ANNEXES

to the Inter-University Cooperation Agreement
Between the University of Pisa (Italy) and the University of Malaga (Spain)
for Issuing a Double Master's Degree

CONTENTS

ANNEX A - STRUCTURE AND CONTENTS OF THE "LAUREA MAGISTRALE IN INFORMATICA" AT THE UNIVERSITY OF PISA

The *Laurea Magistrale in Informatica* aims at educating specialists with solid foundations in computer science and high qualification in information technologies. Starting from the academic year 2017/18 the programme is organized into four curricula, with the goal to train professionals with high specialization in key areas of computer science:

- Artificial Intelligence (AI)
- Data and Knowledge: Science and Technologies (KD)
- ICT Solutions Architect (ICT)
- Software: Programming, Principles, and Technologies (SW)

Each curriculum has its own study plan, including a set of mandatory courses and a set of elective courses to be chosen from a specific group. The courses are entirely taught in English.
In the following for each curriculum the overall structure is described, together with the group of elective courses and the contents of the mandatory courses. Next the description of the elective courses is presented. Up-to-date information on the Laurea Magistrale can be found at the follwing URL:
https://www.di.unipi.it/en/education/mcs

Curriculum "Artificial Intelligence (AI)": OVERALL STRUCTURE

FIRST YEAR	Semester	ECTS: 63
Artificial intelligence fundamentals	1	6
Computational mathematics for learning and data analysis	1	9
Machine learning	1	9
Group: AI electives 6 cfu	1	6
Human language technologies	2	6
Parallel and distributed systems: paradigms and models	2	9
Intelligent systems for pattern recognition	2	6
Group: AI electives 9 cfu	2	9
SECOND YEAR		ECTS: 57
Smart applications	1	9
Group: AI electives 9 cfu	1	9
Group: Free choice	1	9
Group: AI electives 6 cfu	2	6
Master's thesis	2	24

Group: AI elective (9 CFU)	Semester	see
Algorithm engineering	1	KD
Data mining	1	KD
Mobile and cyber-physical systems	2	ICT
Group: AI elective (6 CFU)		
Information retrieval	1	KD
Computational neuroscience	2	
Robotics	2	
Semantic web	1	

Curriculum "Artificial Intelligence" (AI): Description of Mandatory Courses

Course Title	Aims and Contents	Cred.	Sem.
Artificial intelligence fundamentals	The course aims to offer a view of the classical/symbolic approach to Artificial Intelligence and serves as a basis for more in depth treatment of specific theories and technologies for building complete A.I. systems	6	1

	integrating different approaches and methods.		
Computational mathematics for learning and data analysis	Students are expected to acquire: some knowledge of the main techniques and methods for the solution of numerical and optimization problems; some understanding of the connections between typical techniques of numerical analysis and optimization algorithms; tools for modeling (through numerical analysis and optimization) specific problems from the following areas: regression and parameter estimation in statistics, approximation and data fitting, machine learning, data mining, image and signal reconstruction.	9	1
Machine learning	The course introduces the machine learning principles and models, including basic theory of learning. The course provides the Machine Learning basis for both the aims of building new adaptive Intelligent Systems and powerful predictive models for Intelligent Data Analysis. The focus is on the critical analysis of the characteristics for the design and use of the algorithms for learning functions from examples and for the rigorous experimental evaluation. The student who successfully completes the course will be able to demonstrate a solid knowledge of the main models and algorithms for learning functions from data, with a focus on Neural Networks and related methods. The student will be aware of the general conceptual framework of modern machine learning; of the basic principles of computational learning processes; of rigorous validation techniques; of the critical characteristics for the use of the learning models to design intelligent/adaptive systems and predictive models for data analysis.	9	1
Human language technologies	The course presents principles, models and the state of the art techniques for the analysis of natural language, focusing mainly on statistical machine learning approaches and Deep Learning in particular. Students will learn how to apply these techniques in a wide range of applications using modern programming libraries.	6	2
Parallel and distributed systems: paradigms and models	The course aims at providing a mix of foundations and advanced knowledge in the field of parallel computing specifically targeting data intensive applications. A first part of the course will provide the necessary background related to the parallel hardware, from multicore to accelerators up to distributed systems such as clusters and cloud. Then the principles of parallel computing will be addressed, including measures characterizing parallel computations, mechanisms and policies supporting parallel computing and typical data intensive patterns. Eventually a survey of existing programming frameworks will be included, aimed at preparing the students to use and exploit the more modern and advanced framework currently used in both research and production institutions. As a result, the student attending the course will be given a general perspective of the parallel computing area as well as a comprehensive survey of the currently available frameworks for data intensive computing.	9	2
Intelligent systems for pattern recognition	The course introduces students to the design of A.I. based solutions to complex pattern recognition problems and discusses how to realize applications exploiting computational intelligence techniques. The course also presents fundamentals of signal and image processing. Particular focus will be given to pattern recognition problems and models dealing with sequential and time-series data. A final project will introduce students to the implementation of a pattern recognition application or to the development of computational intelligence applications.	6	2

