NEURAL AND EVOLUTIONARY COMPUTATION (EMaCS-01-01)				
DEGREE PROGRAM:		Master in Computer Science for the Human-Centric and Sustainable Industry		
SEMESTER: First	**TYPE:** Basic	**CREDITS:** 6 ECTS	**WORKLOAD:** 150 hours	**MENTORING:** 4 hours/week
LANGUAGE: English				

OBJECTIVES	
General	Aware that AI algorithms work in ways that are usually not visible or easily understood by users (often referred as "black box" decision), it may be impossible to trace back how and why an algorithm makes specific suggestions or predictions. In this subject, the student will gain introductory knowledge to modern bio-inspired AI models: Neural Networks and Evolutionary Computing; including different types and existing variants of these techniques, their basic functioning and capabilities for solving different types of problems and the way they provide their results and should be interpreted.
Specific	• Be aware of the classification or taxonomy of advanced algorithms proposed in the field of Artificial Intelligence and Soft Computing. • Understand the fundamentals of some of the algorithms based on artificial intelligence applied by many companies to their operations: automatic classification, pattern/image recognition, fraud/intrusion detection systems, predictive fraud/intrusion detection systems, prediction, recommendation systems, etc. • Understand the solutions that neural networks can provide and how they are currently being applied to industrial problems, health, economics, social networks, etc. • Obtain sufficient knowledge to implement artificial neural networks and apply them to real problems, being able to compare and apply these to real problems, being able to compare between different neural models architectures and training algorithms. In addition to the basic knowledge, advanced aspects such as Deep Learning are also covered. • Recognize the typical characteristics of the optimisation problems that a computer engineer may encounter: load balancing, route calculation and autonomous navigation, scheduling, automatic pattern classification, etc. • Obtain a general knowledge of the range of solutions provided by evolutionary computing to the above-mentioned problems. To know the advantages and disadvantages of each of these techniques depending on each type of problem. • Be able to use, understand and analyse the results provided by evolutionary computing software, as well as to programme some of the basic algorithms of this paradigm.

SUSTAINABILITY

The course "Neural and Evolutionary Computation" makes significant contributions to sustainability by fostering competences and learning outcomes that align with the principles of sustainable development. The exploration of Artificial Neural Networks and Evolutionary Computing equips students with the knowledge to address real-world problems, ranging from industrial challenges to issues in health, economics, and social networks. The course recognizes the importance of AI algorithms in decision-making, emphasizing the need for transparency and interpretability, which are crucial aspects in ensuring ethical and sustainable AI applications. The consideration of sustainability challenges in different application areas, such as load balancing, route calculation, and autonomous navigation, reflects the course's commitment to addressing problems that have an impact on the environment and society. Furthermore, the incorporation of bio-inspired AI models and the discussion of ethical values in AI

development underline the course's emphasis on creating technology that aligns with sustainability goals and ethical considerations.

RESILIENCE AND HUMAN-CENTRIC DEVELOPMENT

The "Neural and Evolutionary Computation" course actively contributes to resilience and human-centric development by nurturing competences and learning outcomes that prioritize user needs, ethical considerations, and the development of adaptive solutions. The exploration of Artificial Neural Networks provides students with a deep understanding of human neural processing, fostering an awareness of how technology can be designed to mimic and support human cognitive functions. The focus on learning, both supervised and unsupervised, supports the development of adaptive systems that can respond to changing environments and user interactions. The inclusion of Evolutionary Computing, with a specific emphasis on recognizing optimization problems and understanding the advantages and disadvantages of different techniques, promotes a resilient approach to problem-solving. Additionally, the attitudinal aspects highlight the importance of ethics, continuous learning, and collaborative processes, aligning with the principles of resilience and human-centric development in the context of AI systems.

SUBJECT MATTER

1. Introduction to Neural Computing
   1.1. Introduction to Neural Computing.
   1.2. Human Neural Processing
2. Artificial Neural Networks
   2.1. Artificial Neuron. Model of a neuron.
   2.2. Types of activation functions.
   2.3. Artificial Neural Network
3. Learning
   3.1. Supervised learning
   3.2. Unsupervised learning
4. Introduction to Evolutionary Computing
   4.1. Introduction to Evolutionary Computing
5. Genetic Algorithms
   5.1. Basic Concepts of Genetic Algorithms
   5.2. Problems solved by Genetic Algorithms
   5.3. Evaluation and Scope of Genetic Algorithms
6. Application Areas of Evolutionary Computing
   6.1. Multi-Objective Problems
   6.2. Advanced Evolutionary Algorithms

COMPETENCES

C2. BROWSING, SEARCHING AND FILTERING DATA, INFORMATION AND DIGITAL CONTENT
C5. PROGRAMMING
C6. USING MACHINE LEARNING AND AI TECHNIQUES
C8. PROTECTING HEALTH AND WELL-BEING
C10. EXPLORATORY AND CRITICAL THINKING
C13. CREATIVELY USING DIGITAL TECHNOLOGIES
C17. COMMUNICATING EFFECTIVELY

