



UNIVERSIDAD
POLITÉCNICA
DE MADRID

PROCESO DE
COORDINACIÓN DE LAS
ENSEÑANZAS PR/CL/001



E.T.S. de Ingenieros de
Telecomunicacion

ANX-PR/CL/001-01

GUÍA DE APRENDIZAJE

ASIGNATURA

93000944 - Analítica De Contenidos Multimedia A Gran Escala

PLAN DE ESTUDIOS

09AT - Master Universitario En Teoria De La Señal Y Comunicaciones

CURSO ACADÉMICO Y SEMESTRE

2025/26 - Segundo semestre

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1. Datos descriptivos

1.1. Datos de la asignatura

Nombre de la asignatura	93000944 - Analítica de Contenidos Multimedia a Gran Escala
No de créditos	4 ECTS
Carácter	Optativa
Curso	Primer curso
Semestre	Segundo semestre
Período de impartición	Febrero-Junio
Idioma de impartición	Inglés/Castellano
Titulación	09AT - Master Universitario en Teoría de la Señal y Comunicaciones
Centro responsable de la titulación	09 - E.T.S. De Ingenieros De Telecomunicacion
Curso académico	2025-26

2. Profesorado

2.1. Profesorado implicado en la docencia

Nombre	Despacho	Correo electrónico	Horario de tutorías *
Alberto Belmonte Hernandez (Coordinador/a)	D-112.2	alberto.belmonte@upm.es	Sin horario. Appointment arranged by email
Federico Alvarez Garcia	D-103	federico.alvarez@upm.es	Sin horario. Appointment arranged by email

Jose Manuel Menendez Garcia	C-300	jm.menendez@upm.es	Sin horario. Appointment arranged by email
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* Las horas de tutoría son orientativas y pueden sufrir modificaciones. Se deberá confirmar los horarios de tutorías con el profesorado.

3. Competencias y resultados de aprendizaje

3.1. Competencias

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

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.

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

3.2. Resultados del aprendizaje

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

RA43 - Ability to develop basic applications in relevant current use cases in the media industry (media search, content recommendation, etc.)

RA42 - knowledge on Big Data technologies and their application to multimedia content

RA41 - Ability to select and apply adequate machine learning techniques to large-scale multimedia datasets and evaluate their performance

4. Descripción de la asignatura y temario

4.1. Descripción de la asignatura

Modern data analysis applications demand the processing of massive, heterogeneous multimedia datasets. Extracting meaningful insights from such data is a complex and multidisciplinary task. This course provides students with the theoretical and practical tools to address this challenge across five key areas.

Topic 1: Advanced EDA and XAI in ML and DL

The course begins with a deep dive into Exploratory Data Analysis (EDA), introducing essential techniques such as data visualization, transformation, dimensionality reduction, clustering, and outlier detection. A strong emphasis is placed on Explainable AI (XAI), equipping students with strategies to interpret model decisions. These concepts are consolidated in a lab session where EDA and XAI methods are applied to real-world datasets.

Topic 2: Image and Audio processing and Deep Learning. Methods and architectures.

Students will explore both classical and deep learning techniques for extracting features from images and audio. This includes the study of visual descriptors (e.g., histograms, texture, spatio-temporal features), motion analysis in videos, and audio signal descriptors. Deep learning architectures for visual and audio representation learning are

introduced and applied in practice through lab work focused on multimedia analysis and knowledge extraction (object detection, segmentation, image generation...).

Topic 3: Recommender Systems: Classical, Advanced, and Learning-Based

The course covers the evolution of recommender systems, from basic content- and collaborative-based methods to advanced hybrid systems and deep learning-based recommenders. Students will implement and test various algorithms in lab sessions, gaining insights into personalization, ranking, and recommendation strategies.

Topic 4: Text Analysis and NLP: From Classical to Advanced Techniques

This module introduces text preprocessing, classical NLP methods (e.g., Bag of Words, TF-IDF), and modern deep learning-based approaches, such as word embeddings and Transformer architectures. Students will work with real textual data to extract features, perform classification or sentiment analysis, and build pipelines for textual understanding.

Topic 5: Multimodal Systems: Introduction to Multimodality

The course culminates with an introduction to multimodal AI systems that integrate text, image, audio, and other data types. Students will examine architectures capable of fusing multiple modalities and discuss current challenges and applications in this field.