Smart applications	The course aim is to explore methods and technologies for the development of smart connected applications, i.e. applications which exhibit intelligent behaviour -- through the use of artificial intelligence techniques introduced in other courses -- and that are deployed in immersive environments, including smart objects (as embodied by Internet of Things devices), mobile devices (smartphones, tablets), wearables (smartwatches, fitness trackers), home automation devices, web technologies, and cloud services and infrastructure. As such, applications considered for the course will include elements of context-awareness, sensor intelligence, spoken-language interfaces, The course will be based around a single case study for a novel smart application.	9	1

Curriculum "Data and Knowledge: Science and Technologies (KD)": OVERALL STRUCTURE

FIRST YEAR	Semester	ECTS: 63
Algorithm engineering	1	6
Data mining	1	9
Information retrieval	1	6
Computational mathematics for learning and data analysis	1	9
Advanced databases	2	9
Bioinformatics	2	6
Parallel and distributed systems: paradigms and models	2	9
Group: KD electives 6 cfu	2	6
SECOND YEAR		ECTS: 57
Group: KD electives 6 cfu	1	6
Group: KD electives 9 cfu	1	9
Group: Free choice	1	9
Group: ICT electives 9 cfu	2	9
Master's thesis	2	24

Group: AI elective (9 CFU)	Semester	see
Human languages technologies	2	AI
ICT risk assessment	2	ICT
Mobile and cyber physical systems	2	ICT
Machine learning	1	AI
Group: AI elective (6 CFU)		
Big data analytics	1	
ICT infrastructures	1	ICT
Peer to peer systems and blockchains	2	ICT
Scientific and large data visualization	1	
Social and ethical issues in computer technology	2	

Curriculum "Data and Knowledge: Science and Technologies (KD): Description of Mandatory Courses

Course Title	**Aims and Contents**	**Cred.**	**Sem.**
Algorithm engineering	The student who successfully completes the course will have the ability to design and analyze (theoretically and experimentally) advanced algorithms and data structures for the efficient solution of combinatorial problems involving all basic data types, such as integers, strings, (geometric) points, trees and graphs. These algorithmic tools will be designed and analyzed in several models of computation— such	6	1

