clustering
3. Self-organizing maps

METODOLOGÍA DOCENTE

Aspectos metodológicos generales de la asignatura

Each session will combine theory and practice. The instructor will explain the basics of the subject and will go into depth in the more important issues with illustrative examples. Students will be grouped in order to put the proposed methods and techniques in practice in a collaborative way.

Metodología Presencial: Actividades

Lectures: The lecturer will introduce the fundamental concepts of each unit, along with some practical recommendations, and will go through worked examples to support the explanation. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class either on paper or using a software package.

CG1, CG3, CG7, CE3

Lab sessions: Under the instructor's supervision, students, divided in small groups, will apply the concepts and techniques covered in the lectures and will become familiar with the practical application of the most relevant algorithms using software tools and libraries.

CG1, CG2, CG3, CG4, CG5, CG6, CG7, CE3

Tutoring for groups or individual students will be organized upon request.

Metodología No presencial: Actividades

Personal study of the course material and resolution of the proposed exercises.

CG1, CG3, CG7, CE3

Lab session preparation, analysis of the results and report writing.

CG1, CG2, CG3, CG4, CG5, CE3

RESUMEN HORAS DE TRABAJO DEL ALUMNO





IN-CLASS HOURS

Lectures	Lab Sessions	Assessment
28	28	4

OUT-OF-CLASS HOURS

Self-study	Lab preparation	Reporting
60	50	10

ETC credits	6 (180 hours)
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EVALUACIÓN Y CRITERIOS DE CALIFICACIÓN

Calificaciones

Regular assesment

- Theory will account for 50%, of which:
 - Midterm: 15%
 - Final exam: 35%
- Lab will account for the remaining 50%

In order to pass the course, the weighted average mark must be greater or equal to 5 out of 10 points, and the mark of the final exam must be greater or equal to 4 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Retake

Lab marks will be preserved. In addition, all students will take a final exam. The resulting grade will be computed as follows:

- Final exam: 50%
- Lab practices: 50%

As in the regular assessment period, in order to pass the course, the weighted average mark must be greater or equal to 5 out of 10 points, and the mark of the final exam must be greater or equal to 4 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Course rules

- Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:
 - Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.
 - Regarding laboratory, absence to more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit.



- Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

BIBLIOGRAFÍA Y RECURSOS

Bibliografía Básica

- Slides prepared by the lecturer (available in Moodlerooms).
- G. James, D. Witten, T. Hastie, and R. Tibshirani, *An Introduction to Statistical Learning with Applications in python*, Springer, 2023.
- A. Géron-Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow. Second. O'Reilly Media, Inc.. 2019
- S. Raschka, V. Mirjalili.-Python Machine Learning. Third Edition, 2019
- R. J. Hyndman , G. Athanasopoulos- Forecasting: principles and practice, 3rd edition, OTexts, 2021
- B. Auffarth- Machine Learning for time-series with python. Packt Publishing 2021

Bibliografía Complementaria

- M. Deisenroth, A. Faisal, C.S. Ong.-Mathematics for Machine Learning. First edition. Cambridge University Press. 2020
- C. M. Bishop. -Pattern Recognition and Machine Learning. First. Springer-Verlag New York Inc. 2007
- G. Bonaccorso. Hands-On Unsupervised Learning with Python. First. Packt. 2019
- T. Hastie, . Tibshirani, J.Friedman-The Elements of Statistical Learning. Second edition. Springer. 2017
- A. Burkov -The Hundred-Page Machine Learning Book. 2019
- A. Burkov.-Machine Learning Engineering. Andriy Burkov. 2020
- A. A. Patel. -Hands-On Unsupervised Learning Using Python: How to Build Applied Machine Learning Solutions. O'Reilly Media, 2019