

EIT Digital Master School

Data Science

What can I study at the entry and exit points?



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Entry - 1st year, common courses

Aalto University (Aalto), Finland

Link to the university: <https://into.aalto.fi/display/eneitictinno/Data+Science+2020-2022>

Contact: Wilhelmiina Hämäläinen; wilhelmiina.hamalainen@aalto.fi

Entry year, autumn semester

Compulsory major courses (19 ECTS)

Code	Course name	Credits
SCI-E1010	Introduction course for Master's students: Academic Skills	1 ECTS
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements	3 ECTS
CS-E4710	Machine Learning: Supervised Methods	5 ECTS
CS-E3190	Principles of Algorithmic Techniques	5 ECTS
CS-E4650	Methods of Data Mining	5 ECTS

Compulsory I&E Courses (7 ECTS)

Code	Course name	Credits
CS-E5120	Introduction to Digital Business and Venturing	3 ECTS
CS-E5130	Digital Business Management	4 ECTS

Optional major courses (select at least 7 ECTS over the two semester)

Autumn courses

Code	Course name	Credits
CS-E5710	Bayesian Data Analysis	5 ECTS
CS-E4850	Computer Vision	5 ECTS

CS-E4190	Cloud Software and Systems	5 ECTS
CS-E5740	Complex Networks	5 ECTS
CS-E4002	Special Course in Computer Science	1-10 ECTS
CS-E4003	Special Assignment in Computer Science	1-10 ECTS
ELEC-E5500	Speech Processing	5 ECTS
ELEC-E5510	Speech Recognition	5 ECTS
31E00910	Applied Microeconometrics I	6 ECTS

Entry year, spring semester

Compulsory major courses (10 ECTS)

Code	Name	Credits
CS-E4800	Artificial Intelligence	5 ECTS
CS-E4890	Deep Learning	5 ECTS

Compulsory I&E Courses (17 ECTS)

Code	Course name	Credits
TU-E4100	Startup Experience	9 ECTS
CS-E5140	Global Business in the Digital Age	4 ECTS
CS-E5430	ICT Innovation Summer School	4 ECTS

Optional major courses (select at least 7 ECTS over the two semesters)

Spring courses

Code	Name	Credits
CS-E4820	Machine Learning: Advanced Probabilistic Methods	5 ECTS

CS-E4830	Kernel Methods in Machine Learning	5 ECTS
CS-E4840	Information Visualization	5 ECTS
CS-E4580	Programming Parallel Computers	5 ECTS
CS-E4002	Special Course in Computer Science	1-10 ECTS
CS-E4003	Special Assignment in Computer Science	1-10 ECTS
MS-C1620	Statistical Inference	5 ECTS
ELEC-E5550	Statistical Natural Language Processing	5 ECTS
30E03000	Data Science for Business	6 ECTS
31C01000	Topics in Economic Theory and Policy	6 ECTS
23E47000	Digital Marketing	6 ECTS

Total for the whole year: 60 ECTS

Note for exit year at partner university: According to Finnish legislation, a master's thesis is a public document and its contents cannot be confidential. Therefore, the material of the thesis must be chosen so that it does not include any information that could be classified as a business secret of the financing company. More information about Master's thesis process for Aalto entry students [here](#).

KTH Royal Institute of Technology (KTH), Sweden

Link to the university: <https://www.kth.se/en>
[Programme](#)

Contact: Henrik Boström; bostromh@kth.se

FIRST SEMESTER

Compulsory courses

- [DD2421 Machine Learning](#)
- [ID2214 Programming for Data Science](#)
- [II2202 Research Methodology and Scientific Writing](#)

Elective courses

- [ID2223 Scalable Machine Learning and Deep Learning](#)
- [DD2257 Visualization](#)
- [DD2423 Image Analysis and Computer Vision](#)
- [DD2434 Machine Learning, Advanced Course](#)
- [DD2447 Statistical Methods in Applied Computer Science](#)

I&E

- [ME1033 Open and User Innovation](#)
One of ME1033, ME2062, ME2094, ME2095 shall be chosen
- [ME2094 Internet Marketing](#)
One of ME1033, ME2062, ME2094, ME2095 shall be chosen

SECOND SEMESTER

Compulsory courses

- [ID2211 Data Mining, Basic Course](#)

Elective courses

- [ID2225 Learning Machines](#)
- [ID2210 Distributed Computing, Peer-to-Peer and GRIDS](#)
- [ID2203 Distributed Systems, Advanced Course](#)
- [DD2476 Search Engines and Information Retrieval Systems](#)
- [DD2437 Artificial Neural Networks and Deep Architectures](#)
- [DD2424 Deep Learning in Data Science](#)
- [DD2418 Language Engineering](#)
- [DD2380 Artificial Intelligence](#)

I&E

- [ME2062 Technology-based Entrepreneurship](#)
One of ME1033, ME2062, ME2094, ME2095 shall be chosen
- [ME2095 e-Business Strategies](#)
One of ME1033, ME2062, ME2094, ME2095 shall be chosen

Technical University of Madrid (UPM), Spain

Links to the university:

- www.fi.upm.es
- <http://www.fi.upm.es/?id=masterdatascience>

Contact: Marta Patiño;

First Semester (30 ECTS):

- I&E 6 ECTS
- Cognitive systems 4.5 ECTS
- Statistical data analysis 4.5 ECTS
- Cloud Computing and Big Data Ecosystems Design 4.5 ECTS
- Big Data 6 ECTS
- Machine Learning 4.5 ECTS

Second Semester (30 ECTS):

- I&E 18 ECTS

Electives (12 ECTS)

- Data Science Seminars 4.5 ECTS
- Data acquisition 4.5 ECTS
- Information retrieval, extraction and integration 4.5 ECTS
- Graph analysis and social networks 3 ECTS
- Deep learning 3 ECTS

Université Côte d'Azur (UCA), France

Link to the university: <http://univ-cotedazur.fr/en>
[Programme](#)

Contact: Francoise Baude; francoise.baude@unice.fr

FIRST SEMESTER

Compulsory courses

(all are taught in English except those with the * sign). Students need to get at least an average mark of 10/20 in a block in order to get the corresponding ECTS.

