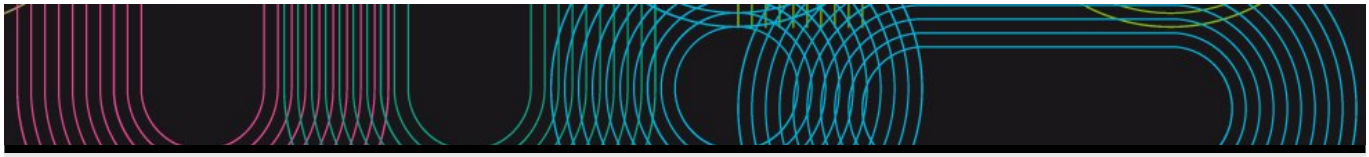

IDENTIFYING DATA				
(*)Deseño de produtos e servizos intelixentes no sector biomédico				
Subject	(*)Deseño de produtos e servizos intelixentes no sector biomédico			
Code	V04M192V01209			
Study programme	Máster Universitario en Ingeniería Biomédica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	4.5	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Comesaña Campos, Alberto			
Lecturers	Comesaña Campos, Alberto			
E-mail	acomesana@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	This subject, developed within the framework of the advanced studies in Biomedical Engineering, aims to train its students in the field of Artificial Intelligence applied to the conceptualization, design, and implementation of intelligent clinical decision support systems, understood and applied to both healthcare products and diagnostic services. To this end, the teaching approach will prioritise, on the one hand, the understanding of the fundamental theoretical concepts underlying models of artificial intelligence, both those based on symbolic reasoning and those based on statistical learning, and, on the other hand, the practical realisation of these articulated models through the design and programming of the information flows of the corresponding algorithms. The content will cover essential knowledge related to the concept of intelligent systems, exploring its meaning and variants, which will involve a methodological exploration of the inherent logics and guiding principles of the different inference processes, in order to subsequently comment on and develop the implementation of intelligent systems through different approaches, covering symbolic and statistical inference processes. Due to the specific nature of the theoretical content of the subject, a gradual and progressive understanding, supported by hermeneutic debate, of the interpretation of propositional and first-order logic, of the concept of uncertainty and risk, of the bases of inference in learning techniques, of the distinction and applicability of the different paradigms of reasoning, of the importance in clinical decision-making of the predictive techniques of artificial intelligence and, in general, of the conceptual design of coherent, robust and reliable intelligent systems will be promoted. All this is aimed at acquiring, understanding and applying the knowledge and cognitive resources necessary to develop the ability to create intelligent system schemes that can be translated into products and services in the biomedical sector, with a proven predictive and preventive capacity, and endowed with reasoning and decision-making abilities. At the end of the course, the student will be able to demonstrate the necessary theoretical and practical competence to create an intelligent product or service that solves a real complex problem in the field of biomedical engineering, which implies facing a problematic issue with a multiplicity of influencing variables, the permanent presence of uncertainty in its traditional variants, a relevant associated risk and, above all, the absence of a valid analytical, experimental or numerical model for its solution. Finally, in addition to the skills and abilities already mentioned, the subject will include transversal training in data processing, programming fundamentals, the collection, analysis and presentation of clinical results and the development of proofs of concept, as well as other knowledge implicit in the study of intelligent systems.			

Training and Learning Results	
Code	
A2	That the students can apply their knowledge and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
A4	Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously.

A5	Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous.
B3	Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
B5	Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works.

Expected results from this subject

Expected results from this subject	Training and Learning Results
Design intelligent products and services applied in the field of biomedical engineering.	A2 A4 B5
Ability to represent human intelligence and experience in order to help solve complex problems and as decision support in biomedicine	A2 A4 A5 B3 B5

Contents

Topic	
1. Intelligent Systems	1.1. Definition of Intelligent System within the field of Artificial Intelligence. 1.2. Intelligent products and services in the biomedical sector. 1.3. Evolution of intelligent systems: from symbolic reasoning to statistical learning methods.
2. Knowledge Representation	2.1. Knowledge-based systems. 2.2. Logical representation of knowledge. 2.3. Principles of propositional and first-order logic. 2.4. Inference mechanisms. 2.5. Applications in products and services for biomedical engineering.
3. Uncertainty and Risk	3.1. Definition in the context of biomedical engineering of engineering decisions. 3.2. Classification and types of uncertainty. 3.3. Decisions with uncertainty. 3.4. Uncertainty management. 3.5. Empirical definition of risk associated with uncertainty. 3.6. Uncertainty and risk in the biomedical sector.
4. Expert Systems	4.1. Definition and theoretical contextualization. 4.2. Types and components of expert systems. 4.3. Development of expert systems. 4.4. Deterministic models and stochastic models. 4.5. Inferential approaches. 4.6. Applications in products and services for biomedical engineering.
5. Machine Learning algorithms. Regression, classification, and clustering algorithms.	5.1. Machine learning: Definition applied to non-connectionist approaches. 5.2. Regression models. 5.3. Classification models. 5.4. Clustering models. 5.5. Data pretreatment. 5.6. Training methods. 5.7. Controlled data augmentation techniques. 5.8. Applications in products and services for biomedical engineering.
6. Neural Networks	6.1. Definition and theoretical contextualization. 6.2. The connectionist paradigm versus the symbolic one. 6.3. Usual types and architectures. 6.4. Training methods. 6.5. Types of learning: supervised, unsupervised, reinforced. 6.6. Applications in products and services for biomedical engineering.
7. Evolutionary Algorithms	7.1. Definition and theoretical contextualization. 7.2. Programming and evolutionary strategies. 7.3. Programming and genetic algorithms. 7.4. Genetic algorithm operators. 7.5. Applications in products and services for biomedical engineering.

