

UVA IN VALENCIA PROGRAM

DS 4021

Analytics II: Machine Learning

Course description

This course continues where Analytics I (DS-3021) left off, moving into more advanced and powerful approaches, particularly neural networks, kernel-based algorithms, and ensemble learning. You will gain a deeper understanding of core ML concepts while comparing methods and discussing how performance, complexity, and predictive power evolve as models become more sophisticated.

The course emphasizes understanding over blind implementation. More than often, you will implement models from scratch rather than relying solely on libraries. You will be challenged to evaluate their assumptions, strengths, and weaknesses. Self-learning and group work are central components, developed through a mix of labs, team-based projects, combining theory, application, discussion and reflection. The course is structured to support students from diverse backgrounds, with ample opportunities for collaboration, TA support, and office hours.

Ultimately, Analytics II seeks to provide a first experience as a real-life practicing data scientist, where advanced models and critical thinking are typically required. It also aims to expand your toolkit with new methods and encourages you to share discoveries with your peers as you improve your ability to generate meaningful insights from data.

What you will learn

These are the main learning objectives:

- Deepen their understanding of machine learning by exploring more advanced and state-of-the-art methods, including support vector machines, ensemble techniques, and neural networks.
- Understand the importance of structured workflows in solving data science problems.
- Gain first exposure to implementing machine learning models from scratch using PyTorch and applying them to real-world datasets.
- Apply machine learning models real-world datasets using the gold-standard library for machine learning, (scikit-learn).

- Critically evaluate and compare the performance of different models, considering trade-offs between accuracy, interpretability, and computational cost.
- Develop and document reproducible data science workflows, including code annotation, version control (GitHub), and final deliverables.
- Engage in collaborative, project-based learning by working effectively within a group to complete lab assignments and a final project.
- Demonstrate self-directed learning and adaptability by tackling tasks beyond the core material and seeking solutions independently.
- Communicate technical findings clearly and effectively, both in written reports and oral presentations.
- Reflect on individual contributions, strengths, and areas for improvement, incorporating peer and self-critique into a growth-oriented learning process.

How you will learn

Since Data Science is inherently collaborative, nearly every week will include a group-based lab session. These labs are designed not only to help you practice what you have learned that week, but also to push you out of your comfort zone by encouraging you to learn something new. Machine Learning requires a strong element of self-directed learning, and these sessions will help you build that skill.

Grade scale and breakdown

- **Labs (50%):** Throughout the course, and in most weeks, we will have eight in-class graded labs. These are designed to help you either practice the skills presented in class or explore new material related to the week's theme. These are group assignments, and you are expected to work closely with your group mates to divide and complete the different tasks. The main deliverable will be a completed Jupyter Notebook, submitted by the group, which will determine the grade for the assignment. Additionally, each member of the team will submit an individual report describing the specific tasks they contributed to. Each member must submit this individual report separately in order to receive a grade. The deadline for submission of all required materials is typically one week after their publication.
- **Final Project (30%):** The course will culminate in a final project involving work with a dataset of your choice. This is a combined group and individual assignment, and you will work with the same group with which you submitted the lab assignments. As a group, you will submit a final GitHub repository, including all well-annotated code and a final report summarizing your findings. Individually, each member of the team will also submit a GitHub repository containing the code they contributed to different parts of the project, as well as an individual report describing the specific tasks they contributed to. Each member must submit their individual GitHub repository separately in order to receive a grade. The final project grade will be the average of the group component and the individual component. This is an open-ended project designed to allow each group to explore a topic of interest from the semester in greater depth.

- **Exams (20%):** This will be two individual written exams covering material from throughout the course. One mid-term (10%) and one final exam (10%). The exams will take place on the dates stipulated by the University for this course.

Grades will be awarded according to the UVA grading scale:

A 10-9 (90-100%)	B+ 7,9-7 (70-79%)	C 5,4-5 (50-54%)	F 4,9-0 (Below 50%)
A- 8,9-8 (80-89%)	B 6,9-6 (60-69%)		
	B- 5,9-5,5 (55-59%)		

Materials

Primary Texts, all available for free (see UVA in Valencia platform for links):

- Python Machine Learning with PyTorch and Scikit-Learn, 4th Edition.
- Introduction to statistical learning.
- The Elements of Statistical Learning: Data Mining, Inference, and Prediction.
- Pattern Recognition and Machine Learning.

