DS&AI

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Curriculum Development in Data Science and Artificial Intelligence

599600-EPP-1-2018-1-TH-EPPKA2-CBHE-JP

Data Science and Artificial Intelligence Curricula in Europe

We teach today's students
With yesterday's knowledge
For a future we don't know.

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Abstract

In this report we survey and identify existing master programmes in Europe in data science and artificial intelligence. It is not intended purely as a description of the current data science and artificial intelligence graduate curricula in Western Europe. Rather, it aims to provide an account of a common core of what a Data Science and Artificial Intelligence Master programme should provide.

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1. Introduction

The average introduction to almost any book is somewhat of a bore

--- Boris Karloff

Across many industry sectors, including retail, agriculture, healthcare, banking, finance, and telecommunications, companies in South Asia are launching initiatives to improve their operations and offerings through data-driven techniques[1]. One of the main success factors in this digital transformation is having the right talent with critical skills in data science and artificial intelligence, with the ability to understand both data processing techniques and the business they are operating in.

1.1 Context

Thailand, Indonesia, and Sri Lanka are middle-income countries within the South Asia region. While data science and artificial intelligence based technologies are gaining traction and becoming strategic priorities these countries are still falling behind regional leaders in the technological market, such as Singapore and Malaysia, while the region as a whole is far behind China. Thailand, Indonesia, and Sri Lanka have well-established and growing higher education systems; increasingly focused on quality improvement. However, they fail in educating people who design, develop, deploy, and train data science and artificial intelligence-based technology, as evident from the acute shortage of data analysts in public and private companies[2,3].

These trends make clear that development of talent and capabilities is needed if data science and artificial intelligence are to reach their full potential throughout the region. The success of political and economic initiatives by governments in the south Asian region to transform the current export based economy into an innovation and knowledge based economy will critically depend on the readiness of the labour force for ICT in general and data-driven technologies in particular.

This document focuses on the identification of master level education in data science and artificial intelligence through Europe. It is not intended purely as a description of the current data science and artificial intelligence graduate curricula Western Europe. Rather, it aims to provide an account of a common core of what a Data Science and Artificial Intelligence master programme should provide. This report is compiled using the input from university European partners of the Erasmus+ project on

[1] *The age of analytics: competing in a data driven world*, McKinsey Global Institute, 2016.

[2] *Artificial intelligence and South-East Asia's Future,* McKinsey Global Institute, 2017.

[3] Mathur, Aneja, Anwar, Shridhar, and Sanchez, *Future of Work in Sri Lanka: Shaping technology transitions for a brighter future*, TANDEM research report, International Labour Organization, pp. 1—98, 2019.

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Data science is concerned with the extraction of useful domain knowledge from large, complex data sets. Drawing on the fields of machine learning and data mining, it provides critical support to decision makers in many professions, allowing them to make decisions based on statistically significant patterns in data. Applications include business intelligence, the detection of anomalies in patterns of behaviour, and for example the analysis of services in cloud computing.

Artificial intelligence is an even broader field concerning the theory and development of computational systems able to perform tasks inspired by human intelligence. We can distinguish three main paradigms within the field of Artificial Intelligence:

1. *symbolic AI* – consisting, among others, of inductive logic programming, robotic process automation and expert and fuzzy systems,
2. *statistical AI* – consisting of decision networks, probabilistic programming (including Bayesian program synthesis), computer vision (activities and image recognition as well as machine vision), natural language processing, and machine learning, and
3. *subsymbolic AI* – consisting of distributed artificial intelligence (including agent-based modelling, swarm intelligence and multi-agent systems), ambient computing, natural computing, multi-objectives optimization, affective computing, embodied intelligence, and autonomous systems.

Today the most widely applied discipline within AI is machine learning, a method of data analysis that automates analytical model building without being explicitly programmed. Machine learning comes in at least three “flavours”: supervised learning, unsupervised learning, and reinforcement learning. Supervised learning refers to methods for learning a model from a set of training data containing both input and output results. Regression and classification are typical examples of supervised learning techniques. Unsupervised learning consists of building a model from a set data, via for example visualization or clustering. Reinforcement learning is about taking actions in an environment so as to maximize some notion of cumulative reward, as for example used in robot navigation and games (including chess, Go, and business games).