Project:

A progressive project will be carried out throughout the course, in which students will solve challenges related to each part of the syllabus. These challenges will be presented during the course, allowing students to share their work and results with classmates and instructors, who may ask questions and provide feedback on the work completed.

4.2. Temario de la asignatura

1. Advanced Exploratory Data Analysis and Explainability
 - 1.1. Analytic graphics and techniques for exploratory data analysis
 - 1.2. Data transformation and dimensionality reduction, clustering and outliers detection
 - 1.3. Explainable AI in Machine/Deep learning
 - 1.4. Lab session: EDA, analysis and XAI applied to datasets
2. Image and Audio Feature Extraction techniques and deep learning
 - 2.1. Computer vision and image descriptors: Histograms, Texture, Spatio-Temporal
 - 2.2. Deep Learning for image feature extraction: Architectures and methods
 - 2.3. Audio signal and audio descriptors
 - 2.4. Deep Learning for audio analysis
 - 2.5. Lab session: Image, video, audio analysis and knowledge extraction
3. Recommender Systems
 - 3.1. Simple recommenders and Content-Based recommenders
 - 3.2. Collaborative filtering
 - 3.3. Hybrid recommenders
 - 3.4. Machine/Deep Learning for recommendation
 - 3.5. Lab session: Recommender systems in practice
4. Text analysis and Natural Language Processing (NLP)
 - 4.1. Text mining and cleaning
 - 4.2. Vector space models
 - 4.3. Text clustering, classification and recommendation
 - 4.4. Deep learning for text: From seq2seq to Transformers
 - 4.5. Lab session: Text analytics and NLP
5. Machine/Deep Learning Applications and multimodal systems
 - 5.1. Advanced techniques for multimedia content analysis
 - 5.2. Recent deep learning architectures for multimedia content
6. Project development in pairs or individually

5. Cronograma

5.1. Cronograma de la asignatura *

Sem	Actividad tipo 1	Actividad tipo 2	Tele-enseñanza	Actividades de evaluación
1	Chapter 1 - EDA and data understanding, XAI Duración: 03:00 LM: Actividad del tipo Lección Magistral			
2		Lab 1 - EDA and data understanding, XAI Duración: 03:00 PL: Actividad del tipo Prácticas de Laboratorio		Lab 1 - EDA and data understanding, XAI EP: Técnica del tipo Examen de Prácticas Evaluación Progresiva Presencial Duración: 00:00
3	Chapter 2 - Image feature extraction techniques, analysis, ML and DL. Duración: 03:00 LM: Actividad del tipo Lección Magistral			
4	Chapter 2 - Image/Video and audio feature extraction techniques and Deep Learning Duración: 03:00 LM: Actividad del tipo Lección Magistral			
5		Lab 2 - Image/Video/Audio feature extraction Duración: 03:00 PL: Actividad del tipo Prácticas de Laboratorio		Lab 2 - Image/Video/Audio feature extraction EP: Técnica del tipo Examen de Prácticas Evaluación Progresiva Presencial Duración: 00:00
6	Exam 1: Advanced EDA and XAI Duración: 00:30 OT: Otras actividades formativas / Evaluación	Project session: First deliverable and presentation Duración: 02:30 AR: Aprendizaje basado en retos		
7	Chapter 3 - Recommender systems Duración: 03:00 LM: Actividad del tipo Lección Magistral			
8		Lab 3 - Recommender systems Duración: 03:00 PL: Actividad del tipo Prácticas de Laboratorio		Lab 3 - Recommender systems EP: Técnica del tipo Examen de Prácticas Evaluación Progresiva Presencial Duración: 00:00
9	Exam 2: Image/Video and Audio processing and deep learning Duración: 00:30 OT: Otras actividades formativas / Evaluación	Project session: Second deliverable and presentation Duración: 02:30 AR: Aprendizaje basado en retos		

