Teaching Guide				
Identifying Data				2023/24
Subject (*)	Concurrent. Parallel and Distributed Computation		Code	614G03014
Study programme	Grao en Intelixencia Artificial			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	2nd four-month period	Second	Obligatory	6
Language	Spanish			
Teaching method	Face-to-face			
Prerequisites				
Department	Enxeñaría de Computadores			
Coordinador	Enes Álvarez, Jonatan	E-mail	jonatan.enes@udc.es	
Lecturers	Enes Álvarez, Jonatan	E-mail	jonatan.enes@udc.es	
Web				
General description	In this subject, the student will learn the basic role that the use of parallelism plays when it comes to accelerating the execution of programs in general, and of Artificial Intelligence in particular. The theory knowledge will start with the most basic concepts of parallelism, including its usefulness and applicability, the basic technical context of parallel programs, and the historical evolution (Chapter 1). Next, the main current hardware technologies that are used for parallel processing will be analyzed, includign their underlying technical details that allow to exploit parallelism out of programs (Chapter 2). After this, more advanced concepts regarding parallelism will be introduced, as well as classifications systems, software design patterns that allow to implement parallel programs, and techniques to measure the performance of such programs (Chapter 3). Finally, all of this acquired knowledge will be applied to study the state-of-the-art Artificial Intelligence (Chapter 4). On the more practical side of the subject, the student will complete several sessions with an incremental approach in order to gain the knowledge and ability to program and deploy solutions for parallel processing. These sessions will start with simple technical approaches and abilities, and will progress towards more complete solutions, which will be increasingly related with Artificial Intelligence. In addition, these practical sessions will be self-contained and heavily focused to solving problems or scenarios with several specific techniques or technologies. This subject has a strong dependency with previous subjects like "Fundamentals of Programming I and Fundamentals of Programming II", mostly due to the technical programming ability. To a lesser extent, knowledge from the subject "Fundamentals of Computers" is advisable to understand the empirical behavior and the overall efficiency of some programs.			

Study programme competences / results	
Code	Study programme competences / results
A4	Conocer la estructura, organización, funcionamiento e interconexión de los sistemas informáticos (computador, sistemas operativos y redes de computadores).
A5	Comprender y aplicar los principios y técnicas básicas de la programación paralela y distribuida para el desarrollo y ejecución eficiente de las técnicas de inteligencia artificial.
A6	Capacidad para realizar el análisis, diseño, implementación de aplicaciones que requieran trabajar con grandes volúmenes de datos, aplicando arquitecturas hardware/software adecuadas.
B2	Que el alumnado sepa aplicar sus conocimientos a su trabajo o vocación de una forma profesional y posea las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio.
B5	Que el alumnado haya desarrollado aquellas habilidades de aprendizaje necesarias para emprender estudios posteriores con un alto grado de autonomía.
B7	Capacidad para resolver problemas con iniciativa, toma de decisiones, autonomía y creatividad.

B10	Capacidad para concebir nuevos sistemas computacionales y/o evaluar el rendimiento de sistemas existentes, que integren modelos y técnicas de inteligencia artificial.
C3	Capacidad para crear nuevos modelos y soluciones de forma autónoma y creativa, adaptándose a nuevas situaciones. Iniciativa y espíritu emprendedor.

Learning outcomes			
Learning outcomes	Study programme competences / results		
To understand the interrelationship between operating system's software and the hardware on which it runs.	A4 A6	B10	
To know the different models of parallel systems and their programming	A5	B7 B10	
Be able to develop codes that make optimal use of the hardware resources available on the computer.	A4 A5 A6	B2 B7	
Being able to develop codes that run in parallel systems of concurrent, shared and distributed memory, as well as in hardware accelerators	A4 A6	B2 B7	C3
To understand the importance of development, analysis and optimization of parallel codes in the context of Artificial Intelligence.		B5 B10	C3

Contents	
Topic	Sub-topic
Chapter 1 - Introduction and previous concepts	* The process and sequential program * Lifecycle of a process * Threads * Paralell program * Usefulness of parallelism
Chapter 2 - Hardware parellelism, hierarchy	* Levels of parallelism * Internal processor parallelism (hidden) * Processor functionalities (low-level parallelism) * Processor accessible resources (high-level parallelism) * Pool of machines (Cluster and Supercomputer) * Distributed computing * Specific devices * State of the art of processors
Chapter 3 - Software parallelism, design and implementation	* Flynn taxonomy * Frameworks and languages for parallelism * Key concepts * Paradigms for parallel processing * Parallel programs analysis * Parallel programs design
Chapter 4 - Parallelism for Artificial Intelligence	* Parallelism in IA application * Massive and distributed data processing * Data processing in GPU

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Guest lecture / keynote speech	A4 A5 B5 B10 C3	30	20	50