1.2 Methodology

The description of existing curricula on data science and artificial intelligence in Europe is based on two questions:
Q1: What is the content of existing DS&AI curricula?
Q2: How is lectured in existing DS&AI curricula (good practices)?

The answer to the above questions has been obtained through a questionnaire sent to around 90 universities in Europe. We divided the universities in three large groups: Western Europe (Belgium, Germany, Netherlands, United Kingdom) Scandinavian region and Eastern countries (Czech Republic, Finland, Hungary, Norway, Poland, Portugal, Romania, Slovakia, Spain, and Sweden), and Balkan and Mediterranean countries (Bulgaria, Cyprus, France, Greece, Italy, Romania, Slovenia, Spain, and Turkey). Except for the Scandinavian region and Eastern countries, the response to the questionnaire was very low (35%, but none from Western Europe and the Balkans and only one from a Mediterranean country), and in some cases (4 out of 90) the universities we approached did not have any master programme related to data science or artificial intelligence. When we got no response, we collected all the information that was available ourselves via their website (although in few countries no information in English was available), and complemented the missing information by means of telephone interviews. In a few cases, we obtained detailed information via email. A copy of the questionnaire used can be found in Appendix A.

2. Data Science and Artificial Intelligence in Europe

Thanks to data science and artificial intelligence,
machines can now be programmed to the next thing right.
But only humans can do the next right thing.
--- Dov Seidman

2.1 Introduction

In agreement with the Framework for Qualifications of the European Higher Education Area Subject benchmark the objective of a master programme Data Science and Artificial Intelligence in Europe is to provide students with a suitable basis for a further career, both in research as well as in industry and society in general. As such, it provides the student with the specific knowledge and abilities, exemplified in the form of a master diploma that allows graduates access to a PhD programme in Artificial Intelligence and related disciplines. Also, it prepares graduates for a position in which they can earn their own subsistence, for example by working in knowledge-intensive companies.

A European Master programme in Data Science and Artificial Intelligence provides sufficient training in independent scientific reasoning, conduct, and communication to reach internationally accepted standards of academic skills at that level. Graduates can communicate original ideas in their own language (and often in English) to a public of specialists and non-specialists. Graduates are provided with the necessary knowledge and tools needed to formulate an informed opinion about the meaning, the ethical, and the social impact of Data Science and Artificial Intelligence in society and they are aware of their responsibility towards society. The above objectives are specified into different sets of learning outcomes or final qualifications. In Europe, the set of learning outcomes must comply with international standards presented in terms of the Dublin descriptors for the master's profile. These are general statements about the ordinary outcomes that are achieved by students after completing a master programme and obtaining a master degree.

The identification of European master programmes in Data Science and Artificial Intelligence is rather tricky because traditionally, the field of artificial intelligence is concerned with the study of cognitive processes that play a role in human perception, reasoning and action, and building intelligent systems. This implies that the field of artificial intelligence is closely related to other disciplines such as computer science, mathematics, psychology, linguistics and philosophy. Similarly, the field of data science belongs to both computer science and statistics. Consequently, there are several specialised study programmes divergent not only with respect to the field they are based on (computational sciences, cognitive science, and statistical science) but also in regard of the application areas (e.g., engineering, life science, and business science).

Most programs have a duration of two years (120 ECTS). There are exceptions, most notably in the United Kingdom, but also in other countries, where programmes have a nominal duration of one year, some worth a total of 90 ECTS, others only 60 ECTS. ECTS are credits representing the workload and defined learning outcomes ("what the individual knows understands and is able to do") of a given course or programme. They have been adopted by most of the countries in the European Higher Education Area. 60 ECTS are the equivalent of a full year of study or work. In a standard academic year credits are usually broken down into several smaller components and assigned to courses, internships and thesis work. The way to assign credits to thesis projects and internships varies and appears programme-dependent. In some cases, thesis and internship are combined together as a unique educational component.

