| Teaching Guide | | | | | |
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| Identifying Data | | | | | 2023/24 |
| Subject (*) | Deep Learning | | | Code | 614544013 |
| Study programme | Máster Universitario en Intelixencia Artificial | | | | |
| Descriptors | | | | | |
| Cycle | Period | Year | | Type | Credits |
| Official Master's Degree | 2nd four-month period | First | | Optional | 6 |
| Language | English | | | | |
| Teaching method | Face-to-face | | | | |
| Prerequisites | | | | | |
| Department | Ciencias da Computación e Tecnoloxías da Información | | | | |
| Coordinador | Mosqueira Rey, Eduardo | | E-mail | eduardo.mosqueira@udc.es | |
| Lecturers | Mosqueira Rey, Eduardo | | E-mail | eduardo.mosqueira@udc.es | |
| Web | | | | | |
| General description | The course introduces methods that mimic human perception and learning through abstractions based on multilevel assimilation. Focusing on the concept of artificial neural networks, the student will be trained not only in the use of different generation strategies, but also in those that are best adapted to each particular application case. Regularization and stability techniques will also be described in order to maximize the performance of the generated models. | | | | |

| Study programme competences / results | |
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| Code | Study programme competences / results |
| A11 | CE10 - Ability to implement, validate and apply a stochastic model starting from the observed data on a real system, and to perform a critical analysis of the obtained results, selecting those ones most suitable for problem solving |
| A12 | CE11 - Understanding and command of the main techniques and tools for data analysis, both from the statistical and the machine learning viewpoints, including those devised for large volumes of data, and ability to select those ones most suitable for problem solving |
| A13 | CE12 - Ability to outline, formulate and solve all the stages of a data project, including the understanding and command of basic concepts and techniques for information search and filtering in big collections of data |
| A16 | CE15 - Knowledge of computer tools in the field of machine learning and ability to select those ones most suitable for problem solving |
| B2 | CG02 - Successfully addressing each and every stage of an AI project |
| B3 | CG03 - Searching and selecting that useful information required to solve complex problems, with a confident handling of bibliographical sources in the field |
| B4 | CG04 - Suitably elaborating written essays or motivated arguments, including some point of originality, writing plans, work projects, scientific papers and formulating reasonable hypotheses in the field |
| B5 | CG05 - Working in teams, especially of multidisciplinary nature, and being skilled in the management of time, people and decision making |
| B6 | CB01 - Acquiring and understanding knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, frequently in a research context |
| B7 | CB02 - The students will be able to apply the acquired knowledge and to use their capacity of solving problems in new or poorly explored environments inside wider (or multidisciplinary) contexts related to their field of study |
| B8 | CB03 - The students will be able to integrate different pieces of knowledge, to face the complexity of formulating opinions (from information that may be incomplete or limited) and to include considerations about social and ethical responsibilities linked to the application of their knowledge and opinions |
| B9 | CB04 - The students will be able to communicate their conclusions, their premises and their ultimate justifications, both to specialised and non-specialised audiences, using a clear style language, free from ambiguities |
| C3 | CT03 - Use of the basic tools of Information and Communications Technology (ICT) required for the student's professional practice and learning along her life |
| C4 | CT04 - Acquiring a personal development for practicing a citizenship under observation of the democratic culture, the human rights and the gender perspective |
| C7 | CT07 - Developing the ability to work in interdisciplinary or cross-disciplinary teams to provide proposal that contribute to a sustainable environmental, economic, political and social development |

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| C8 | CT08 - Appreciating the importance of research, innovation and technological development in the socioeconomic and cultural progress of society |
| C9 | CT09 - Being able to manage time and resources: outlining plans, prioritising activities, identifying criticisms, fixing deadlines and sticking to them |

| Learning outcomes | | | |
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| Learning outcomes | Study programme competences / results | | |
| To understand the functioning of Artificial Neuron Networks. | AC10<br>AC11 | | CC8<br>CC9 |
| Be able to design Deep Learning architectures | AC10<br>AC11<br>AC12<br>AC15 | BC2<br>BC3<br>BC4<br>BC5<br>BC6<br>BC7<br>BC8<br>BC9 | CC4<br>CC7<br>CC8<br>CC9 |
| Be able to obtain models capable of pattern classification and image recognition. | AC10<br>AC11<br>AC15 | BC2<br>BC3<br>BC4<br>BC6<br>BC7<br>BC8<br>BC9 | CC3<br>CC4<br>CC8<br>CC9 |
| Be able to visualize and analyze the learning information of a Deep Learning architecture. | AC10<br>AC11 | BC4<br>BC9 | CC8<br>CC9 |

| Contents | |
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| Topic | Sub-topic |
| 1. Introduction to deep learning | Shallow learning<br>Deep learning<br>Deep Learning libraries<br>Examples |
| 2. Regularization and optimization in deep learning | Introduction to regularization<br>Regularization via data<br>Regularization via model<br>Regularization via objective function<br>Optimization |
| 3. Convolutional neural networks (CNNs) | Introduction to CNNs<br>Convolutional layer<br>Pooling layer<br>Fully connected layer<br>CNNs examples<br>Pretrained models<br>Residual networks<br>Inception networks<br>Xception networks |