10	Chapter 4 - Text feature extraction techniques, analysis and Deep learning Duración: 03:00 PL: Actividad del tipo Prácticas de Laboratorio			
11		Lab 4 - Text analysis, NLP and Deep learning Duración: 03:00 PL: Actividad del tipo Prácticas de Laboratorio		Lab 4 - Text analysis, NLP and Deep learning EP: Técnica del tipo Examen de Prácticas Evaluación Progresiva Presencial Duración: 00:00
12	Exam 3: Recommender systems Duración: 00:30 OT: Otras actividades formativas / Evaluación	Project session: Third deliverable and presentation Duración: 02:30 AR: Aprendizaje basado en retos		
13	Chapter 5 - Advanced techniques and analysis in multimedia data Duración: 03:00 LM: Actividad del tipo Lección Magistral			
14	Exam 4: Text processing and NLP Duración: 00:30 OT: Otras actividades formativas / Evaluación	Project session: Fourth deliverable and presentation Duración: 02:30 AR: Aprendizaje basado en retos		
15				
16				
17				Project development and presentations TG: Técnica del tipo Trabajo en Grupo Evaluación Progresiva Presencial Duración: 02:00 Progressive evaluation Exams EX: Técnica del tipo Examen Escrito Evaluación Progresiva Presencial Duración: 02:00 Project development and examination TI: Técnica del tipo Trabajo Individual Evaluación Global Presencial Duración: 01:00 Final exam EX: Técnica del tipo Examen Escrito Evaluación Global Presencial Duración: 03:00

Para el cálculo de los valores totales, se estima que por cada crédito ECTS el alumno dedicará dependiendo del plan de estudios, entre 26 y 27 horas de trabajo presencial y no presencial.

6. Actividades y criterios de evaluación

6.1. Actividades de evaluación de la asignatura

6.1.1. Evaluación (progresiva)

Sem.	Descripción	Modalidad	Tipo	Duración	Peso en la nota	Nota mínima	Competencias evaluadas
2	Lab 1 - EDA and data understanding, XAI	EP: Técnica del tipo Examen de Prácticas	Presencial	00:00	6.25%	4 / 10	CB09 CB07 CB06 CB10
5	Lab 2 - Image/Video/Audio feature extraction	EP: Técnica del tipo Examen de Prácticas	Presencial	00:00	6.25%	4 / 10	CB09 CB07 CB06 CB10
8	Lab 3 - Recommender systems	EP: Técnica del tipo Examen de Prácticas	Presencial	00:00	6.25%	4 / 10	CB09 CB07 CB10
11	Lab 4 - Text analysis, NLP and Deep learning	EP: Técnica del tipo Examen de Prácticas	Presencial	00:00	6.25%	4 / 10	CB09 CB07 CB06 CB10
17	Project development and presentations	TG: Técnica del tipo Trabajo en Grupo	Presencial	02:00	35%	5 / 10	CB09 CB07 CB06 CE02 CE01 CT05 CB10
17	Progressive evaluation Exams	EX: Técnica del tipo Examen Escrito	Presencial	02:00	40%	4 / 10	CB09 CB07 CE01 CT05 CB10

6.1.2. Prueba evaluación global

Sem	Descripción	Modalidad	Tipo	Duración	Peso en la nota	Nota mínima	Competencias evaluadas
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17	Project development and examination	TI: Técnica del tipo Trabajo Individual	Presencial	01:00	35%	5 / 10	CB09 CB07 CB06 CB10
17	Final exam	EX: Técnica del tipo Examen Escrito	Presencial	03:00	65%	5 / 10	CB09 CB07 CB06 CE02 CB10 CE01 CT05

6.1.3. Evaluación convocatoria extraordinaria

Descripción	Modalidad	Tipo	Duración	Peso en la nota	Nota mínima	Competencias evaluadas
Extraordinary exam	TI: Técnica del tipo Trabajo Individual	Presencial	03:00	65%	5 / 10	CB09 CB07 CB06 CE02 CE01 CT05 CB10
Project development and examination	EX: Técnica del tipo Examen Escrito	Presencial	00:00	35%	5 / 10	CB09 CB07 CB06 CB10

6.2. Criterios de evaluación

Progressive Evaluation:

This form of assessment consists of three main components

Laboratories: A total of four lab sessions will take place during class hours, in which students will be required to solve different proposed tasks. A minimum grade of 4 out of 10 in each lab is required to average it with the other assessment components. Attendance to these sessions is mandatory. If a student fails to attend any lab or does not reach the minimum required grade, they will automatically be evaluated through the global assessment mode.