2.2 Curricular aspects

The objective of the master programme is to provide students with a suitable basis for a further career, both in research as well as in industry and society in general. Graduates should be prepared for a number of different roles and careers at key positions in society. They should have

- a basic understanding of all the key areas of Data Science and Artificial Intelligence,
- an advanced understanding in some of the key areas of Data Science and Artificial Intelligence, and
- a specialist knowledge of at least one of the key areas in Data Science and Artificial Intelligence.

Our starting point in this report is a set of core topics and skills, present in a master programme either as a dedicated course or as a substantial topic within one or more courses. We consider core topics, support knowledge and electives. Core topics are defined by master level courses on key areas of data science and artificial intelligence, while the elective courses give additional and specialistic knowledge on these areas. We consider also support modules, and academic skills. While core and elective topics are about courses grounded in data science and artificial intelligence, the support modules are about course or part of it that on a different related discipline that is needed to understand core and elective courses. The academic skills are specific neither to data science, to artificial intelligence nor to related disciplines.

Subject names and content are not standardized. For each programme, the more content related part of the above subjects is defined in terms of topics and learning objectives. The learning objectives of each topic (often divided into more courses) are related to the learning outcomes of the entire programme. The formal framework is provided by the Dublin descriptors, which give an overview of the academic competences of a bachelor (first cycle), master (second cycle) and PhD (third cycle) programme. In all three cycles, these descriptors include the following components: knowledge and understanding, applying knowledge and understanding, making judgements, communication and lifelong learning skills. For a two years master programme the Dublin descriptors are given below.

	Dublin Descriptors Master	**Master (2-years ; 120 ECTS credits ; second cycle ; EQF level 7**[3] Qualifications that signify completion of the master degree are awarded to students who:
D1	Knowledge and understanding	have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within a research context
D2	Applying knowledge and understanding	can apply their knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study
D3	Making judgements	have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements
D4	Communication	can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and nonspecialist audiences clearly and unambiguously
D5	Lifelong learning skills	have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous

For example, the core topic Machine Learning may be described through a set of courses including one on Reinforcement Learning. This course could treat topics such as

- Core techniques and approaches in reinforcement learning
- The multi-armed bandits problem
- Markov decision processes; dynamic programming, Monte Carlo methods
- Approximate solutions, including linear and non-linear function approximation
- Applications and case studies, including AlphaGo and Q learning for game.

The learning objectives depends on the topics but also on the lecturing and the assessment methods. For this course the learning objectives could be

- Understand the key features and components of reinforcement learning;
- Knowledge of theoretical foundations on basic and advanced reinforcement learning techniques;
- Understand the scientific state-of-the-art in the field of reinforcement learning;
- Define an application problem as a reinforcement learning problem;
- Understand how to apply leaned reinforcement learning techniques on a new problem.

[4] Here the abbreviation EQF refers to the European Qualifications Framework. More information can be found at https://ec.europa.eu/ploteus/en/content/descriptors-page

In this case, the first three objectives are related to the Dublin descriptor D1 while the last two are related to D2. The fourth objective is also related to D3.

2.2.1 Core topics

Core topics define the key areas of a curriculum in Data Science and Artificial Intelligence and are therefore present as a dedicated course or as a substantial topic within one or more mandatory courses in the programme. From the data we collected, it is not always obvious which of the 8 key core topics a course covers, and some of the conclusions below are merely our interpretation of the data due to lacking definition in terms of learning objectives and detailed topics of the courses forming a master programme. Without a detailed definition of each course, it is difficult to be certain where the dividing line lies between the areas.