	as RAM, 2-level memory, cache-oblivious, streaming— in order to take into account the architectural features and the memory hierarchy of modern PCs.		
Data mining	The formidable advances in computing power, data acquisition, data storage and connectivity have created unprecedented amounts of data. Data mining, i.e., the science of extracting knowledge from these masses of data, has therefore been affirmed as an interdisciplinary branch of computer science. Data mining techniques have been applied to many industrial, scientific, and social problems, and are believed to have an ever deeper impact on society. The course objective is to provide an introduction to the basic concepts of data mining and the process of extracting knowledge, with insights into analytical models and the most common algorithms. Morover, the course will present advanced techniques which are variants of the basic techniques and will discuss the algorithmical aspects.	9	1
Information retrieval	The student who successfully completes the course will have the ability to design a simple search engine and/or one of the numerous IR tools which are at the core of modern Web applications. The syllabus includes study, design and analysis of IR systems which are efficient and effective to process, mine, search, cluster and classify documents, coming from textual as well as any unstructured domain.	6	1
Computational mathematics for learning and data analysis	See Curriculum AI	9	1
Advanced databases	Data management systems occupy a central position in our information-based society, and computer scientist and database application designers should have a good knowledge about both the theoretical and the engineering concepts that underline these systems to ensure the application performance desired. The student who completes the course successfully will be able to demonstrate advanced knowledge of the main issues related to the implementation of classical centralized relational database and of modern data managemente systems, in order to be a sophisticated user of data management technology and a high-performance applications developer.	9	2
Bioinformatics	This course has the goal to give the student an overview of algorithmic methods that have been conceived for the analysis of genomic sequences. We will focus both on theoretical and combinatorial aspects as well as on practical issues such as whole genomes sequencing, sequences alignments, the search of patterns in biological sequences, the inference of repeated patterns and of long approximated repetitions, the computation of genomic distances, and several biologically relevant problems for the management and investigation of genomic data.	6	2
Parallel and distributed systems: paradigms and models	See Curriculum AI	9	2

Curriculum "ICT Solutions Architect" (ICT): OVERALL STRUCTURE

FIRST YEAR	Semester	ECTS: 63
Advanced programming	1	9
Advanced software engineering	1	9
Algorithm engineering	1	9
ICT infrastructures	1	6
ICT risk assessment	2	9
Mobile and cyber-physical systems	2	9
Peer to peer systems and blockchains	2	6
Group: ICT electives 6 cfu	2	6
SECOND YEAR		ECTS: 57
Group: Free Choice	1	9
Group: ICT electives 9 cfu	1&2	18
Group: ICT electives 6 cfu	1	6
Master's thesis	2	24

Group: ICT elective (9 CFU)	Semester	see
Data mining	1	KD
Machine learning	1	AI
Parallel and distributed systems: paradigms and models	2	AI
Software validation and verification	1	SW
Group: ICT elective (6 CFU)		
Information retrieval	1	KD
Intelligent systems for pattern recognition	2	AI
Scientific and large data visualization	1	
Security methods and verification	2	

Curriculum "ICT Solutions Architect" (ICT): Description of Mandatory Courses

Course Title	**Aims and Contents**	**Cred.**	**Sem.**
Advanced programming	The course aims to provide the students with a deep understanding of how high level programming concepts and metaphors map into executable systems and which are their costs and limitations; to acquaint the students with modern principles, techniques, and best practices of sophisticated software construction; to introduce the students to techniques of programming at higher abstraction levels, in particular component programming and functional programming; to present state-of-the-art frameworks incorporating these techniques.	9	1
Advanced software engineering	The course aims to introduce some the main aspects in the design, analysis, development and deployment of modern software systems. Service-based and cloud-based systems are taken as references to present design, analysis and deployment techniques. DevOps practices are discussed, and in particular containerization is introduced. The course includes a "hands-on" lab where students will experiment weekly the design, analysis, development and deployment techniques introduced.	9	1
Algorithm engineering	See curriculum KD	9	1
ICT infrastructures	The course aims to introduce students to the computing infrastructures powering cloud services. At the end of the course a student should be able to understand the general organization of a datacenter and the	6	1

	logical infrastructure that power virtualization and containers. The course starts from physical infrastructures such as power and datacenter organization. The network fabric is introduced, with particular focus on SDN techniques used to balance East-West and North-South traffic. Storage and compute are then introduced with special attention to hyperconverged systems.		
ICT risk assessment	At the end of this course, the student should be able to discover and analyze the weaknesses and the vulnerabilities of a system to evaluate in a quantitative and formal way the risk it poses. The student should be able to select and deploy a cost-effective set of countermeasures at the various implementation levels to improve the overall ability of the system to withstand its attackers. Focus of the course is on a predictive approach where risk assessment and management is a step in the system design. The student should also be able to know the various tools that can support the assessment and simplify both the assessment and the selection of countermeasures. In this framework, the focus on cloud computing makes it possible to cover the most complex assessment.	9	2
Mobile and cyberphysical systems	The course covers mobile and cyber-physical systems by providing an overview of issues, solutions, architectures, technologies and standards. It offers to the students an overall, coherent view of the organization of IoT systems, from the networking and sensing levels to the applications. Specifically, it shows how mobile, heterogeneous elements (from low-end sensors to high-end devices) form pervasive networks integrated in the internet and how they interact among themselves and with the surrounding physical world.	9	2
Peer to peer systems and blockchains	Introduction of the basic technologies for the development of highly distributed systems and of some real scenarios exploiting them. Presentation of the disruptive technology of blockchains, and its numerous applications to different fields.	6	2

