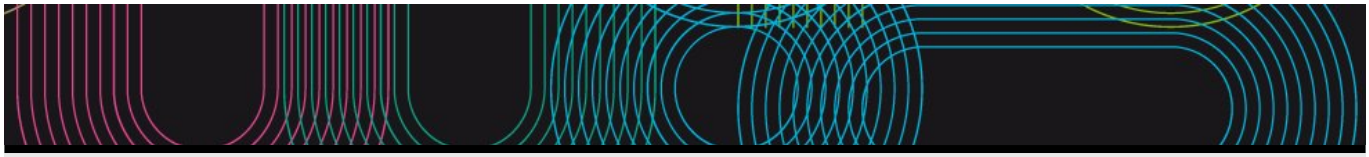

IDENTIFYING DATA				
(*)Deseño de produtos e servizos intelixentes no sector biomédico				
Subject	(*)Deseño de produtos e servizos intelixentes no sector biomédico			
Code	V04M192V01209			
Study programme	Máster Universitario en Ingeniería Biomédica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	4.5	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Comesaña Campos, Alberto			
Lecturers	Comesaña Campos, Alberto			
E-mail	acomesana@uvigo.es			
Web				
General description	This subject, developed in the framework of advanced Biomedical Engineering studies, is aimed at training its students in the field of artificial intelligence applied to the conceptualization, design and implementation of intelligent clinical decision support systems, understood and applied both in health products and diagnostic services. To do this the teaching approach will prioritize, on the one hand, the understanding of fundamental theoretical concepts that underlie artificial intelligence models, both those based on symbolic reasoning and those based on statistical learning, and, on the other hand, the practical realization of these articulated models through the design and programming of the information flows of the corresponding algorithms. The contents will cover essential knowledge related with the concept of intelligent system, delving into its meaning and variants, which will entail a methodical exploration of the inherent logics and guiding principles of the different inferential processes, to subsequently comment on and develop the implementation of intelligent systems through different approaches that will cover symbolic and statistical inferential processes. Due to the inherent particularity of the theoretical contents of the subject, a gradual and progressive understanding will be promoted, supported by the hermeneutical debate, of the interpretation of propositional and first-order logic, of the concept of uncertainty and risk, of the inferential grounds in the learning techniques, of the distinction and applicability of the different paradigms of reasoning, of the meaning within the clinical decision of the predictive techniques of artificial intelligence and, in general, of the conceptual design of coherent, robust and reliable intelligent systems. 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 recreated in products and services within the biomedical sector with proven predictive and preventive capacity and endowed with reasoning capacity and decision. The student of this subject, at the end of the course, must demonstrate the necessary competence, both theoretical and practical, to create an intelligent product or service that solves a real complex problem within the field of biomedical engineering, which implies facing a problematic issues with a multiplicity influence variables, 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 resolution. Finally, in addition to the skills and abilities already exposed, the subject will include transversal trainings in data processing, programming fundamentals, collection, analysis and presentation of clinical results and development of proofs of concept, as well as other knowledge implicit in the study of intelligent systems.			

Skills	
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.

Learning outcomes

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. 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 on products and services	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	4	0	4
Laboratory practical	8	2	10
Practices through ICT	4	1	5
Objective questions exam	1	4	5
Essay questions exam	1	6	7
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 contents will be exposed by the lecturer during the classes complemented through the debate and interpretation of the same. They will be coordinated with the scheduled practical activities.
Problem solving	In a complementary way to the exposition of the theoretical contents, different application exercises will be proposed and solved, which the students must solve in a comprehensive and justified 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 teaching of the subject, a series of objective and short-answer evaluation questionnaires referring to the theory topics will be carried out, either considering all the topics as a whole or individualizing each one of them.	20	A2 A5	B3

Essay questions exam	At the end of the teaching of the subject, an exam will be held that will include development questions related to its theoretical and practical contents.	25	A2 A5	B3 B5
Problem and/or exercise solving	Problems solved in class, after being reviewed and corrected, can be collected and complemented with new ones. All of them must be commented and justified to finally be delivered. Its understanding, explanation and detailed justification will be valued.	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 classes, a complete technical report of the results achieved during the practices of the subject must be made. Said report must describe the solution (intelligent service or product) reached, 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 reached.	35	A4 A5	B5

Other comments on the Evaluation

The evaluation of the subject contemplates the assessment of the student's work, both individually and in groups, face-to-face or non-presential, carried out by the lecturer and weighted as indicated in the Assesment section.
To determine the qualification of all the evaluation tests, a numerical assessment system will be used with values between 0.0 and 10.0 points, in accordance with current legislation (R.D. 1125/2003 of 5th September, BOE. Nr. 224 of 18th September). In any case, the subject is considered passed when the grade obtained equals or exceeds 5.0 points out of 10.
The subject presents two differentiated modalities in its first call for evaluation: continuous evaluation and non-continuous evaluation. In the second announcement or edition, the evaluation will be carried out only through the corresponding exam.

