UAB
Universitat Autònoma de Barcelona

Neural Networks and Deep Learning

2026/2027

Code: 104407
Credits: 6

Degree programme	Type	Course
Computational Mathematics and Data Analytics	OB	3

Contact lecturer

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Teaching staff

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Group languages

You can consult this information at the end of the document.

Prerequisites

To have completed the subjects of Materia 7: Artificial Intelligence, Machine Learning, and the subjects of Modelling and Inference (2nd), Complex Data Analysis (2nd), and Information Theory (3rd).

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

- CM22 (Apply the most suitable learning techniques to solve computational problems in different case studies.) Apply the most suitable learning techniques to solve computational problems in different case studies.
- CM23 (Assess the results and limitations of the most common learning techniques.) Assess the results and limitations of the most common learning techniques.
- CM24 (Apply deep learning mechanisms based on neural networks to be able to design the most

suitable architecture for a given problem, checking that fundamental rights and duties and democratic values are not violated.) Apply deep learning mechanisms based on neural networks to be able to design the most suitable architecture for a given problem, checking that fundamental rights and duties and democratic values are not violated.
- KM20 (Identify the human knowledge representation techniques.) Identify the human knowledge representation techniques.
- KM21 (Define computational solutions in multiple domains to make decisions based on the exploration of alternatives, uncertain reasoning and task planning.) Define computational solutions in multiple domains to make decisions based on the exploration of alternatives, uncertain reasoning and task planning.
- SM19 (Develop optimum search schemes for different problems through knowledge representation and classification.) Develop optimum search schemes for different problems through knowledge representation and classification.

Contents

Neural networks

- 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)
- Generative Adversarial Networks
- Attention mechanisms

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Tutoring	5	0.2	
Dedication to practical work	29	1.16	
Practical session	14	0.56	
Project development	16	0.64	
Theory session	20	0.8	
Reading and study of material	45	1.8	
Project Sessions	16	0.64	

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 three 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.

Problem sessions: Problem sessions aim to facilitate interaction, collaborative work and to reinforce the comprehension of the topics seen in the theory classes. During these 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.

Project sessions: towards the end of the course the last sessions will be devoted to a project follow-up. This project will consist of a task that must be solved with the tools and concepts worked on throughout the course.

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
Project Evaluation	45	1	0.04	CM22, CM23, CM24, KM20, KM21, SM19
Problems deliverables	10	0	0	CM22, CM23, CM24
Examinations	45	4	0.16	CM22, KM20, KM21, SM19

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:

Final grade = 0.45 * Theory Grade + 0.45 * Project Evaluation + 0.1 * Problems Portfolio Grade

This formula will be applied whenever the theory grade is greater than or equal to 3.5. There is no restriction on the Final or project grades. If the formula result comes out >= 5, but the theory grades do not reach the minimum required, then the final grade will be the smallest value between the result of applying the previous formula and 4.5.

Theory Grade

The theory grade aims to assess the individual abilities of the student in terms of the theoretical contents of the subject, this is done continuously during the course with two partial exams:

Theory Grade = 0.5 * Exam Grade 1 + 0.5 * Exam Grade 2

These exams aim to make an individualized evaluation of the abilities of each student to solve problems using the techniques explained in class, as well as to evaluate the level of conceptualization that the student has made of the techniques seen. If the calculation of the formula results in a theory grade < 3.5, it will be necessary to take the retake exam.

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 problemsets, in the opposite case,the problems grade will be 0.

Project Evaluation Grade

The most practical training part of this subject is based on the development of a project that is done at the end of the course. It has an essential weight in the overall grade of the subject and it is expected students face the problem of designing a solution to a challenge that is presented in a contextualized way and that, therefore, requires the design of a full solution, from the beginnig, processing data to the end, designing and training a neural network model. In addition, students must demonstrate their skills to work as a team and convincingly present the results.

The projects will be evaluated through follow-up sessions, a deliverable, and an oral presentation that the students will give in class. If a group member is unable to attend a follow-up session, they will receive a zero for that session. Although this is a group activity with a shared grade, the grade may be adjusted for individual members if it becomes evident during the evaluation process that contributions were not balanced. In some cases, this adjustment may lead to a failing grade for a member if it is shown that their contribution to the project was zero or virtually none.

If the project is not approved, there will be no 2nd chance of any kind.

2n Chance Exam

If the theory grade does not reach 3.5 or the final grade does not reach 5, students must take a retake exam where all the contents of the subject taken throughout the course will be evaluated. If passed, the maximum grade for the retake exam will be 5.

Important notes

- This subject does not foresee the single assessment system.
- The use of Artificial Intelligence (AI) technologies is allowed, except in those activities that are otherwise specified, as an integral part of the development of the work, provided that the final result reflects a significant contribution of the student in the analysis and personal reflection. The student should clearly identify which parts have been generated with this technology, specify the tools used, and include

critical reflection on how these have influenced the process and the final outcome of the activity. The non-transparency of the use of AI will be considered academic dishonesty and may lead to a penalty in the grade of the activity, or greater sanctions in cases of severity.

- 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 evaluationactivities qualified in this way and bythis procedure will not berecoverable. 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.
- In case there the student does not deliver any exercise solutions, does not participate in any practical evaluation, and does not take any exam, the corresponding grade will be a non-evaluable. In any other case, the no shows count as a 0 for the calculation of the weighted average.
- 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 thecourse, 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.

Bibliography

Books:

- Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 1st Ed. 2016
- Deep learning with Python, François Chollet, Manning Publications, 1st Ed., 2017
- Christopher Bishop & Hugh Bishop, *Deep Learning: Foundations and Concepts,* 2023.
- Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2011
- Neural Networks for Pattern Recognition, Christopher Bishop, Oxford University Press, 1st ed., 1996

Books online

- Michael Nielsen's *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), PyTorch, TensorBoard orWeights & Biases for training monitor.

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	1	Catalan	second semester	morning-mixed