Curriculum "Software: Programming, Principles, and Technologies" (SW): OVERALL STRUCTURE

FIRST YEAR	Semester	ECTS: 63
Languages, compilers and interpreters	1	9
Competitive programming and contests	1	6
Algorithm design	2	9
Principles for software composition	2	9
Group: SW elective 9 cfu	1&2	18
Group: SW elective 6 cfu	1&2	12
SECOND YEAR		ECTS 57
Software validation and verification	1	9
Laboratory for innovative software	2	6
Group: ICT electives 9 cfu	1	9
Group: Free choice	1	9
Master's thesis	2	24

Group: SW elective (9 CFU)	Semester	see
Advanced programming	1	ICT
Advanced software engineering	1	ICT
Computational mathematics for learning and data analysis	1	KD
Machine learning	1	AI

Mobile and cyberphysical systems	2	ICT
Parallel and distributed systems: paradigms and models	2	AI
Smart applications	1	AI
Group: SW elective (6 CFU)		
Bioinformatics	2	KD
Foundations of computing	2	
ICT infrastructures	1	ICT
Information retrieval	1	KD
Security methods and verification	2	

Curriculum "Software: Programming, Principles, and Technologies" (SW): Description of Mandatory Courses

Course Title	Aims and Contents	Cred.	Sem.
Languages, compilers and interpreters	The student who successfully completes the course will be able to contribute to the design and implementation of a modern programming language. The syllabus includes Regular and context-free languages, Recognizers: scanners and parsers, Contextual analysis, Intermediate representations, Symbol table: representation and handling, Functional and procedural abstractions, Static analysis (data flow, control flow, ...), Optimizations and Code generation.	9	1
Competitive programming and contests	The goal of the course is to improve programming and problem solving skills of the students by facing them with difficult problems and by presenting the techniques that help their reasoning in the implementation of correct and efficient solutions. The importance of these skills has been recognized by the most important software companies worldwide, which evaluate candidates in their job interviews mostly by the ability in addressing such difficult problems. A natural goal is to involve the students in the intellectual pleasure of programming and problem solving, also preparing them for the most important international online contests, for internships in most important companies and their interviews.	6	1
Algorithm design	The course focuses on developing algorithmic design skills, exposing the students to complex problems that cannot be directly handled by standard libraries (being aware that several basic algorithms and data structures are already covered by the libraries of modern programming languages), thus requiring a significant effort in problem solving. These problems involve all basic data types, such as integers, strings, (geometric) points, trees and graphs, as a starting point and the syllabus is structured to highlight the applicative situations in which the corresponding algorithms can be successfully applied. Brainstorming activities will be central to help students learning from their mistakes.	9	2
Principles for software composition	This course introduces concepts and techniques in the study of advanced programming languages, as well as their formal logical underpinnings. The central theme is the view of individual programs and whole languages as mathematical entities about which precise claims may be made and proved. The course will cover the basic techniques for assigning meaning to programs with higher-order, concurrent and probabilistic features (e.g., domain theory, logical systems, well-founded induction, structural recursion, labelled transition systems, Markov chains, probabilistic reactive systems) and for proving their fundamental properties, such as termination,	9	2

	normalisation, determinacy, behavioural equivalence and logical equivalence. In particular, some emphasis will be posed on modularity and compositionality, in the sense of guaranteeing some property of the whole by proving simpler properties of its parts. Emphasis will be placed on the experimentation of the introduced concepts with state-of-the-art tools.		
Software validation and verification	The goal of the course is to introduce techniques for verifying and validating software properties, either by analysing a model extracted from a program with model checking, or by testing the software before (the next) deployment, or equipping the running software with tools that monitor its execution.	9	1
Laboratory for innovative software	Practical development of software requires an understanding of successful methods for bridging the gap between a problem to be solved and a working reliable software system. This course will train the student to develop large software systems working in real projects by exploiting the techniques and the skills acquired in the fundamental courses of the curriculum.	6	2

