



POLITÉCNICA

INTERNATIONAL
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COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



E.T.S. de Ingenieros de
Telecomunicacion

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000943 - Machine Learning Lab

DEGREE PROGRAMME

09AT - Master Universitario en Teoría de la Señal y Comunicaciones

ACADEMIC YEAR & SEMESTER

2020/21 - Semester 1

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1. Description

1.1. Subject details

Name of the subject	93000943 - Machine Learning Lab
No of credits	4.5 ECTS
Type	Optional
Academic year of the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	09AT - Master Universitario en Teoría de la Señal y Comunicaciones
Centre	09 - Escuela Técnica Superior de Ingenieros de Telecomunicación
Academic year	2020-21

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Luis Alfonso Hernandez Gomez (Subject coordinator)	C-330	luisalfonso.hernandez@upm.es	Sin horario. Appointment arranged by email
Eduardo Lopez Gonzalo	C-330	eduardo.lopez@upm.es	Sin horario. Appointment arranged by email

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Aprendizaje Predictivo Y Descriptivo

3.2. Other recommended learning outcomes

- It is highly recommended to follow this course simultaneously with the subject Predictive and Descriptive Learning unless you have a theoretical background in Machine Learning and Deep Learning
- Previous exposure to a programming language, such as MATLAB, R or Python

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB07 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB08 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CB09 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo

CE01 - Analizar y aplicar técnicas para el diseño y desarrollo avanzado de equipos y sistemas, basándose en la teoría de la señal y las comunicaciones, en un entorno internacional

CE02 - Evaluar y sintetizar los resultados de un trabajo en equipo en proyectos relacionados con la teoría de la señal y las comunicaciones, en un entorno internacional.

CE03 - Valorar y contrastar la utilización de las diferentes técnicas disponibles para la resolución de problemas reales dentro del área de teoría de la señal y comunicaciones.

CT01 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa

CT03 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas

CT04 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo

CT05 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente

CT06 - Capacidad para emitir juicios sobre implicaciones económicas, administrativas, sociales, éticas y medioambientales ligadas a la aplicación de sus conocimientos

4.2. Learning outcomes

RA7 - Capacidad para desarrollar y evaluar técnicas de aprendizaje automático y diseñar sistemas de aprendizaje para datos masivos

RA34 - Capability to develop and evaluate machine-learning techniques and to design big data learning systems

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

In this laboratory students will learn how to apply the variety of Machine Learning methods presented in the Predictive and Descriptive Learning course to practical scenarios. Students will practice using scientifically-oriented processing environments and most common programming languages and machine learning libraries (TensorFlow, Keras, Python scikit-learn, ML libraries in R).

Along the course students will address practical problems on the application of the variety of Machine Learning methods presented in the Predictive and Descriptive Learning course. Experimental activities will cover both predictive or supervised learning (from classical linear and logistic regression or random forest and SVM to Deep Learning -Feed-forward, Convolutional Networks, Recurrent Networks) and descriptive or unsupervised prevised learning (principal component analysis, t-SNE and cluster analysis). Several realistic and practical scenarios and use cases will be addressed (as those proposed in Kaggle competition, www.kaggle.com). Students will practice using scientifically-oriented languages and cloud environments, mainly working with Python and R languages. Through all lab activities students will have to gain practice on model accuracy using cross-validation and on how to draw precise conclusions and valuable interpretations from machine learning results and models.

The students will acquire the skill to apply the variety of Machine Learning methods on to practical scenarios. Main course outcome will be to consolidate the theoretical study of machine learning techniques along this Master Programme. Through hands-on experience case studies students will learn how to select and accurately assess the performance evaluation of machine learning methods. They will also acquire solid criteria on what could be best model for a given data and task as well to be able to draw precise conclusions and interpretations from experimental results. By the end of the course, students should be able to:

- Understand how to apply the most used models and techniques for predictive and descriptive learning to different real scenarios.

- Design a proper experimental methodology for accurately assessing and gaining knowledge from the use of each one of the different machine learning techniques.

- Work with both scientifically-oriented processing environments and cluster computing frameworks for big data

processing that can be used in a wide range of applications in science and industry.