There is a European (and possibly international) consensus that most of our proposed eight core topics define the key areas of data science and artificial intelligence, and are therefore covered by mandatory courses in master programmes. In fact, the great majority of the master programmes we examined have courses related to

- Algorithmic Problem Solving (search, decision making, optimisation)
- Knowledge Representation, Extraction and Reasoning (data mining, deep learning)
- Machine Learning (supervised, unsupervised, reinforcement learning)

A large number of (but not all) master programmes cover other topics such as

- Intelligent Autonomous Agents and Multi-Agent Systems
- Interaction (Perception, Human-Computer Interaction, Communication)

and to a bit less extend computational linguistics. Only few universities have mandatory courses related to cognitive science or about giving the context of artificial intelligence (history, philosophy, and ethics). Important omissions in the above list of key areas are, for example, given by mandatory courses on traditional computer science and mathematical topics, such as databases, computer architectures, information theory, and security. More data science and artificial intelligence area omitted in the above list but covered by some mandatory courses are

- Graph Theory and Network Science (social network analysis, complex networks)
- Probabilistic models and Reasoning under Uncertainty (statistical learning, Bayesian inference, fuzzy logics).

2.2.2 Elective topics

The set of core topics does not need, by itself, to constitute a complete master programme. Every programme may include additional elective topics relating to artificial intelligence, data science,

computer science, cognitive psychology, but also courses related to application areas such as bioinformatics and business analytics.

Most of the European master programmes on data science and artificial intelligence have elective courses on

- Computational Intelligence
- Computer Vision
- Evolutionary Algorithms (Genetic Algorithms, Evolutionary Computing)
- Language and Speech Technology
- Neural Networks
- Text Mining and Information Retrieval
- Reinforcement Learning,
- Robotics

Other electives offered by few European master programmes cover topics on

- Cognition and Cognitive Modelling
- Computational and Cognitive Neuroscience
- Ethical, Legal and Social Aspects of AI
- Perception (Computational and Natural)
- Reasoning under Uncertainty
- Virtual Reality and Gaming
- Web and Artificial Intelligence

2.2.3 Support knowledge

Support knowledge define the basic body of know-how assumed to successfully understand core and elective topics. Only few programmes do not assume any prior knowledge (18% of the programmes in the Mediterranean and Baltic countries!). Virtually all other master programmes assume knowledge coming from Computer Science (Programming in Java, C++ or Python, Algorithms and Data Structures, Databases), and from Mathematics (Calculus, Discrete Mathematics, Linear Algebra, Probability Theory and Statistics). In general, knowledge of Logic (Propositional and Predicate Logic) is not required, perhaps a sign of the current interest of artificial intelligence in statistical and sub-symbolic techniques, methods and tools. By far, most of the master programmes are taught in English, and as a result students from outside the European Union are often required to have an internationally recognized English certificate, like TOEFL or Cambridge.

The majority of the master programmes provide some form of support knowledge as dedicated but not necessarily mandatory courses. This is especially true for courses on programming, database, algorithms and probability theory and statistics.

2.2.4 Academic skills

Apart from knowledge and understanding, every master programme supports, in different forms, the development of a set of general academic skills. Via specific courses or using an appropriate choice of work and assessment methods analytic skills, teamwork, modelling, written and oral communication are considered the most important academic skills, directly followed by empirical methods, argumentation and presentation.

2.3 Didactic aspects

All the programmes we examined have their own didactic principles, sometimes defined at an institute level, or at the university level. Not many documents on didactic aspects were available on the general websites of the programmes, so the information available is somewhat dependent on those programmes that answered our questionnaire. Instead of presenting this partial information, below we give several examples of best practices concerning didactic aspects, not necessarily related to data science or artificial intelligence programmes.

2.3.1 Research-oriented education

The key concept of research-oriented education is to provide education embedded within a research environment. The research orientation is not only reflected in the thesis, but also in several courses, in which students write a scientific essay or paper. All courses are taught by full time faculty members, who are actively contributing to the international scientific endeavour. In this context, the staff is often required to have a University Teaching Qualification (UTQ) certificate as well as an International English certificate. The university often provides possibilities for Advanced University Teaching Qualification certificate.

Several courses and the thesis projects offer opportunities for students to contribute to current research of the staff. Students are stimulated to publish their research in international conferences and journals. An international environment is stimulated through exchange programmes and regular visits of external professors.