Description of Elective Courses

Course Title	**Aims and Contents**	**Cred**	**Sem**
Big data analytics	This course is meant to put at work the many data analytics technologies and competences: data mining, machine learning, social network analytics, visual analytics in realizing a whole big data analytics project: from acquiring and analyzing big data from multiple sources to the purpose of discovering the patterns and models that explain certain phenomena, till the validation and presentation of the discoveries. The students will be exposed to experience in different domains: mobility and transportation, urban planning, demographics, economics, social relationships, opinion and sentiment, etc.; and on the analytical and mining methods that can be used.	6	1
Computational neuroscience	The objectives of the course include bio-inspired neural modelling, spiking and reservoir computing neural networks, advanced computational neural models for learning, architectures and learning methods for dynamical/recurrent neural networks for temporal data and the analysis of their properties, the role of computational neuroscience in real-world applications (by case studies).	6	2
Foundation of Computing	Students are expected to learn the essential properties of some widely employed models of computation for higher order, concurrency, interaction, mobility. Algebraic semantics and elementary category theory are employed.	6	2
Robotics	The course introduces the fundamentals of robotics, viewed as an application domain for computer science, intelligent systems, and machine learning; provide students with the basic tools to integrate and program a robotic system, with special attention to the realization of perception-action schemes and behaviour control; improve students' experimental work capacity, through the analysis of case studies and laboratory work.	6	2
Scientific and large data visualization	Scientific Visualisation is an area concerned with the visualisation of large and complex data sets, where the data might come from experiments or computations. Visualisation is a way, in many cases the only possible way, to achieve insight and knowledge inside large structured amount of data.	6	1

	The course will discuss discrete models for data representation in low dimensional spaces, scalar and vectorial data in 2D, 3D and for temporal series and algorithms for processing and visualizing massive datasets.		
Security methods and verification	The student who successfully completes the course will be able to demonstrate a good knowledge of security issues that arise in Computer Science and to have an idea of how formal methods can help in addressing them. Furthermore the student will have the ability to read and understand a research paper on formal methods applied to security.	6	2
Semantic web	The course presents Semantic web technologies, making the student able to design and implement knowledge bases based on ontologies encoded with Semantic Web languages, and offered access as Linked Data.	6	1
Social and ethical issues in computer technology	The course aims to provide a thorough overview of the many ethical and social issues raised by computer technology, with particular attention to Artificial Intelligence and its multifarious impact on society and human existence. Students will learn about the most compelling social and ethical challenges posed by information technologies and how to approach them in a rigorous and critical fashion. Conceptual analysis will be supported by discussion of practical case studies.	6	2

ANNEX B - STRUCTURE AND CONTENTS OF THE "MASTER UNIVERSITARIO EN INGENIERIA INFORMÁTICA" AT THE UNIVERSIDAD DE MÁLAGA

OVERALL STRUCTURE

FIRST YEAR	**60**
Management of Technology and Innovation in TIC	4,5
Design and Configuration of Secure Networked Systems	6,0
Data Science and Engineering I	6,0
Application Development in the Cloud	4,5
Technologies for developing IoT systems	4,5
Graphics and Multimedia Systems	4,5
Information System and Technology Strategy Management	7,5
Security and Privacy in Application Environments	4,5
Data Science and Engineering II	4,5
High performance for Data and Cybersecurity	4,5
Infrastructure for Cloud computing	4,5
Industrialization and deployment of IoT systems	4,5
SECOND YEAR	**30**
Optative courses	18
Master's thesis	12