5.2. Syllabus

1. Introduction to Machine Learning Lab
 - 1.1. Designing a Machine Learning System
 - 1.2. Introducing Python for DataScience and Machine Learning
2. Linear Regression
 - 2.1. Developing interpretable Linear Regression models
3. Classification
 - 3.1. Developing and understanding Logistic Regression models
4. Resampling methods
 - 4.1. Using Cross-Validation and Bootstrap
5. Tree-Based Methods
 - 5.1. Decision trees, Bagging, Random Forests and Boosting
6. Support Vector Machines
 - 6.1. Kernels and Support Vector Machines
7. Descriptive Learning
 - 7.1. Principal Components Analysis, t-SNE, K-means and Hierarchical Clustering
8. Introduction to Deep Learning
 - 8.1. Simple Neural Network in TensorFlow (Basic Deep Learning Design Methodology)
 - 8.2. Feed-Forward Neural Networks (TensorFlow and Keras)
 - 8.3. Convolutional Networks for Images and Signals (TensorFlow and Keras)
 - 8.4. Recurrent Neural Networks: Signal and Natural Language Processing use cases (Keras)
 - 8.5. Advanced Deep Learning architectures
9. Building Machine Learning Pipelines

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1	Introduction to Machine Learning Systems Duration: 03:00 Lecture		Introduction to Machine Learning Systems Duration: 03:00 Lecture	
2		Linear and Logistic Regression Models Duration: 03:00 Laboratory assignments	Linear and Logistic Regression Models Duration: 03:00 Laboratory assignments	
3		Linear and Logistic Regression Models Duration: 03:00 Laboratory assignments	Linear and Logistic Regression Models Duration: 03:00 Laboratory assignments	
4		Resampling methods Duration: 03:00 Laboratory assignments	Resampling methods Duration: 03:00 Laboratory assignments	
5		Tree-based models Duration: 03:00 Laboratory assignments	Tree-based models Duration: 03:00 Laboratory assignments	
6		Support Vector Machines Duration: 03:00 Laboratory assignments	Support Vector Machines Duration: 03:00 Laboratory assignments	
7		Descriptive Learning Duration: 03:00 Laboratory assignments	Descriptive Learning Duration: 03:00 Laboratory assignments	
8		Python for DataScience and Machine Learning Duration: 03:00 Laboratory assignments	Python for DataScience and Machine Learning Duration: 03:00 Laboratory assignments	
9		Review: Developing Machine Learning models Duration: 03:00 Laboratory assignments	Review: Developing Machine Learning models Duration: 03:00 Laboratory assignments	Evaluation: Developing Machine Learning models Individual presentation Continuous assessment Not Presential Duration: 00:10
10		Feed-forward Networks in TensorFlow and Keras Duration: 03:00 Laboratory assignments	Feed-forward Networks in TensorFlow and Keras Duration: 03:00 Laboratory assignments	
11		Convolutional Networks for Images and Signals Duration: 03:00 Laboratory assignments	Convolutional Networks for Images and Signals Duration: 03:00 Laboratory assignments	
12		RNN for Signals and NLP Duration: 03:00 Laboratory assignments	RNN for Signals and NLP Duration: 03:00 Laboratory assignments	

13		Pipelines and Advanced Deep Learning Duration: 03:00 Laboratory assignments	Pipelines and Advanced Deep Learning Duration: 03:00 Laboratory assignments	
14				
15				
16				
17				Final project evaluation Group presentation Continuous assessment Not Presential Duration: 00:15 Evaluation: Developing Machine Learning models Individual presentation Final examination Not Presential Duration: 00:10 Final project evaluation Group presentation Final examination Not Presential Duration: 00:15

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
9	Evaluation: Developing Machine Learning models	Individual presentation	No Presential	00:10	40%	/ 10	CB08 CB09 CT01 CB07 CT03 CB06 CE02 CT05 CB10
17	Final project evaluation	Group presentation	No Presential	00:15	60%	/ 10	CT01 CB07 CT03 CB06 CE02 CT04 CE01 CT06 CE03 CT05 CB10 CB08 CB09

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Evaluation: Developing Machine Learning models	Individual presentation	No Presential	00:10	40%	/ 10	CT01 CB07 CT03 CB06 CB08 CB09 CE02 CT05 CB10