8. Decision Support Systems	8.1. Definition and theoretical contextualization. 8.2. Components and development. 8.3. Relationship with intelligent systems. Complementary operation. 8.4. Verification, validation and contrast of results. 8.5. Search for the best hypothesis. 8.6. Applications of biomedical decision systems.
Assignments Practical implementation of an intelligent system on products and services in the field of biomedical engineering. Throughout the assignments, students will be required to design, develop, and conceptually test a new intelligent system that incorporates, at a minimum, a symbolic or statistical inference model. Afterwards, they must apply it as a tool to support clinical decision-making.	1. Definition of the problem within the biomedical engineering sector. 2. Evaluation of its relevance and integration with an intelligent product or service. 3. Search for solutions in the field of artificial intelligence. 4. Identification of criteria, variables, descriptors and any other relevant information. 5. Proposal of conceptual diagram of solution and evaluation of data flow. 6. Implementation of the solution. 7. Validation of results. 8. Dissemination, communication and presentation of the proposed solution.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	15	33
Problem solving	2	0	2
Laboratory practical	8	2	10
Practices through ICT	4	1	5
Objective questions exam	1.5	4	5.5
Essay questions exam	2.5	6	8.5
Problem and/or exercise solving	0	4.5	4.5
Laboratory practice	0	24	24
Report of practices, practicum and external practices	0	20	20
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Lecturing	The theoretical content will be presented by the lecturer during the classes, complemented by discussion and interpretation of the same. They will be coordinated with the planned practical activities.
Problem solving	In a complementary way to the presentation of the theoretical contents, different application exercises will be proposed and developed, which the students will have to solve in a comprehensive and reasoned way.
Laboratory practical	In groups, the students of the course, under the supervision and control of the lecturer, must develop and implement an intelligent system applied to a product or service within biomedical engineering.
Practices through ICT	In the development of the practices of the subject, the students must actively use different information and communication technologies, even implementing some of them.

Personalized assistance

Methodologies	Description
Laboratory practical	Proposition and review of the outcomes of the course activities, aiming to support individually the learning process in small groups of students. An appropriate follow-up will be performed on student's work to verify that the best practices shown in theory classes are applied, and that the procedimental recommendations provided by the lecturer are followed. The tutorial sessions can be carried out using IT tools (email, video-call, Moovi forums, etc.) according to the modality of prior concertation of the virtual place, date and time.

Assessment

	Description	Qualification	Training and Learning Results	
Objective questions exam	During the course, a series of objective and short-answer evaluation questionnaires will be carried out on the theoretical topics, either considering all the topics as a whole or individualizing each of them.	20	A2 A5	B3

Essay questions exam	At the end of the course there is an examination which includes development questions relating to the theoretical and practical content of the course.	25	A2 A5	B3 B5
Problem and/or exercise solving	The problems solved in class, after being checked and corrected, can be collected and supplemented with new ones. All of them will have to be commented on and justified before they are finally handed in. Their understanding, explanation and detailed justification will be assessed.	5	A2 A5	B3 B5
Laboratory practice	In the practices of the subject, an intelligent system must be designed, developed and implemented that responds to a real problem existing in the biomedical engineering sector. Said system will be exemplified and merged with a usual biomedical product or service. Among other issues, the correct definition of the problem, its relevance and degree of complexity, the requirement in the acquisition of knowledge, the identification of variables and criteria, the evolution in the approach to the solution, as well as the degree of autonomy of the student will be assessed and their work in identifying the solution. During the practices, mandatory periodic deliveries and individual and/or group meetings could be considered.	15	A4 A5	B3 B5
Report of practices, practicum and external practices	At the end of the course, a complete technical report of the results obtained during the practical sessions of the subject must be prepared. In this report the solution (intelligent service or product) obtained must be described, justifying it appropriately. It will include, at least, an introduction to the problem, a detailed conceptual and methodological description, an application example, a comparative discussion and some general conclusions. In addition, the commented source code must be submitted in an added file, as well as any other necessary mathematical development. Among other issues, the theoretical justification, the architecture of the solution, its management of uncertainty and the degree to which it solves the problem initially posed will be assessed. Other aspects that will be considered will be the writing, technical presentation, student involvement in classes and work, adjustment to delivery times and the possible presentation and defense of the solution obtained, which is compulsory.	35	A4 A5	B5

Other comments on the Evaluation

The assessment of the subject will include the lecturer's assessment of the student's work, both individual and group, whether face-to-face or remote, weighted as indicated in the Assessment section.

