COURSE DATA

DATA SUBJECT

Code: 36441
Name: Deep learning
Cycle: Undergraduate Studies
ECTS Credits: 4.5
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1406 - Degree in Data Science	Escola Tècnica Superior d'Enginyeria	4	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1406 - Degree in Data Science	Deep Learning	ELECTIVES

COORDINATION

SORIA OLIVAS EMILIO

MARTIN GUERRERO JOSE DAVID

LAPARRA PEREZ-MUELAS VALERO

SUMMARY

The subject "Deep Learning (DL)" deals with probably the most popular topic in machine learning. The basic idea of the DL is to build neural networks (already studied in the subject "Connectionist Models", third year of the degree) but with the particularity that there is a large number of connections between neurons as a result of using multilayer architectures.

The idea of using this type of architecture is not new; Since the dawn of neural network research, it was logical to think that greater connectivity would lead to greater modeling capabilities. Added to the technological difficulties due to the high calculation capacity required, was the lack of effective training methods, so it was not until these problems began to be solved between 2005 and 2010, when DL began to be used in different practical problems.

The spectacular results in applications unapproachable so far, such as image segmentation or classification, automatic translation or sentiment analysis have made this discipline one of the most active at an academic level (with numerous new proposals and associated publications), technological (where the routine use of GPUs has allowed their use in increasingly complex problems) and social (since many applications have spread systematically).

A priori, any problem that can be solved by means of a shallow neural networks can also be solved by DL, with greater modeling performance, provided that the data set is sufficiently large and diverse. However, most applications are usually related to images and prediction of temporal sequences (very commonly within the framework of natural language processing).

The main approaches to DL are the following:
- Autoencoders.
- Convolutional neural networks.
- Recurrent neural networks.
- Generative approaches.

The course will begin by introducing and reviewing the most important concepts to take into account DL, the most usual kinds of applications and the suitability of different solutions for each type of application. Once the work framework is presented, convolutional neural networks, already introduced in the subject \" Connectionist Models\", will be quickly reviewed, and the rest of the approaches will be described in more detail. Finally, approaches related to other types of learning will be introduced, such as Deep Reinforcement Learning.

Practical classes will reinforce the concepts introduced in theory by means of Python implementations to solve a series of practical problems: some academic problems to consolidate the theoretical notions and also practical problems to show the applicability and versatility of the AP.

The theory classes will be taught in Spanish and the practical and laboratory classes as stated in the course info available on the degree website.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

This is an optional course of the 4th year of the degree, when it is hence assumed that the student has already achieved the basic knowledge to develop his professional activity as a data scientist. The course can be viewed as an extension of two third grade courses (36426 - Machine Learning and especially 36428 - Connectionist Models).

COMPETENCES / LEARNING OUTCOMES

1406 - Degree in Data Science

(CB3) Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.

(CB4) Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.

(CE03) Ability to solve classification, modelling, segmentation and prediction problems from a set of data.

(CE07) Ability to model dependency between a response variable and several explanatory variables, in complex data sets, using machine learning techniques, interpreting the results obtained.

(CE13) To know how to design, apply and evaluate data science algorithms for the resolution of complex problems.

(CG02) Ability to solve problems with initiative and creativity and to communicate and transmit knowledge, abilities and skills, which should include the ethical and professional responsibility of the activity of a data scientist.

(CG03) Capability to elaborate models, calculations, reports, to plan tasks and other works analogous to the specific field of data science.

(CT03) Ability to defend your own work with rigor and arguments and to expose it in an adequate and accurate way with the use of the necessary means.

(CT05) Ability to evaluate the advantages and disadvantages of different methodological and / or technological alternatives in different fields of application.

DESCRIPTION OF CONTENTS

1. Introduction

1. The deep learning framework.
- Definitions.
- Shallow and deep neural networks.
- Deep networks versus kernel methods.
- Parallelization.

2. Relevant contributions.

3. Review of convolutional neural networks.
- Rectified linear activation functions: RELU and variants.
- Dropout.
- Modeling flexibility and transfer learning.

4. Featured applications.

2. Recurrent networks

1. Prediction of time series.

2. Deep recurrent networks for the prediction of time series with variable length.

3. Gradient control
- Uncontrolled vanishing and exploding of the gradient.
- The LSTM (Long Short-Term Memory) network.
- The GRU (Gated Recurrent Unit) network.