Course planning and calendar

Date	Contents
07/09/2026	Course introduction, Introduction to PyTorch
09/09/2026	Regularized Regression through PyTorch and Stochastic Gradient Descent
14/09/2026	Principal component Analysis as a processing step. Introduction to Pipelines
16/09/2026	LAB 1: Partial Least Squares Regression (PLS)
21/09/2026	Support Vector Machine I: The linear case
23/09/2026	Support Vector Machine II: The non-linear case through the Kernel trick
28/09/2026	LAB 2: Predicting Seismic Building Response with Support Vector Regression
30/09/2026	Kernels are everywhere: Kernel PCA + Kernel Ridge Regression
05/10/2026	LAB 3: Non-Linear dimensionality reductions t-SNE and UMAP
07/10/2026	Neural Networks I: Introduction & Multi-Layer Perceptrons (MLPs)
12/10/2026	Día de la Hispanidad
14/10/2026	LAB 4: Manual implementation of MLP for classification and Regression using toy data
19/10/2026	Neural Networks II: Deeper into model building, training and optimization
21/10/2026	LAB 5: Application of Neural Networks to Real Data
26/10/2026	(MIDTERM EXAMS) *
28/10/2026	(MIDTERM EXAMS) *
02/11/2026	Neural Networks III: Improving generalization
04/11/2026	LAB 6: Implementing an autoencoder for non-linear dimensionality reduction
09/11/2026	Bagging: Bootstrap Aggregating and Random Forest
11/11/2026	Boosting: Adaptive Boosting and Gradient Boosting
16/11/2026	LAB 7: Classifying Internet of Things Device Types with Bagging and Boosting Methods
18/11/2026	Clustering I: k-Means
23/11/2026	Clustering II: Hierarchical Clustering, Gaussian Mixture Models
25/11/2026	Clustering III: Validation
30/11/2026	LAB 8: Clustering
02/12/2026	Final Project Time
07/12/2026	(No class) Puente
09/12/2026	Final Project Time
14/12/2026	(FINAL EXAMS) *
16/12/2026	(FINAL EXAMS) *

* Specific dates for midterm and final exams will be finalized by the University later this term to ensure a balanced schedule across all courses.

Important information

1) Use of Spanish at the Center

The use of Spanish at the Center is strongly encouraged. Remember that you have come to Spain to learn Spanish and immerse yourself in its culture, and there is no better way to do so than by using Spanish on as many occasions as possible.

2) Class Attendance and Tardiness

2.1) Attendance and punctuality are essential for the successful completion of the course. Consequently, unexcused absences and lateness will negatively affect the final grade.

2.2) Only one unexcused absence is permitted. Please bear this in mind when planning trips or outings.

2.3) Arriving more than 5 minutes late to class will count as half an absence (1/2). It is the student's responsibility to notify the instructor of an absence before the class begins.

2.4) Arriving more than 30 minutes late to class will be considered an absence.

2.5) Four (4) unexcused absences will result in the student not receiving credit for the course.

2.6) Only documented absences will be considered excused: a religious holiday, a family emergency, or a medical appointment. Medical absences must be supported by a doctor's note and submitted at reception on the day the student returns to class after the incident has ended.

3) Academic Integrity

3.1) The exchange of information is not only permitted but is also a way of enriching the knowledge acquired during the course. However, all work submitted for each course must be individual and original in every respect. Any sources and direct quotations used must be properly cited.

3.2) Remember that the use of artificial intelligence to complete assignments or examinations is strictly prohibited unless an instructor expressly states otherwise. Such use constitutes a lack of authenticity, and may amount to direct plagiarism, in addition to undermining the development of critical thinking and writing skills, which are among the primary goals of this program. Failure to comply with this rule will result in a grade of "F" for the course.

3.3) Any work that has received credit for one course will NOT be accepted for credit in another course. There will be NO exceptions to this rule. Reusing such work will result in immediate failure of the second course. If assignments for two different courses are related in any way and the student has questions about whether the second project is permissible, the matter must be discussed with all instructors involved. This will prevent any possible unintentional violation of this rule.

3.4) As with punctuality, assignments must be submitted on time. Any late submission will result in a reduction of the grade for that assignment.

3.5) Failure to comply with the provisions set out above will result in the loss of the corresponding course credits for the course in which these rules have been violated.

3.6) If you have a documented special need that requires academic accommodations (SDAC), it must be certified by your home institution. Please contact the Head of Studies in Valencia, Mari'a Andre's (maria.andres@uvavalencia.org).

4) Activities, Workshops, and Lectures

Throughout the course, various activities, workshops, and lectures are organized. Participation may be voluntary or mandatory if the instructor considers the activity relevant to the course.

5) Classroom Conduct

5.1) It is very important that all students arrive to class on time, prepared, and with the materials needed for the day. During class, students must treat one another and the instructor with respect, demonstrate a positive attitude, and help create a participatory and collaborative environment that supports effective learning. Any violation of these expectations will have direct consequences.

5.2) Electronic devices (laptop, mobile phone, smartwatch) may be used in class only for course-related purposes. If a student uses such technology for personal reasons during class, the student may be penalized with an unexcused absence.

5.3) The use of computer or electronic technology during examinations is prohibited unless the instructor determines otherwise in accordance with the examination format.

6) Course Content

On occasion, and always within the context of the course, certain "sensitive" topics may be addressed both inside and outside the classroom. Therefore, if a student feels offended by such content in a particular class, the student may leave the class, and doing so will not have any negative effect whatsoever on the final grade. Faculty members will always be open to communication and dialogue in order to promote better intercultural understanding.

7) Final Clarification

The instructor may modify or add activities and/or change the dates indicated according to the learning needs of the group. Effective learning requires not only careful planning, but also a certain degree of flexibility.