2.3.2 Problem-based education

In problem-based education (also known as Project-Centred Learning), the students learn to apply the knowledge they gained in the courses in realistic and challenging projects. In small groups students perform all aspects of medium to large scale projects. The projects can come from a variety of sources, which implies a good connectivity of the programme with companies, for example via internships. The method is typically divided in three parts: case studies, role-playing, and solutions. Case studies are presented to students in some form matching the real world problem, roleplaying has students dividing their tasks as in a real-world situation, and solution involves the development of critical thinking skills and problem-solving abilities.

To build an effective curriculum, explicit attention has to be paid to integration, analysis and application of the courses. The goal is for students to become familiar with the culture of research and the practice as academic professionals.

2.3.3 Student activating education

The underlying didactic concepts of Student Activating Education are self-responsibility, self-management and goal directed education, cooperative learning including the pre-organized and self-organized form, and conceptual learning in a challenging learning environment. Activating methods organize the teaching process, so that the education objectives would be achieved mainly on the basis of students´ own learning. The emphasis is on thinking and problem solving. Methods include face to face teaching in small classes, e-learning, blended learning, and group work.

As for research oriented education, the staff is often required to have a University Teaching Qualification (UTQ) certificate as well as an International English certificate. The use of a foreign language in teaching and of an international and multi-cultural class are seen as other activating methods. The university often provides possibilities for Advanced University Teaching Qualification (ATQ) trajectories in which lecturers further professionalize their didactic skills.

2.4 Conclusion

In this document we focused on the identification of the curricula of master level education in data science and artificial intelligence through Europe. While there is no common international framework describing a curriculum in data science and artificial intelligence most universities tend to agree on what are core courses (programming, knowledge representation and machine learning) and on the topic of the electives offered. Interestingly, many university cover also not technical aspects in data science and artificial intelligence, such as ethical, legal, philosophical, and social ones. Apart from commonalities in knowledge and understanding, all programmes we examined have their own didactic principles and good practices that we have categorized and shortly presented here.

Appendix A Questionnaire for European Curricula

Q1: **Core topics** define the key areas of a curricula in Data Science and Artificial Intelligence. Which of the following core topics and skills are present in your master programme either as a dedicated course or as a substantial topic within one or more *mandatory* courses?

- ☐ Algorithmic Problem Solving (Search, Decision Making, Optimisation)
- ☐ Cognitive Science
- ☐ Computational Linguistics
- ☐ Context of Artificial Intelligence (History, Philosophy, Ethics)
- ☐ Intelligent Autonomous Agents and Multi-Agent Systems
- ☐ Interaction (Perception, Human-Computer Interaction, Communication)
- ☐ Knowledge Representation, Extraction and Reasoning (Data mining, deep learning)
- ☐ Machine Learning (supervised, unsupervised, reinforcement learning)
- ☐ Other, namely: ….

Q2: The set of core topics does not need, by itself, to constitute a complete master programme. Every programme may include additional **elective topics** relating to artificial intelligence, data science, computer science, cognitive psychology, but also to application areas such as bioinformatics and business analytics. Which of the following topics and skills are present in your master programme either as a dedicated course or as a substantial topic within one or more *not necessarily mandatory* courses?

- ☐ Cognition and Cognitive Modelling
- ☐ Computational and Cognitive Neuroscience
- ☐ Computational Intelligence
- ☐ Computer Vision
- ☐ Ethical, Legal and Social Aspects of AI
- ☐ Evolutionary Algorithms (Genetic Algorithms, Evolutionary Computing)
- ☐ Language and Speech Technology
- ☐ Neural Networks
- ☐ Perception (Computational and Natural)
- ☐ Reasoning under Uncertainty
- ☐ Reinforcement Learning
- ☐ Robotics
- ☐ Text Mining and Information Retrieval

- ☐ Virtual Reality and Gaming
- ☐ Web and Artificial Intelligence
- ☐ Others, namely: ….

Q3: **Support knowledge** defines the basic body of know-how needed to successfully understand the programme courses. Which of the following support knowledge are students assumed to have *when starting* your master programme?