4. Attention Models: Transformer networks.

3. Autoencoders

1. Justification and need of autoencoders. Main approaches.

2. Linear and non-linear autoencoders.

3. Variational autoencoders.

4. Generative approaches

1. Generative versus discriminative approaches.

2. Generative Adversarial Networks: GAN.

3. Variants of GAN

5. Deep Reinforcement Learning

1. Review of reinforcement learning.

2. Deep approaches.

6. Laboratory practice

The laboratory practices will allow to consolidate the contents studied in theory through the model implementations and the practical resolution of academic and real problems. There will be five laboratory practices

1. Convolutional networks.

2. Recurent networks and transfer learning.

3. Autoencoders.

4. GAN networks.

5. Deep Reinforcement Learning.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	25,00
Laboratory	15,00
Classroom practices	5,00
Total hours	**45,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	2,00
Individual or group project	9,00
Independent study and work	30,00
Preparation of lessons	5,00
Preparation for assessment activities	16,50
Resolution of case studies	5,00
Total hours	**67,50**

TEACHING METHODOLOGY

The teaching methodologies of this course are:

MD1 - Theoretical activities (CG3, CB4, CT3, CT5, CE3, CE7, CE13): Expository development with the participation of the students in solving specific questions. Individual evaluation questionnaires.

MD2 - Practical activities (CG2, CB3, CT5, CE3, CE7, CE13): Learning by means of problem solving, exercises and case studies that allow to acquire different competences of the course.

MD4 - Work in the laboratory and / or computer classroom (CG2, CG3, CB3, CB4, CT3, CT5, CE3, CE7, CE13): Learning by carrying out activities developed individually or in small groups and carried out in laboratories and / or computer classrooms.

EVALUATION

The final grade for the course will be obtained as a weighted average of the theory and practical components. According to the credits assigned to each part, theory will account for 2/3 of the final grade, and practice for the remaining third.

The theory grade for the first exam session will be determined as follows:

- SE1 (30%; CG2, CG3, CB3, CB4, CT5, CE3, CE7, CE13): Objective tests, consisting of one or more exams with theoretical questions, synthetic problems, and real practical problems. To pass the course, a minimum grade of 5 out of 10 will be required in this part.
- SE2 (60%; CG2, CG3, CB3, CB4, CT3, CT5, CE3, CE7, CE13): Reports, written assignments, and oral presentations.
- SE3 (10%; CG2, CB4, CT3, CE3, CE7, CE13): Continuous assessment of each student, based on participation and engagement in the teaching-learning process, including regular attendance and the periodic resolution of assigned questions and problems.

Regarding the practical component, 40% of the grade will correspond to SE2 (CG2, CG3, CB3, CB4, CT3, CT5, CE3, CE7, CE13) and 60% to SE1 (CG2, CG3, CB3, CB4, CT5, CE3, CE7, CE13). To pass the course, a minimum grade of 5 out of 10 will be required in SE1. Of the 40% related to continuous assessment, 70% will come from the completion of exercises proposed during the practice session, which may be evaluated by the instructor at the end of the session. The remaining 30% will come from the preparatory work before the session, which will be quickly assessed at the beginning of each session. Practical work may be done individually or in pairs; SE1 will be assessed individually. Furthermore, the instructor may choose to evaluate the regular practice sessions individually, even if the work was completed in pairs.

The second exam session will be assessed in the same way as the first, except that in the theory part, SE1 will weigh 60%, SE2 40% (this part will not be recoverable), and SE3 will weigh 0%. In the practical part, 20% will correspond to SE2 (not recoverable) and 80% to SE1.

In any case, the evaluation system will follow the guidelines set forth in the Evaluation and Grading Regulations of the University of Valencia for Bachelor's and Master's Degrees (https://webges.uv.es/uvTaeWeb/MuestraInformacionEdictoPublicoFrontAction.do?accion=inicio&idEdictoSeleccionado=5639).

Any clear case of copying or plagiarism in any activity that is part of the evaluation will result in the impossibility of passing the course and will be subject to disciplinary procedures as established in the ACTION PROTOCOL AGAINST FRAUDULENT PRACTICES AT THE UNIVERSITY OF VALENCIA (ACGUV 123/2020).

REFERENCES

- Ian Goodfellow, Yoshua Bengio and Aaron Courville (2016). Deep learning. The MIT Press.
- Valentina Emilia Balas, Sanjiban Sekhar Roy, Dharmendra Sharma, Pijush Samui (2019). Handbook of Deep Learning Applications. Springer
- Nikhil Ketkar (2017). Deep learning with Python: a hands-on introduction. Apress.
- Charu C. Aggarwal (2018). Neural Networks and Deep Learning: A Textbook. Springer.
- Kaizhu Huang, Amir Hussain, Qiu-Feng Wang, Rui Zhang (2019). Deep Learning: Fundamentals, Theory and Applications. Springer.
- Ovidiu Calin (2020). Deep Learning Architectures: A Mathematical Approach. Springer.
- Santanu Pattanayak (2017). Pro Deep Learning with TensorFlow: A Mathematical Approach to Advanced Artificial Intelligence in Python. Apress.