Project/Course Programme

Name of the course	Fundamentals of machine learning		
Subject / branch of study	Fundamentals of machine learning		
Module	Basic		
Degree	International Courses Offered in E.T.S.I. Telecomunicación		
Study Plan	907	**Code**	75097
Teaching Period	Autumn/Winter Semester	**Category**	Elective
Level		**Course Year**	1st
ECTS Credits	6 ECTS		
Language of instruction	English		
Responsible teacher/s	Dr. Ignacio de Miguel Jiménez Dra. Noemí Merayo Álvarez Dr. Ramón J. Durán Barroso		
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Department	Signal Theory, Communication and Telematic Engineering		

1. Presentation

1.1 Contextualization

Machine learning is a set of techniques that allow a computer to be able to learn from data. This type of techniques is taking a great relevance in engineering and research. The course analyzes basic aspects of machine learning such as generalization theory, the effects of errors and noise, the trade-off between bias and variance, the risks associated with machine learning (and how to avoid them), in addition to the techniques of model validation. The subject also studies and applies various supervised learning techniques (linear models, neural networks, SVM, ...) and unsupervised learning. Moreover, the course gives an introduction to Python programming language (including NumPy, pandas, scikit-learn and matplotlib) and its use for machine learning techniques.

1.2 Relationship with other courses within the subject and/or module

There is a very close relationship with the subjects of the transversal elective block of the Máster en Investigación en Tecnologías de la Información y las Comunicaciones: “Aprendizaje Automático Avanzado”, “Arquitecturas Paralelas y Deep Learning” y “Fundamentos de Big Data”. Those courses are taught in Spanish.

1.3 Prerequisites

Good knowledge in maths and basic programming skills.

2. Competencies

2.1 General Competencies

- Critical capacity towards current knowledge as an essential means for detecting new challenges to be solved and therefore critically and constructively evaluating the research results of others. [CG 1]
- Ability to analyse and to apply the specific technical knowledge of their area in new environments and contexts, taking into account the most significant parameters and variables of each new situation. [CG 5]
- Ability to know and to use techniques and tools related to modelling, simulation, experimentation and validation of technical proposals, as well as to evaluate them through established parameters of goodness. [CG 10]
- Ability to develop the ability to learn and work in groups both in known and restricted environments, as well as in international consortia in which cultural factors intervene. [CG 11]
- Ability to continue in lifelong learning through the assimilation of the techniques and attitudes of autonomous and self-directed work. [CG 13]
- Ability to use at least one foreign language, preferably English, as a means of oral and written communication within their participation in the international scientific-technological community. [CG 14]

2.2 Specific Competencies

- Ability to understand the basic theory of machine learning and its practical implications in system design. [CE-AD 2]
- Ability to describe and apply various machine learning models. [CE-AD 3]
- Ability to describe and to apply optimization, regularization, validation and aggregation techniques in the development of systems based on machine learning. [CE-AD 4]
- Ability to use the most relevant methods and parameters for the evaluation and validation of data analysis models in each specific case. [CE-AD 5]
- Ability to describe the fundamental concepts associated with the areas of data analysis and Big Data. [CE-AD 6].

3. Objectives

At the end of the course the student must be able to:

- Explain what machine learning is and enumerate the type of machine learning types.
- Describe the basic theory of machine learning and its practical implications in system design.
- Describe and apply various models of supervised and unsupervised machine learning.
- Describe and apply regularization, validation and aggregation techniques in the development of systems based on machine learning.
- Implement systems based on machine learning using Python.

4. Contents and/or thematic modules

Thematic module 1: Fundamentals of Machine Learning

Workload in ECTS credits: 6.0

a. Contextualization and justification

The same shown in section 1.1

b. Learning objectives

The same shown in section 3

c. Contents

- LESSON 0: Presentation and introduction to Python
- LESSON 1: Introduction to machine learning
- LESSON 2: Is it feasible to learn? (First part)
- LESSON 3: The linear model: Classification and linear regression
- LESSON 4: Is it feasible to learn? (Second part)
- LESSON 5: The linear model: Logistic regression
- LESSON 6: Regularization
- LESSON 7: Validation
- LESSON 8: Neural networks
- LESSON 9: Support vector machines (SVM)
- LESSON 10: Decision trees
- LESSON 11: Some aspects to take into account in the design of supervised learning systems
- LESSON 12: Clustering
- LESSON 13: Dimensionality reduction
- LESSON 14: Recommender systems
- LESSON 15: Association rules

d. Teaching method

- Participative master classes
- Resolution of practices using Python (Students must have their own laptop and install Anaconda software).

e. Working plan

See Annex I (which will be delivered at the beginning of the course).

f. Assessment

The evaluation of the acquisition of competences will be based on:

- Assessment of the attitude and participation of the student in the training activities
- Resolution of practices by the student

g. Basic bibliography

- Y.S. Abu-Mostafa, M. Magdon-Ismail and H.T. Lin, Learning from Data: A Short Course, Amlbook.com, 2012.
- M. Kuhn and K. Johnson, Applied Predictive Modeling, Springer, 2016.

h. Complementary bibliography

- T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition. Springer 2009.
- I.H. Witten, E. Frank, M.A. Hall and C.J. Pal, Data Mining: Practical Machine Learning Tools and Techniques, Fourth Edition, Morgan Kaufmann, 2016.
- R.D. Peng, R Programming for Data Science, Leanpub 2018.

i. Resources

The following resources will be required:

- Work environment in the Moodle platform: Campus Virtual of the Universidad de Valladolid.
- Documentation, including complementary readings and educational videos.
- Computer and software environment Anaconda.

j. Timing

ECTS LOAD	EXPECTED PERIOD FOR IMPLEMENTATION
Fundamentals of Machine Learning	Autumn/Winter Semester

5. Teaching method and methodological principles

- Participative master class
- Resolution of practices using Python (Students must have their own laptop and install Anaconda software).

6. Table of estimated dedication time of the student to the course

CLASS ACTIVITIES	Number of hours	OUT OF CLASS ACTIVITIES	Number of hours
Theoretical-practical classes (T / M)	30	Individual self-study and work	90
Laboratories (L)	30		
Total	**60**	**Total**	**90**

7. Assessment

Assessment instruments	FINAL GRADE percentage	Observations
Assessment of lab exercises	90%	
Assessment of the attitude and participation of the student in the training activities	10%	

Assessment Criteria

• **Ordinary call:**
  ○ Student must get 50% among both categories to pass.
  ○ The best student will be granted with class honours if she/he gets more than 90%.
• **Extraordinary call:**
  ○ The assessment of the second category of previous table is maintained.
  ○ Student must get 50% among both categories to pass.

8. Final considerations

Annex I, where detailed planning is described, will be delivered at the beginning of the course.