Project Development and Presentations: Throughout the course, and after each lab session, students will be assigned challenges related to different parts of the syllabus. These challenges must be completed individually or in pairs (maximum two students per group) and will together form the course-long project. The work must be submitted on the same day it is presented in class (tentative presentation dates are listed in the course schedule). Attendance is mandatory on these days, as they also include the assessment tests described in the next point. A minimum average grade of 5 out of 10 in the overall project is required to pass the course.

Exams: Four short written exams will be held, each focusing on different parts of the syllabus, and scheduled on the same days as the project presentations. Each exam will last no longer than 30 minutes. All exams will carry equal weight in the assessment, and there is no minimum grade for each exam individually. However, the average of the four exams must be at least 4 out of 10 to be considered in the final grade and to pass the course.

Global Assessment:

If the minimum grade required in any of the components of the progressive assessment is not achieved, students will be evaluated through the following two components:

Project Submission and Exam: Students must submit the complete version of the project at least one week before the exam via the designated platform. In addition, they will take a written exam about their project during the final exam session. If the student did not meet the minimum grade requirement in the project during the progressive assessment, it must be improved and resubmitted. The minimum average grade required to pass will be 5 out of 10, calculated from the average of the submitted project and the written exam. If the project was passed during the progressive assessment, it does not need to be submitted again.

Final Exam: A written exam covering the full theoretical and practical syllabus of the course. A minimum grade of 5 out of 10 is required to be considered in the final average.

Extraordinary Assessment:

This assessment follows the same criteria as the global assessment. The project must be submitted one week before the extraordinary exam via the designated submission platform. If the project was already submitted and passed during the regular call (progressive or global), it does not need to be submitted again, and the same weightings will apply as specified for the extraordinary assessment.

Additional Notes:

The final grade will be the sum of the weighted components according to the established percentages. A final score of 5 out of 10 or higher is required to pass the course under any assessment mode.

If any of the minimum grade requirements are not met, or if any required component has not been completed, the final grade for that call will not exceed 4.5 out of 10. This rule applies to all types of assessment described above.

Any evaluation or submission may require an additional oral examination by the instructor to confirm that the work was completed by the student without unauthorized assistance from AI systems, or that such systems were only used in the appropriate and permitted sections.

7. Recursos didácticos

7.1. Recursos didácticos de la asignatura

Nombre	Tipo	Observaciones
Pentreath, N. (2015). Machine Learning with Spark. Packt Publishing Ltd.	Bibliografía	Machine Learning with Spark
Segaran, T. (2007). Programming collective intelligence: building smart web 2.0 applications. " O'Reilly Media, Inc.".	Bibliografía	Programming collective intelligence: building smart web 2.0 applications
Aggarwal, C. C., & Zhai, C. (2012). Mining text data. Springer Science & Business Media.	Bibliografía	Mining text data. Springer Science & Business Media.
Python Data Science Handbook - Jake VanderPlas	Bibliografía	Data analysis
Python for Data Analysis, Data Wrangling with Pandas, NumPy, and IPython - Wes Mckinney	Bibliografía	Data analysis
Hands On Machine Learning with Scikit Learn and TensorFlow - Aurelien Geron	Bibliografía	Machine Learning and Deep Learning
Data Analysis and Visualization Using Python Analyze Data to Create Visualizations for BI Systems - Dr. Ossama Embarak	Bibliografía	Data analysis and visualization
Introduction to Machine Learning with Python: A Guide for Data Scientists - Sarah Guido	Bibliografía	Artificial intelligence
Modern Computer Vision with PyTorch, Second Edition	Bibliografía	The book explain and provide practical examples of the latest multimodal models, CLIP, and Stable Diffusion.

Transformers for Natural Language Processing - Packt	Bibliografía	From classical nlp to transformer architectures
Recommender Systems A Multi-Disciplinary Approach	Bibliografía	Recommender systems from classical to advanced
Explainable AI (XAI) Made Easy: A Complete Guide to Demystifying the Complexities of Artificial Intelligence for Everyone	Bibliografía	XAI techniques
Deep Learning for Audio: A Comprehensive Journey From Theory to Deployment	Bibliografía	Advanced audio processing

8. Otra información

8.1. Otra información sobre la asignatura

In this subject we align with the the Sustainable Development Goals (SDG) 4, 5 and 9.

Especially this subject will support in the activities to be carried out:

4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.

5.B Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.

9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.