- ☐ Programming in Python
- ☐ Programming in Java
- ☐ Programming in C++
- ☐ Programming in other languages
- ☐ Databases
- ☐ Algorithmic
- ☐ Data Structures
- ☐ Digital Systems
- ☐ Propositional and Predicate Logic
- ☐ Calculus
- ☐ Discrete Mathematics
- ☐ Linear Algebra
- ☐ Probability Theory and Statistics
- ☐ Other, namely ….

Q4: Which of the following support knowledge is provided by your master programme as a dedicated but *not necessarily mandatory* courses?

- ☐ Programming in Python
- ☐ Programming in Java
- ☐ Programming in C++
- ☐ Programming in other languages
- ☐ Databases
- ☐ Algorithmic
- ☐ Data Structures
- ☐ Digital Systems
- ☐ Propositional and Predicate Logic
- ☐ Calculus
- ☐ Discrete Mathematics

- ☐ Linear Algebra
- ☐ Probability Theory and Statistics
- ☐ Other, namely ….

Q5: Apart from knowledge and understanding, every master programme support in different form the development of a set of **general academic skills**. Which of the following academic skills is topic in specific course or addressed by an appropriate choice of work and assessment methods throughout the programme?

- ☐ Analytic skills
- ☐ Empirical methods
- ☐ Modelling
- ☐ Teamwork
- ☐ Written and oral communication
- ☐ Argumentation and presentation
- ☐ Others, namely ….

Q6: How many *European Credits* is your master programme?

- ☐ 60 EC
- ☐ 90 EC
- ☐ 120 EC
- ☐ Other, namely ….

Q7: How many European Credits are dedicated to a *mandatory internship*?

- ☐ 0 EC (we do not have a mandatory internship)
- ☐ 1-10 EC
- ☐ 10-15 EC
- ☐ 15-20 EC
- ☐ More than 20 EC

Q8: How many European Credits are dedicated to the *master thesis*?

- ☐ Less than 10 EC
- ☐ 10-20 EC
- ☐ 20-30 EC
- ☐ 30-40 EC
- ☐ More than 40 EC, namely ….

Q9: Which is the *language of instruction* your master programme?

- ☐ English
- ☐ French
- ☐ German
- ☐ Spanish
- ☐ Other, namely ….

Q10: How does your programme ensure the continuing *professionalization of the lecturers* in a manner consistent with your didactic methods?

- ☐ Requiring a University Teaching Qualification (UTQ) certificate for all lectures
- ☐ Providing possibilities for Advanced University Teaching Qualification certificate
- ☐ Requiring an International English certificate
- ☐ Other way, namely ….

Q11: How does your programme organize the *teaching and learning process*?

- ☐ Via summative evaluation procedures (e.g. via oral or written student evaluations at the end of course)
- ☐ Via formative evaluation procedures (e.g via post-course (statistical) analysis of student works, assignments, examinations)
- ☐ Via diagnostic evaluation procedures (e.g. via tests prior to instruction to find students' strengths, weaknesses, knowledge, and skills)
- ☐ Other ways, namely ….

Appendix B European universities we considered

Belgium

Master Artificial Intelligence, KU Leuven

Bulgaria

Master Data Science, Varna Free University "Chernorizets Hrabar"

Cyprus

Master Intelligent Systems, University of Cyprus

Master Business Intelligence and Data Analytics, The Cyprus Int. Institute of Management

Master Data Analytics, UCLan Cyprus

Czech Republic

Technical University of Liberec

Czech Technical University in Prague

Egypt

Robotics, Control and Smart Systems, The American University in Cairo

Finland

University of Oulu

France

Master Artificial intelligence, Sorbonne University

Master Artificial Intelligence, Centrale Supelec

Master Artificial Intelligence & Advanced Visual Computing, École Polytechnique

Master Data Sciences and Business Analytics, ESSEC Business School / Centrale Supelec