To determine the grade for all the assessment tests, a numerical grading system will be used, with values ranging from 0.0 to 10.0 points, in accordance with current legislation (R.D. 1125/2003, of 5 September, BOE. No. 224, of 18 September). In any case, the subject is considered passed if the grade obtained is at least 5.0 out of 10.

The subject offers two different evaluation modalities in its first evaluation period: continuous evaluation and non-continuous or global evaluation. In the second period, the evaluation is carried out exclusively by means of the corresponding global examination.

Comments for the First Assessment Period / Ordinary Exam Period

The student may follow the above modalities:

- Continuous evaluation modality

In this modality, the student will pass the subject if he/she obtains a minimum of five points (5.0) out of 10 without having to take the corresponding ordinary period examination. Each assessment test is worth 10 points. It is necessary to obtain a minimum of 5.0 points out of 10 in each of the assessment tests and in each part or subpart of those tests in order to pass the subject. Students who do not pass the continuous assessment, i.e. who do not pass each and every one of the assessment tests set, will be required to take the corresponding additional tests and, if applicable, to take the second period examination. This is subject to the considerations and clarifications deemed appropriate by the teacher.

- Non-continuous or global evaluation modality

At the beginning of the course, enrolled students have a deadline set by the School of Industrial Engineering to explicitly opt out of continuous evaluation. In this case, the enrolled student must inform the professor as soon as this has been requested and confirmed.

A student who opts out of continuous evaluation in order to pass the subject must take a single final examination on the date set by the School for the first assessment period, covering all the theoretical and practical content of the subject,

including short answer questions, long answer questions, problem solving and the development of practical scenarios. Additionally, it will be necessary to design and justify the functioning of an intelligent system implemented in a product or service within biomedical engineering. In order to pass the subject, students must achieve an overall mark of at least 5.0 out of 10 in each of these tests.

Comments for the Second Assessment Period / Extraordinary Exam Period

Students who have not passed the subject in the ordinary period by any of the above modalities will have a second opportunity to pass the subject by taking the second period examination on the date set by the School of Industrial Engineering.

The second period examination will cover all the theoretical and practical content of the subject, including short answer questions, long answer questions, problem solving and the development of practical cases. Additionally, it will be necessary to design and justify the functioning of an intelligent system implemented in a product or service within biomedical engineering. In order to pass the subject, students must achieve an overall mark of at least 5.0 out of 10 in each of these tests.

Ethical Behavior

Students are expected to demonstrate appropriate ethical behaviour. In the event of unethical behaviour (cheating, plagiarism, use of unauthorized electronic devices, etc...) it will be assumed that the student does not meet the necessary requirements to pass the subject. In this case, the overall grade for the current academic year will be a fail (0.0). The use of teaching aids or electronic devices during examinations is not permitted unless specifically authorized. Bringing unauthorized materials or electronic devices into the examination room will be considered grounds for failing the subject for the current academic year and the overall grade will be a fail (0.0).

Sources of information

Basic Bibliography

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Fakhreddine O. Karray y Clarence de Silva, **Soft computing and intelligent systems design : theory, tools, and applications**, Pearson-Addison Wesley, 2004

Enrique Castillo , José Manuel Gutiérrez y Ali S. Hadi, **Expert systems and probabilistic network mode**, Springer Science & Business Media, 2012

George J. Klir y Bo Yuan, **Fuzzy sets and fuzzy logic**, Prentice Hall, 1995

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Ian Goodfellow, **Deep learning**, MIT Press, 2017

Andrés Rodríguez, **Deep Learning Systems: Algorithms, Compilers, and Processors for Large-Scale Production. Synthesis Lectures on Computer Architecture**, Morgan & Claypool Publishers, 2020

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Complementary Bibliography

Timothy J. Ross, **Fuzzy logic with engineering applications**, John Wiley & Sons, 2009

Mohssen Mohammed, Muhammad Badruddin Khan y Eihab Bashier Mohammed Bashier, **Machine learning: algorithms and applications**, CRC Press, 2016

Mehmed Kantardzic, **Data mining: concepts, models, methods, and algorithms**, IEEE Press; Wiley, 2020

Kenji Suzuki, **Computational Intelligence in Biomedical Imaging**, Springer, 2014

Radim Bris, Jaroslav Majernik, Krzysztof Pancerz, Elena Zaitseva, **Applications of Computational Intelligence in Biomedical Technology**, Springer, 2006

Rezaul Begg, Daniel T.H. Lai y Marimuthu Palaniswami, **Computational intelligence in biomedical engineering**, CRC Press, 2008

Sachi Nandan Mohanty, **Machine learning for healthcare applications**, Wiley-Scrivener, 2021

Donna L. Hudson y Maurice E. Cohen, **Neural networks and artificial intelligence for biomedical engineering**, Institute of Electrical and Electronics Engineers, 2000

Recommendations

Subjects that it is recommended to have taken before

(*)Estatística avanzada para a enxeñaría biomédica/V04M192V01101

Other comments

It is strongly recommended that students taking this course have prior knowledge of programming, especially in numerical calculation environments.

Likewise, it is recommended that they be able to read, interpret and understand texts written in English.