Laboratory practice	A5 A6 B2 B5 B7 B10	30	50	80
Objective test	A4 B2 B5 B7 B10 C3	3	11	14
Personalized attention		6	0	6
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	Description
Guest lecture / keynote speech	* Theory sessions will introduce the basic knowledge later used on practice sessions. * Other concepts will also be explained in detail, either because they are key to understand the technologies and techniques used on the practice sessions, or because they are more advanced and are crucial to understand the paper that parallelism has on nowadays society.
Laboratory practice	* Each practice lessons will be briefly explained by the teacher on a lesson class, and the students are expected to start it right away. * Practice sessions will be self-contained and will deal with several specific problems or scenarios where parallelism plays an important role and where previously explained techniques or technologies are used. * Each practice will focus on a single scenario or problem and will be composed of previous description and explanation, a proposed code to be analyzed and used, and a series of questions to work on. The student will have to work on the practice, starting on its first practice session and then continuing on its out-of-classroom time. The questions can range from performing an extension of the code, to performing an empirical study of its performance using several parallelism configurations, describing its behavior or functioning, or other types of questions overall focused at assessing the degree to which the student comprehended the problem and the solution.
Objective test	* At the end of the term, and exam will be carried out to evaluate all the subject's knowledge, primarily the concepts from the theory sessions, but also to a lesser extent the ones from the practice sessions.

Personalized attention	
Methodologies	Description
Guest lecture / keynote speech Laboratory practice	* Personalized attention will focus on supporting the students with the overall subject. * On the one hand, personalized attention will be available for those that have some issue understanding any concept exposed on the theory sessions, so that no student has any difficulty in keeping up with the classes and with those topics that will be the subject of evaluation. * On the other hand, personalized attention will also be available for any student that requires some help with specific issues that arise from the practice lessons, whether they are due to technical problems or more deep understanding issues of the key concepts dealt with. Although this help will be available for any practice lesson throughout the term, it is advisable to deal with any doubt or problem either during the practice lesson or shortly afterwards. Those students with an approved dispensation for non-attendance at classes can also benefit by using this personalized attention to ask for the practice briefing as it was given during the ordinary practice classes.

Assessment			
Methodologies	Competencies / Results	Description	**Qualification**

Laboratory practice	A5 A6 B2 B5 B7 B10	* All the practice lessons will be assessed and graded. Such assessments can be individual using a questionare, or in a group through a submission. Groups will be formed previously and once created, can not be changed throughout the course. * The dates and timelines for practice assessments and submissions will be previously informed to the students. _____ ____	50
Objective test	A4 B2 B5 B7 B10 C3	* Written exam carried out individually at the end of the term. * It will mainly evaluate and assess concepts from the theory lessons. * To a lesser point, some questions will also be present to re-asses key concepts from the practice lessons.	50

Assessment comments
In order to pass the subject:a minimum of 40% is required on the objective test, or final exam (2 points out of 5).a minimum of 40% is required on the practice lessons (2 points out of 5).Practice sessions will be NON REPEATABLE for the second chance.Part-time students can attend any practice class group, once it has been previously notified.Part-time students or students with approved dispensation for non-attendance at classes can submit their practice lessons taking into account the longest group-specific deadline available. In case a practice lesson is assessed using a quiz, a different date will be previously negotiated if needed.In order to comply with the current legislation in regards to gender equality, 2 measures will be taken:Parity groups are to be formed, as much as possibleAll the quizzes and the final objective test will be corrected using a blind method in order to assure the student's anonimity.

Sources of information	
Basic	- ---------- (Tema 1). ----------. - Jesús Carretero Pérez (2021). Sistemas operativos: una visión aplicada. Madrid : McGraw-Hill - Francisco Almeida (2008). Introducción a la programación paralela. Madrid : Paraninfo Cengage Learning - ---------- (Tema 2). ---------- . - Sarah L. Harris (2021). Digital design and computer architecture . Amsterdam : Elsevier, Morgan Kaufmann - Julio Ortega Lopera (2005). Arquitectura de computadores . Madrid : Thomson - David A. Patterson (2014). Computer organization and design: the hardware/software interface . Waltham, MA : Morgan Kaufmann - ---------- (Tema 3). ---------- . - Giancarlo Zaccone (2015). Python parallel programming cookbook . Packt Publishing - Jan Palach (2014). Parallel programming with Python . Packt Publishing - ---------- (Tema 4). ---------- . - Tomasz Drabas (2017). Learning PySpark . Packt Publishing - Alberto García García (2020). Programación de GPUs usando Compute Unified Device Architecture (CUDA). Paracuellos del Jarama : Ra-M
Complementary	- William Stallings (2005). Sistemas operativos: aspectos internos y principios de diseño . Madrid : Pearson - Bertil Schmidt (2017). Parallel programming: concepts and practice . Cambridge, MA : Morgan Kaufmann - Peter S. Pacheco (2021). An introduction to parallel programming . Burlington, MA : Morgan Kaufmann - Jorge Luis Ortega-Arjona (2010). Patterns for parallel software design. Sussex, UK: Wiley series in software design patterns - John L. Hennesy (2019). Computer architecture: a quantitative approach. Cambridge, Massachusetts : Morgan Kaufmann - John Cheng (2014). Professional CUDA C programming. Hoboken : John Wiley & Sons

Recommendations
Subjects that it is recommended to have taken before
Programming I/614G03006 Programming II/614G03007 Introduction to Computers/614G03012
Subjects that are recommended to be taken simultaneously
Algorithms/614G03008
Subjects that continue the syllabus
Other comments
It is recommended to have some knowledge and ability to program with Python, as all it will be the language used for all of the practice lessons.It is recommended to have some degree of expertise with a Linux operating system, mainly process and filesystem management.