

Degree programme	Type	Course
Bachelor in Artificial Intelligence	OB	2

Contact lecturer

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Group languages

You can consult this information at the [end](#) of the document.

Prerequisites

To have completed the first-year subjects of Fundamentals of Machine Learning, Fundamentals of Programming, Fundamentals of Mathematics, Probability and Statistics, and Data Engineering.

Objectives

This subject aims to give a practical introduction to neural network models and deep learning.

The students will consolidate and extend their theoretical background, by building on top of previous subjects on machine learning and complementing previous knowledge with new concepts on neural network design, deep learning frameworks, and the training process for such models.

The students should finish this subject, having a broad knowledge of different neural network architectures and their typical use scenarios, and a demonstrated capacity to critically choose the right architecture and training mechanisms for each task.

Finally, the students will receive hands-on training and acquire practical experience on using current deep learning frameworks to solve specific tasks.

Learning outcomes

- CM07 (Integrate machine learning-based solutions into the design, deployment, and deployment of AI applications.) Integrate machine learning-based solutions into the design, deployment, and deployment of AI applications.
- KM23 (Explain the principles and mathematical formulation on which machine learning algorithms are based.) Explain the principles and mathematical formulation on which machine learning algorithms are based.
- KM24 (Identify the advantages and disadvantages of different learning algorithms and paradigms in their application to learning problems.) Identify the advantages and disadvantages of different learning algorithms and paradigms in their application to learning problems.
- KM25 (Describe neural network-based deep learning mechanisms and architectures for application to learning problems.) Describe neural network-based deep learning mechanisms and architectures for application to learning problems.
- SM24 (Develop the process of implementing and training machine learning models using an appropriate optimisation method, employing the appropriate data pre-processing and initialisation techniques, and the necessary regularisation techniques.) Develop the process of implementing and training machine learning models using an appropriate optimisation method, employing the appropriate data pre-processing and initialisation techniques, and the necessary regularisation techniques.
- SM25 (Critically and reasoned analysis of the results of the application of a machine learning model according to the requirements of the problem.) Critically and reasoned analysis of the results of the application of a machine learning model according to the requirements of the problem.
- SM26 (Select the appropriate paradigms, algorithms, and architectures for a learning problem, based on the domain and type of problem, the available data, and any other constraints or requirements.) Select the appropriate paradigms, algorithms, and architectures for a learning problem, based on the domain and type of problem, the available data, and any other constraints or requirements.
- SM27 (Efficiently and optimally use the computing resources needed for training and validating learning models.) Efficiently and optimally use the computing resources needed for training and validating learning models.

Contents

- Neural networks
 - McCulloch-Pitts Neurons and Perceptron
 - Multi-layer perceptron
 - Backpropagation
-
- Training process
 - Initialization
 - Optimization algorithms
 - Regularization techniques
 - Tasks and cost functions
-
- Deep neural network architectures
 - Convolutional networks
 - Recurrent networks
 - Unsupervised learning (autoencoders)
 - Attention and Transformers
 - Metric learning (Siamese and triplet networks)

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Theory Classes	24	0.96	KM23, KM24, KM25

Work on problems / projects	30	1.2	CM07, SM24, SM25, SM26, SM27
Individual studying	20	0.8	KM23, KM24, KM25
Tutoring	2	0.08	KM23, KM24, KM25
Laboratory Sessions	21	0.84	CM07, SM24, SM25, SM26, SM27
Work on problems / projects	40	1.6	CM07, SM24, SM25, SM26, SM27

Neural network design is guided by the types of problems that it aims to solve. Throughout this subject it will be that typology of problems that will provide the motivation of each section and will direct the organization of the contents.

There will be two types of sessions:

Theory classes: The objective of these sessions is for the teacher to explain the theoretical background of the subject. For each one of the topics studied, the theory and mathematical formulation is explained, as well as the corresponding algorithmic solutions.

Laboratory sessions: Laboratory sessions aim to facilitate interaction, collaborative work and to reinforce the comprehension of the topics seen in the theory classes. During laboratory sessions the students will work through practical cases that require the design of solutions using the methods studied in theory classes. Problem solving will be initiated in the class and will be complemented by a weekly *set of problems* to work through at home.

The above activities will be complemented by a system of tutoring and consultations outside class hours.

Course Project: A course project will be carried out during the semester, where students will have to solve a specific problem of certain complexity. The students will work in small groups of 2-3 students, where each member of the group must equally contribute to the final solution. These working groups will be maintained until the end of the semester and must be self-managed in terms of distribution of roles, work planning, assignment of tasks, management of available resources, conflicts, etc. To develop the project, the groups will work autonomously, while some of the laboratory sessions will be used (1) for the teacher to present the projects' theme and discuss possible approaches, (2) for monitoring the status of the project and (3) for the teams to present their final results.

For this subject, the use of Generative Artificial Intelligence (AI) technologies is allowed exclusively in support tasks, such as text correction or translations. The student must not use AI technologies to develop code that will be submitted as part of the weekly exercises or the course project. The student must clearly identify which parts have been generated with this technology, specify the tools used and include a critical reflection on how these have influenced the process and the final result of the activity. The lack of transparency of the use of AI in this assessable activity will be considered a lack of academic honesty and may lead to a partial or total penalty in the grade of the activity, or greater sanctions in serious cases.