STRUCTURE AND CONTENTS OF THE FIRST YEAR AT THE UNIVERSIDAD DE MÁLAGA

Course Title	**Aims and Contents**	**Cred.**	**Sem.**
Management of Technology and Innovation in TIC	This course focuses on the knowledge and skills aimed at training the relevant technological knowledge responsible for the management and leadership of innovation projects, defining standards for the company and managing relationships with other agencies and businesses.	4,5	1
Design and Configuration of Secure Networked Systems	The main aim of the course is to learn specific aspects related to the design, deployment and configuration of secure networked systems. More precisely, the course will cover network perimetral security and network hardening (firewalls, VPNs and IDSs) as well as operating systems security (Unix and Windows) problems and countermeasures. Further, the course will pay attention to security issues in Trusted Platforms and Virtualization Platforms.	6,0	1
Data Science and Engineering I	Computational and statistical techniques form the core of the modeling and inference phases in the data analysis workflow. The course offers students the theoretical and practical knowledge necessary to face data analysis in the important areas of Machine Learning, Deep Learning, Big Data, or Data Mining.	6,0	1
Application Development in the Cloud	In this course, the students will learn the different service models of Cloud Computing, together with the basics of cloud application development, using	4,5	1

	languages like Java or Pyhton, web development frameworks, and NoSQL databases. In addition, students will get guidelines to choose among different cloud providers the best suited for deploying a particular application, considering also financial issues.		
Technologies for developing IoT systems	Developing an IoT system for a real application is the main objective of this subject. Through this example, we will study the main technologies required for a IoT system, including hardware platforms, sensors and actuators, energy optimization strategies, and communication protocols. Furthermore, the project allows reviewing other aspects, such as requirement definition, technologies integration, standards, planning, teamwork, documentation, etc.	4,5	1
Graphics and Multimedia Systems	Learning of the basics (both technical and mathematical) concepts behind the generation of 3D and stereoscopic computer graphics, and of advanced techniques to combine them with multimedia contents (as, for example, real-time live video grabbing in augmented-reality systems).	4,5	1

Course Title	**Aims and Contents**	**Cred.**	**Sem**
Information System and Technology Strategy Management	Students will acquire skills for making long-term technological decisions. Especially important is to equip students with tools to decide between different products that constitute major software acquisitions for a large company and mark its strategy, the dependencies between them, prioritization, etc.	7,5	2
Security and Privacy in Application Environments	This course covers the study of most common privacy and security threats in different application scenarios such us Mobile, Cloud and IoT, as well as their mitigation strategies. It will focus on how the use of those technologies impact security and privacy.	4,5	2
Data Science and Engineering II	This course aims at introducing students in the Big Data technologies for Data Engineering and Data Science. Thus, the students will learn the differences between NoSQL data models and how to design a data repository for each case. Traditional data sources (relational databases, CVS files, etc.) and NoSQL databases will be the source for data analytics processes that will be introduced with Python.	4,5	2
High performance for Data and Cybersecurity	The main objective of the course is to show the knowledge necessary to carry out an optimization project and improve the performance of an application in the areas of data analytics and cybersecurity. The orientation is eminently practical, showing with simple examples the optimization phases and the most significant techniques, using representative tools of the state of the art. The second part of the course focuses on a collaborative project that will allow students to face, with the knowledge acquired,	4,5	2

	the problem of the optimization of a real application.		
Infrastructure for Cloud computing	his course focuses on the implementation details of infrastructures for cloud computing in a data center including the virtualization of computation, networking and storage services. All the concepts are illustrated by deploying and managing an OpenStack software platform.	4,5	2
Industrialization and Deployment of IoT systems	The objective of the course is to know the most representative technologies and tools to convert a IoT system prototype into a marketable system. Tools for testing and validation will be learned. The technologies for the development of human-machine interfaces for IoT and the integration of these systems in the cloud will be studied. The learning of the contents will follow a methodology based on projects.	4,5	2

STRUCTURE AND CONTENTS OF THE SECOND YEAR AT THE UNIVERSIDAD DE MÁLAGA

Course Title	Aims and Contents	Cred.	Sem.
Subsidiary courses	Every year different subsidiary courses are offered by the MS In the CS among the ones provided in the list reported below.	18	1&2
Master's Thesis		12	1&2