Comments for the First Announcement or edition

The student can follow the modalities previously exposed

- Continuous evaluation modality

In this modality, students will be able to pass the subject if they obtain a mark of five points out of 10 without having to take the test corresponding to the first announcement. Each evaluation test will be valued out of 10 points. It is required to obtain a minimum of 5 points out of 10 in each of the assessment tests and in each part or subpart of said tests. The continuous evaluation modality will have a liberating character referring to those tests already passed, and those tests not passed throughout the continuous evaluation process must be recovered in the first announcement exam. In the same way, those who have passed the subject by the continuous evaluation modality and wish to try to modify the grade obtained in any of the evaluation tests may also take the first announcement official exam. Students who have not passed the continuous assessment must take the first announcement exam under the aforementioned conditions. Those who have not passed any of the continuous assessment tests must examine all the contents of the subject, both theoretical and practical, in the first announcement exam. Said exam may include short-answer questions, long-answer questions, problem solving and development of practical assumptions.

- Non-continuous evaluation modality

At the beginning of the course, enrolled students have a deadline, set by the School of Industrial Engineering, to explicitly waive continuous assessment. In this case, once requested and confirmed, the applicant student must notify the lecturer of this effect.The student who renounces the continuous evaluation to pass the subject must take a single final exam, on the date set by the School for the First Call, which will include all the theoretical and practical contents of the subject and will include short-answer questions, long, problem solving and development of practical assumptions. Students are required to reach a minimum mark of 5.0 points out of 10.0 possible to pass the course.

Comments for the Second Announcement or edition

Those students who had not passed the subject in the First Announcement, in any of the aforementioned modalities, will have a second opportunity to pass the subject by taking the second announcement exam on the date set by the School of Industrial Engineering.The second announcement exam will cover all the theoretical and practical contents of the subject and will include short-answer questions, long-answer questions, problem solving and development of practical assumptions. In addition, it will be necessary to design and justify the operation of an intelligent system implemented in a product or service within biomedical engineering. Students are required to reach a minimum mark of 5.0 points out of 10.0 possible to pass the course.

Ethical behavior

The student is expected to exhibit adequate ethical behavior. In the case of detecting unethical behavior (copying, plagiarism, use of unauthorized electronic devices, and others) it will be considered that the student does not meet the necessary requirements to pass the subject. In this case, the overall grade in the current academic year will be a fail (0.0). The use of any electronic device during the evaluation tests will not be allowed unless expressly authorized. The fact of introducing an unauthorized electronic device in the exam room will be considered reason for not passing the subject in the current academic year and the overall grade will be failed (0.0).

Sources of information

Basic Bibliography

José T. Palma Méndez y Roque Marín Morales, **Inteligencia Artificial Técnicas, métodos y aplicaciones**, 978-84-481-5618-3, McGraw-Hill, 2008

Stuart J. Russell y Peter Norving, **Inteligencia artificial : un enfoque moderno**, 842054003X, 2ª ed., Pearson Prentice Hall, 2004

Enrique Castillo, José Manuel Gutiérrez y Ali S. Hadi, **Expert systems and probabilistic network models**, 0-387-94858-9, Springer, 1997

Fakhreddine O. Karray y Clarence de Silva, **Soft computing and intelligent systems design : theory, tools, and applications**, 0-321-11617-8, Pearson-Addison Wesley, 2004

Ian Goodfellow, **Deep learning**, 9780262035613, MIT Press, 2017

Paul Wilmott, **Machine learning: an applied mathematics introduction**, 9781916081604, Panda Ohana Publishing, 2019

Xin-She Yang, **Introduction to algorithms for data mining and machine learning**, 9780128172179, Elsevier, 2019

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

Jefrey W. Herrmann, **Engineering decision making and risk management**, 978-1-118-91933-0, John Wiley & Sons, 2015

Efraim Turban, Jay E. Aronson y Ting-Peng Liang, **Decision support systems and intelligent systems**, 0-130-46106-7, Pearson/Prentice Hall, 2005

Mehmed Kantardzic, **Data mining: concepts, models, methods, and algorithms**, 9781119516071, IEEE Press; Wiley, 2020

Radim Bris, Jaroslav Majernik, Krzysztof Pancerz, Elena Zaitseva, **Applications of Computational Intelligence in Biomedical Technology**, 9783319191478, Springer, 2006

Kenji Suzuki, **Computational Intelligence in Biomedical Imaging**, 978-1-4614-7245-2, Springer, 2014

Rezaul Begg, Daniel T.H. Lai y Marimuthu Palaniswami, **Computational intelligence in biomedical engineering**, 9780849340802, CRC Press, 2008

Donna L. Hudson y Maurice E. Cohen, **Neural networks and artificial intelligence for biomedical engineering**, 9780470545355, Institute of Electrical and Electronics Engineers, 2000

Sachi Nandan Mohanty, **Machine learning for healthcare applications**, 9781119792598, Wiley-Scrivener, 2021

Complementary Bibliography

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.