LEARNING OUTCOMES

Knowledge	• Know that programs produce output data depending on input data, and that different inputs usually yield different outputs (e.g. a calculator will provide output 8 to the 3+5 input and output 15 to the 7+8 input). • Know that, to produce its output, a program stores and manipulates data in the computer system that executes it, and that it sometimes behaves unexpectedly (e.g. faulty behaviour, malfunction, data leakage). • Know that algorithms, and consequently programs, are designed to help solve real life problems; input data models the known information about the problem, while output data provides information relevant to the problem's solution. There are different algorithms, and consequently programs, solving the same problem.

	• Know that there are problems that cannot be solved exactly by any known algorithm in reasonable time, thus, in practice they are frequently dealt with by approximate solutions (e.g. DNA sequencing, data clustering, weather forecasting). • Know that AI and sustainability problems must be tackled by combining different disciplines, knowledge cultures and divergent views to initiate systemic change.
Skills	• Be able to detect issues in a sequence of instructions, and make changes to resolve them (e.g. to find an error in the program and correct it; to detect the reason why the execution time or output of the program is not as expected). • Be able to identify input and output data in some simple programs using AI approaches. • Develop a program, being able to recognise the execution order of instructions, and how information is processed. • Be able to use digital technologies to help turn one's idea into action. • Be able to identify online platforms that can be used to design, develop and test AI enabled apps. • Be able to engage in resolving problems through digital, hybrid and non-digital solutions for the problem (e.g. envisioning and planning preventive maintenance solutions, public reporting systems, resource sharing platforms…). • Develop effective search methods for professional purposes (e.g. to find scientific papers that explain how to solve technical problems). • Be able to make use of information presented as hyperlinks, in non-textual form (e.g. flowcharts, knowledge maps) and in dynamic representations (e.g. data).
Attitudes/values	• Weigh the benefits and disadvantages of using AI-driven search engines (e.g. while they might help users find the desired information, they may compromise privacy and personal data, or subject the user to commercial interests). • Worry about that AI algorithms and AI-enabled system are trained with a dataset that ensure diversity and accounting on the right representation of all its users, not incurring in biased results or assessments. • Be willing to accept that algorithms, and hence programs, may not be perfect in solving the problem that they aim to address. • Consider ethics (including but not limited to human agency and oversight, transparency, non-discrimination, accessibility, and biases and fairness) as one of the core pillars when developing or deploying AI systems. • Have a disposition to keep learning, to educate oneself and stay informed about AI (e.g. to understand how AI algorithms work; to understand how automatic decision-making can be biased; to distinguish between realistic and unrealistic AI; and to understand the difference between Artificial Narrow Intelligence, i.e. today's AI capable of narrow tasks such as game playing, and Artificial General Intelligence, i.e. AI that surpasses human intelligence, which still remains science fiction). • Be open to engage in collaborative processes to co-design and co-create new products and services based on AI systems to support and enhance the capabilities of human workers on industrials settings, as well as improve services and help making better decisions for the sustainability of operations and respect of the environment.

TEACHING METHODS

Method	Class Workload	Individual Workload	Total
Theoretical Sessions	24	34	58
Laboratory Sessions	24	42	66
Research and writing of an applied project	4	20	24

Written Examinations	2	0	2
TOTAL	**54 hours**	**96 hours**	**150 hours**

EVALUATION

Evaluation Procedure	Percentage on the subject grade
Laboratory Programming Assignments and Reports	35%
Applied Project	30%
Written Examinations	35%
TOTAL	**100%**

In order to pass the course, it is necessary to obtain a minimum mark of 4 out of 10 in each of the three evaluation procedures and 5 out of 10 in their weighted average.

PRECONDITIONS

- Basic skills in programming.
- Knowledge of calculus and mathematics at a level of a graduate student (e.g. matrix and vector calculus, Boolean operations, etc.)

DEPARTMENT	Department of Digitalization
LECTURERS	• Bruno Baruque Zanón • Daniel Urda Muñoz
LITERATURE	• Aggarwal, Ch.C., (2018) Neural Networks and Deep Learning, Springer, 978-3-319-94462-3, https://doi.org/10.1007/978-3-319-94463-0. • Bishop, Christopher M., Neural networks for pattern recognition, 1ª, Oxford University Press, 978-0-19-8538642-6. • Goldberg, David E, (1989) Genetic Algorithms in Search, Optimization, and Machine Learning, Addison Wesley, 0201157675. • Haykin, S. McMillan, (1994) Neural Networks. A Comprehensive Foundation, Macmillan, 0023527617. • Ahn, Chang Wook, (2006) Advances in Evolutionary Algorithms: Theory, Design and Practice, Springer, 978-3-540-31758-6,