List of possible subsidiary courses that may be offered by the MS in CS at UMA

Specialty in Cibersecurity

Course Title	Aims and Contents	Cred.	Sem.
Computer Forensics	During this course of specialization, the student will acquire the technical skills to carry out computer forensic analysis and those methodologies that are fundamental for the successful training of a forensic computer practitioner. In particular, the course covers in a horizontal manner the different phases of identifying, obtaining, analyzing and presenting electronic evidences. These skills will be consolidated through a complete use case.	4,5	TBD
Malware Analysis	The ability to detect, analyze, understand, control, and eradicate malware is an increasingly important issue at all levels of business and Defense. This course will introduce students to malware analysis techniques through readings and interactive analysis of real samples. Consequently, students will acquire the necessary ability to analyze the presence and behavior of malware through static and dynamic analysis techniques.	4,5	TBD

Security Engineering	This course will address the problem of the creation of secure software-based systems, focusing on engineering and systematic aspects and approaches, such as "security-by-design" and "privacy-by-design". Students will learn the main components of security engineering such as security requirements, processes and standards, modeling, analysis, design, evaluation and documentation, including latest trends such as security compliance, certification and design-for-certification. We will use a Project Based Learning (PBL) methodology in order to ensure that students reinforce the theoretical content by applying it in a realistic project.	4,5	TBD
Secure programming	This course covers the principles and practices of secure programming. Security models, threats, design principles and secure coding practices will be exposed. A developer with the knowledge of these techniques will minimize vulnerabilities in the software, avoiding to be exploited by attackers. The most representative platforms will be considered, from traditional platforms to mobile devices.	4,5	TBD
Advanced Cryptographic Technologies	This course covers the study of most common cryptographic technologies in wireless, mobile and personal communication systems, including design guidelines, weaknesses identification and cryptanalysis. It will particularly focus on wireless personal area networks, RFID systems, sensor and mobile networks, considering the National Scheme for Security as a global reference.	4,5	TBD
Security in Industrial and Cyber-Physical Systems.	The goal of this course is to study common security threats in control applications and industrial scenarios, as well as their mitigation strategies. It will particularly focus on how the use of the new control technologies, and more precisely, Cyber-Physical Systems (integrated processing and communication components), as well as other relevant paradigms such as Industrial Internet of Things and Industry 4.0, have a big impact on security and privacy of critical sectors.	4,5	TBD

Specialty in Data Science and Engineering

Data Storytelling and Visual Thinking	Data is the new oil and, thus, one of the hot topics in the Computer Science's new challenges. This new oil also has to be processed and packed to become such a valuable good. In this subject, we will learn how to achieve the knowledge paradigm, providing visualization metaphors to represent the insights, and building scripts to effectively communicate them, i.e., telling the story behind the raw data.	4,5	TBD
Data Streams Engineering	Nowadays there are many sources of information where data arrive sequentially and at high speed (sensor networks, financial markets, social networks ...). They are called data streams and mining them requires special techniques because of different restrictions (real time, partial data, concept drift, etc.) The students will learn algorithms and techniques used in data stream mining and real-time analytics.	4,5	TBD

Engineering and Data Science in Social Networks	In today's competitive business environment, there is a need for businesses to collect, monitor, and analyse user-generated data on social media sites, to achieve a competitive advantage. In this subject, the student will learn to create a social media analytics framework that allow businesses to compare customer sentiment on social media to understand where businesses are doing well and improve.	4,5	TBD
Deep Learning	The aim of the course is to introduce the importance of modelling, design, and development of intelligent systems in data science and engineering. The following topics will be covered: Deep neural networks; Training for deep models; Convolutional neural networks; Auto-encoders; Recurrent and recursive networks; Reinforcement learning. The students will develop these ideas in practical projects.	4,5	TBD
Big Data	This subject is aimed at providing the students with a practical background on state-of-the-art Big Data technologies including the Apache projects Hadoop, Spark, and Flink. The main focus will be the distributed processing of batch and streaming data sources with these technologies by developing applications with the Scala and Python programming languages.	4,5	TBD
Accelerating Analytics	This course aims at achieving three main goals: i) to provide a high-level survey of key analytics models and algorithms; ii) to analyze the usage patterns of these models; and iii) to discuss HW and SW opportunities for accelerating analytics workloads.	4,5	TBD

ANNEX C - REQUIREMENTS TO OBTAIN THE DOUBLE DEGREE

To get the double degree, students must follow one of the following study plan templates. Each study plan must be approved by the two Universities.