17	Final project evaluation	Group presentation	No Presential	00:15	60%	/ 10	CB09 CT01 CB07 CT03 CB06 CE02 CT04 CE01 CT06 CE03 CT05 CB10 CB08
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7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Evaluation: Developing Machine Learning models	Individual presentation	Face-to-face	00:10	40%	/ 10	CB09 CT01 CB07 CT03 CB08 CB06 CE02 CT05 CB10
Final project evaluation	Group presentation	Face-to-face	00:15	60%	/ 10	CB07 CT03 CB06 CE02 CT04 CE01 CT06 CE03 CT05 CB10 CB08 CB09 CT01

7.2. Assessment criteria

Students will be qualified through continuous evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students willing to renounce to continuous evaluation must complete the Moodle task entitled "Renounce to continuous evaluation" before the fourth week of the semester (deadline will be announced in Moodle).

Evaluation will assess if students have acquired all the competences of the subject. Thus, evaluation through final assessment will be carried out considering all the evaluation techniques used in continuous evaluation (EX, ET, TG, etc.), and will be celebrated in the exam period approved by Junta de Escuela for the current academic semester and year. Evaluation activities that assess learning outcomes that cannot be evaluated through a single exam can be carried out along the semester.

Extraordinary examination will be carried out exclusively by the final assessment method.

Continuous assessment will consist of:

- Individual presentations to demonstrate skills in developing machine learning models will be made by mid-semester (40% of final grade).
- A final collaborative project will be developed to be evaluated by the end of the semester. Evaluation will cover both individual achievements in Machine Learning, and more specifically Deep Learning models, as well as the development of teamwork skills, as this is one of the learning objectives for the course (final project assessment will represent 60% of the final grade).

Final assessment:

Those students that have renounced to continuous evaluation should address a final examination including both individual presentations to demonstrate skills in developing machine learning models (40% of final grade) and their final collaborative project covering machine learning and deep learning models (60% of the final grade).

Extraordinary examination:

Extraordinary examination consists of an individual presentations to demonstrate skills in developing machine learning models (40% of final grade) and a final collaborative project focused on machine learning and deep learning models (60% of the final grade).

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems	Bibliography	GGéron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. O'Reilly Media, 2019.
Introduction to Statistical Learning	Bibliography	James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013
Python for data analysis	Bibliography	McKinney, Wes. Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. " O'Reilly Media, Inc.", 2012.
Theory and R examples	Bibliography	James, Gareth, Daniela Witten, Trevor Hastie, and Robert Tibshirani. An introduction to statistical learning. Vol. 112. New York: springer, 2013.
Keras: the Python deep learning API	Web resource	https://keras.io/ Keras is an open-source neural-network library written in Python
Tensorflow Intro	Web resource	https://www.tensorflow.org/get_started/
Deep learning with Python.	Bibliography	F Chollet. Manning Publications Co., 2017
Deep Learning with Keras	Bibliography	Gulli, Antonio, and Sujit Pal. Deep Learning with Keras. Packt Publishing Ltd, 2017.

MSTC GitHub	Web resource	https://github.com/MasterMSTC
Andrej Karpathy blog About Hacker's guide to Neural Networks	Web resource	https://karpathy.github.io/

9. Other information

9.1. Other information about the subject

For on-line learning activities we will use UPM Moodle platform and tools. Moodle, GutHub and Youtube will be the environments to share specific course materials. Specific communication frameworks such as Skype for Business or Microsoft Teams could be used allowing UPM students to interact with instructors.

The increasing relevance of technological developments based on Machine Learning makes this course an educational activity directed to contribute to Goal 4.4 in Sustainable Development Goals (SDGs) 2030 United Nations Agenda, empowering our students with relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.

Through approaching practical scenarios in our Lab, students will develop relevant skills and in-depth knowledge on the impact of different Machine Learning techniques on different fields as health, environmental monitoring, smart energy management, or finance. This will help them to become more aware of how technology can contribute to several SDGs goals: end poverty (Goal 1), promote well-being (Goal 2), and promote sustainable management of water, energy, economic growth and industrialization (Goals 5, 6, 7, and 8) as well as to reduce inequality among countries (Goal 10).

Also, due to the relevance of using machine learning to extract value from data in a broad range of economic sectors, the course will also contribute to SDG Goal 17 (Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development) in particular working on systemic issues on Data monitoring and accountability (17.18 and 17.19)