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| 4. Recurrent neural networks (RNNs) | Sequence data<br>Using sequence data without recurrence<br>Simple recurrent networks<br>LSTM networks<br>GRU networks<br>Advanced use of RNNs |
| 5. Autoencoders | Autoencoders<br>Variational autoencoders |
| 6. Generative Adversial Networks (GANs) | Basics<br>How to train GANs<br>DCGAN and WGAN<br>How to evaluate GANs<br>Applications<br>Variations of GANs<br>GAN challenges<br>Advanced GANs |
| 7. Diffusion models | Introduction<br>The theory behind diffusion models<br>Two examples of diffusion models<br>Stable Diffusion<br>Stable Diffusion at work |
| 8. Reinforcement learning | Basics<br>What is Reinforcement learning<br>Solution methods |
| 9. Transformers | Introduction<br>Transformer blocks<br>Encoder-only and decoder-only architectures<br>Encoder-decoder architectures<br>Examples of transformers |

| Planning | | | | |
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| Methodologies / tests | Competencies / Results | Teaching hours (in-person & virtual) | Student?s personal work hours | Total hours |
| Guest lecture / keynote speech | A11 A12 A13 B2 B3 B6 B8 B9 C4 C8 | 21 | 21 | 42 |
| Laboratory practice | A11 A12 A13 A16 B2 B3 B4 B5 B6 B7 B8 B9 C3 C7 C9 | 21 | 84 | 105 |
| Objective test | A11 A12 B7 B9 | 3 | 0 | 3 |
| Personalized attention | | 0 | 0 | 0 |
| (*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | | |

| Methodologies | |
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| Methodologies | Description |
| Guest lecture / keynote speech | Lectures explain the theoretical concepts using different digital resources. |
| Laboratory practice | Laboratory activities are based on the knowledge that students are acquiring in lectures. |
| Objective test | A test shall be administered to assess the theoretical and practical knowledge acquired by students |

| Personalized attention |
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| Methodologies | Description |
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| Laboratory practice | Personalized attention to students includes not only tutorials (either virtual or in-person) to discuss questions, but also the following actions:<br><br>- Monitor the work of laboratory practices proposed by the teacher.<br>- Evaluate of the results obtained in practice and seminars.<br>- Conduct personalized meetings to answer questions about the contents of the subject. |

| Assessment | | | |
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| Methodologies | Competencies / Results | Description | **Qualification** |
| Laboratory practice | A11 A12 A13 A16 B2 B3 B4 B5 B6 B7 B8 B9 C3 C7 C9 | Practice exercises based on the knowledge acquired in the theoretical classes. | 50 |
| Objective test | A11 A12 B7 B9 | Test conducted at the end of the semester with theoretical and practical content. | 50 |

| Assessment comments |
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| Specific evaluation percentages for each part of the course.<br>The evaluation of the course will be carried out in two parts: continuous evaluation (practices) and final exam. In order to pass the course it is essential to obtain a minimum grade of 4 in both parts separately. The final grade of the subject will be the arithmetic mean of the continuous evaluation and the final exam, except in those situations in which the minimum grade has not been reached in any of the two parts, in which case the final grade cannot be higher than 4.How the non-attending students are evaluated.<br>The submission of any of the activities or tests of continuous evaluation by a student will indicate the student has chosen to attend the course. Therefore, from that moment on, even if he/she does not take the final exam, he/she will have used up an opportunity.How the second exam opportunity is evaluated.<br>In the second opportunity (July) the grades of the continuous evaluation and/or the final exam obtained during the four-month period will be kept, as long as the grade in that part is 4 or more points. If the student attends the second opportunity in the continuous evaluation part or the final exam, the grade obtained in the first opportunity for that part will be annulled, and the corresponding grade for that part will be that of the second opportunity. For the continuous evaluation, a deadline will be established for the submission of the practices. The final grade of the course in the second opportunity will be calculated with the same criteria as in the first opportunity. |

| Sources of information | |
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| Basic | - François Chollet (2021). Deep Learning with Python, 2nd Ed.. Manning<br>- Aurélien Géron (2019). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Ed.. O'Reilly<br>- Mohamed Elgendy (2020). Deep Learning for Vision Systems. Manning<br>- Jakub Langr, Vladimir Bok (2019). GANs in Action. Manning<br>- David Foster (2023). Generative Deep Learning - 2nd Ed . O'Reilly |
| Complementary | - Andrew Ferlitsch (2021). Deep Learning Patterns and Practices. Manning<br>- Andrew W. Trask (2019). Grokking Deep Learning . Manning |

| Recommendations |
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| Subjects that it is recommended to have taken before |
| Machine Learning I /614544012 |
| Subjects that are recommended to be taken simultaneously |
| Machine Learning II /614544014 |
| Subjects that continue the syllabus |
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| Other comments |
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(*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.