Students from UNIPI:

FIRST YEAR AT UNIPI
Mandatory courses from the corresponding master's curriculum.
SECOND YEAR AT UMA
The student will propose a Learning Agreement (LA) with the programme of studies to be followed at UMA, which must be approved by the student and the coordinators of both UNIPI and UMA during the first year. • The LA will consist of **36** ECTS from the list of topics the student should take in the second year at UMA, based on the list of courses agreed by both coordinators. • The LA will additionally include the Master's thesis[(1)] (**24 ECTS**).

Students from UMA:

FIRST YEAR AT UMA
Mandatory courses corresponding to the first year of the master.
SECOND YEAR AT UNIPI
The student will propose a Learning Agreement (LA) with the programme of the studies to be followed at UNIPI, which must be approved by the student and the coordinators of both UMA and UNIPI during the first year. • The LA will consist of **24 ECTS** from the list of topics the student should take in the second year at UNIPI, based on the list of courses agreed by both coordinators. • The LA will include the Master's thesis[(1)] (**24 ECTS**). • The University of Pisa will recognize **12 ECTS** as "Free choice"[(2)] courses to students who acquired a 4-year BS Degree in Computer Science, in Computer Engineering, in Software Engineering or similar.

In case the UMA student chooses to obtain the UMA Master specialty in "*Data Science and Engineering"*, UNIPI could grant the UNIPI Master Degree with a specialization in "*Data and Knowledge: Science and Technologies"* (KD). For it, the student must take in the second year at UNIPI 24 ECTS detailed as follows:

1) Algorithm Engineering (9 ECTS)
2) Advanced Databases or Machine Learning (9 ECTS)
3) Big Data Analytics (6 ECTS)

In case the UMA student chooses to obtain the UMA Master specialty in "*Data Science and Engineering"*, UNIPI could grant the UNIPI Master Degree with a specialization in "*ICT Solutions Architect"* (ICT). For it, the student must take in the second year at UNIPI 24 ECTS detailed as follows:

1) Algorithm Engineering (9 ECTS)
2) Peer to peer systems and blockchains (6 ECTS)
3) One additional course of 9 ECTS chosen in the group of "ICT electives", namely:
    a. Parallel and distributed systems: paradigms and model
    b. Software validation and verification
    c. Data mining
    d. Machine learning

[(1)] Each thesis will be co-tutored by one supervisor from the University of Pisa and one supervisor from the University of Malaga.
[(2)] The University of Pisa can recognize these 12 credits to students who acquired a 4-year BS Degree in Computer Science, in Computer Engineering, in Software Engineering, or similar.

ECTS grading scale and grade equivalence

ECTS Grade	Definition	UMA grade	UNIPI grade
A	EXCELLENT- outstanding performance with only minor errors	M.H. 10	30 e lode
B	VERY GOOD- above the average but with some errors	SOBRESALIENTE 9-9.9	29-30
C	GOOD- generally sound work with a number of notable errors	NOTABLE 7-8.9	27-28
D E	SUFFICIENT – performance meets minimum criteria SATISFACTORY- fair but with significant shortcomings	APROBADO 5-6.9	18-26
F Fx	FAIL- considerable further work is Required. FAIL- some more work required before credit can be awarded.	SUSPENSO 0-4.9	0-17

Language requirements

Those students whose first language is not English must demonstrate a level of knowledge, spoken and written at a level equal to or higher than B2 according to the European framework of reference for languages.

Joint committee

The members of this committee will be in charge of the organization of the double degree program, participation of students in the program and approval of the student's Learning Agreement. It will be integrated by the UMA and UNIPI master coordinators.