Master in Big Data Analytics for Business, IESEQ School of Management

Master Data Analytics and Artificial Intelligence, EDHEC Business School

Master Data Science and Artificial Intelligence, Université Cote d'Azur, Nice

Master Machine Learning and Data Mining, Université Jean Monnet

Germany

Master Robotics, Cognition, Artificial intelligence, Technical University Munich

Master Intelligent Adaptive Systems, Universiteit van Hamburg

Master Automation and Robotics, Universiteit Dortmund

Master Intelligent Systems, Bielefeld University

Greece

Master Business Analytics, Athens University of Economics and Business

Master Business Analytics and Decision Sciences, International Faculty CITY College, The University of Sheffield

Hungary

Budapest University of Technology and Economics

Italy

Master Data Science and Business Analytics, Università Commerciale Luigi Bocconi

Master Data Analytics for Business and Economics, Catholic University of the Sacred Heart

Master Business Analytics and Big Data Professionals, MIP Milan Polytechnic University

Master Digital Technology Management, University of Bologna

Norway

University of Stavanger

NTNU: Norwegian University of Science and Technology

Poland

Warsaw University of Technology

University of Zielona Góra

Wroclaw University of Science and Technology

Gdańsk University of Technology

Opole University of Technology

Portugal

ISCTE – Instituto Universitário de Lisboa

University of Beira Interior

University of Aveiro

Universidade NOVA de Lisboa

University of Lisbon

University of Lisbon

Universidade do Minho

Universidade do Minho

Romania

1 Decembrie 1918 Univeristy of Alba Iulia

Dunarea de Jos of Galati University

Politehnica University Timisoara

Master Artificial Intelligence and Distributed Computing, West University of Timişoara

Master Artificial Intelligence, Politehnica University of Bucharest

Slovakia

Technical University of Kosice

University of Žilina

Slovenia

Master Business Informatics, University of Ljubljana

Master Social Informatics, University of Ljubljana

Spain

University of Deusto

Catholic University of Ávila

Master Science in Management (spec. Business Analytics), Pompeu Fabra University

Master Big Data Management and Analytics, Polytechnic University of Catalonia

Master Artificial Intelligence, Polytechnic University of Catalonia

Master Business Analytics, Ramon Llull University

Master Business Intelligence and Analytics, SolidQ

Master's Degree in Artificial Intelligence, Universitat Rovira i Virgili

Master Computer Security Engineering and Artificial Intelligence, Universitat Rovira i Virgili

Master Artificial Intelligence, University of Barcelona

Master Business Analytics and Big Data, IE University

Sweden

Karlstad University

Chalmers University of Technology

Turkey

Data Science, İstanbul Şehir University

Business Analytics, İstanbul Şehir University

Business Analytics, Sabanci University

Big Data Analytics and Management, Bahcesehir University

The Netherlands

Master Artificial Intelligence, Utrecht University

Master Artificial Intelligence, Universiteit van Amsterdam

Master Artificial Intelligence, Radboud University Nijmegen

Master Artificial Intelligence, Rijksuniversiteit Groningen

Master Cognitive science and Artificial Intelligence, Tilburg University

Master Artificial Intelligence, Vrije Universiteit Amsterdam (VU)

Master Artificial Intelligence, Universiteit van Maastricht

Master Computer Science: Data Science, Leiden University

Master Computer Science: Advanced Data Analytics, Leiden University

United Kingdom

Master Artificial Intelligence, University of Edinburgh

Master Artificial Intelligence, Imperial College London

Master Artificial Intelligence, Queen Mary University London

Master Artificial Intelligence, University of Limerick (Dublin)

Master Artificial Intelligence, University of Aberdeen

Master Artificial Intelligence, King's College London

Master of Cyber Security and Artificial Intelligence, University of Sheffield

Master Artificial Intelligence, University of Leeds

Master Artificial Intelligence, University of Manchester

Master Artificial Intelligence, City, University of London

Master Artificial Intelligence, Heriot Watt University

Master Artificial Intelligence, University of Essex

Master Artificial Intelligence with Robotics, University of Hertfordshire

Master Artificial Intelligence, University of St Andrews

Master Artificial Intelligence, Cardiff University