All the information of the subject and the related documents that the students need will be available at the virtual campus (cv.uab.cat).

Annotation: within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes

Practical examination	40%	4	0.16	CM07, SM24, SM25, SM26, SM27
Problem deliverables	10%	5	0.2	CM07, SM24, SM25
Written exams	50%	4	0.16	KM23, KM24, KM25

To assess the level of student learning, a formula is established that combines theoretical and practical knowledge acquisition, and the ability to solve problems.

Final Grade

The final grade is calculated weighted in the following way and according to the different activities that are carried out:

$$\text{Final grade} = 0.5 * \text{Theory Grade} + 0.1 * \text{Problems Portfolio Grade} + 0.4 * \text{Project Grade}$$

This formula will be applied as long as the theory and the practical evaluation grades are higher than 5. There is no restriction on the problems portfolio grade. If doing the calculation of the formula yields ≥ 5 but the theory grade or practical evaluation grade does not reach the minimum required, then a final grade of 4.5 will be given.

Theory Grade

The theory grade aims to assess the individual abilities of the student in terms of the theoretical content of the subject, this is done continuously during the course through two partial exams. The overall theory grade is the average of the grades of the two partial exams.

The mid-term exam (Exam 1) is done in the middle of the semester and serves to eliminate part of the subject if it is passed. The final exam (Exam 2) is done at the end of the semester and serves to eliminate the rest of subject if it is passed.

These exams aim to assess the abilities of each student in an individualized manner, both in terms of solving problems using the techniques explained in class, as well as evaluating the level of conceptualization that the student has made of the techniques seen. In order to obtain a final pass theory grade, it will be required for the both partial exam grades to be higher than 4. If doing the calculation of the formula yields ≥ 5 but the grades of any of the two partial exams do not reach the minimum required, then the grade for theory that will be used in the final calculation will be 4.5.

Recovery exam. In case the theory grade does not reach the adequate level to pass, the students can take a recovery exam, destined to recover the failed part (1, 2 or both) of the continuous evaluation process.

Problems Portfolio Grade

The aim of the problems (exercises) is for the student to train with the contents of the subject continuously and become familiar with the application of the theoretical concepts. As evidence of this work, the presentation of a portfolio is requested in which the exercises worked out will be collated. To obtain a problems grade it is required that the student submits a minimum of 70% of the problem sets, in the opposite case, the problems grade will be 0.

Project Grade

The course project carries an essential weight in the overall mark of the subject. Developing the project requires that the students work collaboratively and design an integral solution to the defined challenge. In addition, the students must demonstrate their teamwork skills and present the results to the class.

The project is evaluated through its deliverables, an oral presentation that students will make in class, and a

self-evaluation process. The participation of students in all three activities (preparing the deliverable, presentation and auto evaluation) is necessary in order to obtain a projects grade. The grade is calculated as follows:

$$\text{Project Grade} = 0.6 * \text{Grade Deliverables} + 0.3 * \text{Grade Presentation} + 0.1 * \text{Grade Self-evaluation}$$

If performing the above calculation yields ≥ 5 but the student did not participate in any of the activities (deliverable, presentation, auto evaluation), then a final grade of 4.5 will be given to the course project.

In case the minimum grade is not achieved, the group will be able to recover the project, restricted to a maximum grade of 7/10.

In case of not submitting the project deliverables, not presenting the project, or considering the contents copied or synthetically generated, the course project will be considered failed.

Important notes

Notwithstanding other disciplinary measures deemed appropriate, and in accordance with the academic regulations in force, evaluation activities will be suspended with zero (0) whenever a student commits any academic irregularities that may alter such evaluation (for example, plagiarizing, copying, letting copy, ...). The evaluation activities qualified in this way and by this procedure will not be recoverable. If you need to pass any of these assessment activities to pass the subject, this subject will be failed directly, without opportunity to recover it in the same course.

If the student does not participate in the course project or in any of the exams, the corresponding grade for the activity and the final grade for the course will be "non-evaluable."

In order to pass the course with honours, the final grade obtained must be equal or higher than 9 points. Because the number of students with this distinction cannot exceed 5% of the total number of students enrolled in the course, it is given to whoever has the highest final marks. In case of a tie, the results of the partial exams will be taken into account.

More details about the evaluation process will be given at class during the first weeks of the semester. In case of any discrepancy between this guide and the information given at class, the information provided at class takes precedence.

Bibliography

Books:

- Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 1st Ed. 2016
- Deep learning with Python, François Chollet, Manning Publications, 2nd Ed., 2022
- Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2011

Online Books:

- Michael Nielsen, *"Neural Networks and Deep Learning"*
- <http://neuralnetworksanddeeplearning.com/>
- Zhang, Z.C. Lipton, M. Li, A.J. Smola, *"Dive into Deep Learning"*, 2021
- <https://d2l.ai/>

Software

For the practical activities of the course we will use Python (NumPy, Matplotlib, SciKit Learn) and PyTorch

Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this [link](#). To access the information, you will need to enter the course CODE

Type of teaching	Group	Language	Semester	Shift
(TE) Theory	71	English	second semester	afternoon
(PAUL) Classroom practices	711	English	second semester	afternoon
(PLAB) Practical laboratories	711	English	second semester	afternoon
(PLAB) Practical laboratories	712	English	second semester	afternoon