Data science 1 (6 ECTS, each course inside is accounted for 3 coefficient)

- Modelisation and optimisation in machine learning
- Technologies for massive data

Elective courses

Electives Data science 1 (15 ECTS, each course listed inside is accounted for 3 coefficient)

- Single subject or interdisciplinary project (personal project in group or individual)
- Students can choose courses belonging to some topics structured this way:
- Data processing supporting technologies:
 - Computer networks
 - Relational databases (taught in French)*
 - BD vers big data (taught in French)*
 - Algorithmic approach to distributed computing
 - Parallelism
 - Content distribution in wireless networks
 - Evolving Internet
 - Software architecture for the cloud (taught in French)*
 - Large Scale Distributed Systems
 - Middleware for the Internet of things
 - Peer to Peer
 - Blockchain and privacy
 - Virtualized infrastructure in Cloud computing
- Data modelling and analysis:
 - Data Science (challenges and industrial experiences)
 - Numerical interpolation (taught in French)*
 - Partial differential equations (taught in French)*
 - Stochastic processes (taught in French)*
 - Problem solving introduction and AI Game
- Application of data science
 - Computational Linguistics
 - Data mining for networks
 - Analysis and indexing of images and videos in big data systems: from shallow to deep learning
 - Compression, analysis and visualisation of multimedia content
 - Multimedia data management
 - Web of data
 - Semantic web
 - Knowledge engineering

I&E

Innovation and Entrepreneurship 1 (9 ECTS, each course inside is accounted for 3 coefficient)

- Entrepreneurship Introduction
- Basics in Innovation and Entrepreneurship
- Business Development Lab Introduction

SECOND SEMESTER

Compulsory courses

Data science 2 (9 ECTS, each course inside is accounted for 3 coefficient)

- Temporal series
- Data valorisation
- Computer vision & machine learning

Electives courses

Elective Data science 2 (6 ECTS, each course inside is accounted for 3 coefficient)

- Personal project in group or individual (can be continuation of semester 1 project)

Students can choose courses belonging to some topics structured this way:

- Data processing supporting technologies:
 - Programmation parallèle (taught in French)*
 - Réseaux avancés et Middleware (taught in French)*
 - Communication and Concurrency
 - BD vers Big Data avancé (taught in French)*
 - Software engineering
 - Security (taught in French)*
- Data modelling and analysis:
 - Augmented reality (taught in French)*
 - Optimisation
 - Graphs
- Application of data science
 - Winter school (on Complex networks)

I&E

Innovation and Entrepreneurship 2 (6 ECTS)

- Digital Business
- Digital IP & Law

Innovation and Entrepreneurship 3 (9 ECTS)

- Business Development Lab (coeff 5) and summer school (coeff 4)

Polytechnic University of Milan (POLIMI), Italy

Link to the university: <https://www.mastereit.polimi.it/Programme>

Contact: Paolo Cremonesi; paolo.cremonesi@polimi.it

LIST OF COURSES

ICT - MANDATORY COURSES (21 ECTS)

FIRST SEMESTER

- [089183](#) DATA BASES 2 - 5 ECTS
- [052532](#) SOFTWARE ENGINEERING 2 - 5 ECTS

SECOND SEMESTER

- [052174](#) MACHINE LEARNING - 6 ECTS
- [095898](#) COMPUTING INFRASTRUCTURES - 5 ECTS

ELECTIVE COURSES: 3 choices (15 ECTS)

FIRST SEMESTER

- [052536](#) SOFT COMPUTING - 5 ECTS
- [090950](#) DISTRIBUTED SYSTEMS - 5 ECTS
- [052534](#) RECOMMENDER SYSTEMS - 5 ECTS
- [095943](#) PRINCIPLES OF PROGRAMMING LANGUAGES - 5 ECTS

SECOND SEMESTER

- [089167](#) DATA MINING AND TEXT MINING - 5 ECTS
- [095946](#) ADVANCED ALGORITHMS AND PARALLEL PROGRAMMING - 5 ECTS

I&E MINOR, INNOVATION & ENTREPRENEURSHIP - MANDATORY COURSES (24 ECTS)

- [052795](#) STRATEGY & MARKETING - 10 ECTS
- [052804](#) DESIGNING DIGITAL BUSINESS INNOVATION LAB - 10 ECTS
- 099356 I&E SUMMER SCHOOL - 4 ECTS

Notes:

- The I&E Minor will be increasingly offered in a blended format, with integrative online modules and innovative teaching methods (blended I&E Education).

- In evaluating students' previous BSc studies, the Admission Committee at POLIMI can provide minor directions on the individual study plans, regarding the choice of courses to be attended.

Université Paris-Saclay (UPS) - formerly Université Paris Sud, France

Link to the university: <https://www.universite-paris-saclay.fr/en>

Contact: Isabelle Guyon

LIST OF COURSES:

Our entry point teaches thorough mathematical, technical, and applied skills in Machine learning, in particular geared towards Natural Language Processing (NLP). From the start, we attach great importance to students interacting closely with researchers in our vast computer science laboratory LISN (Limsi + LRI) on current open questions in our field.

T1:

- PRE1: Applied Statistics
- PRE2: Mathematic for Data Science
- PRE4: Scientific programming.
- PRE 3: Datacomp 1 (relational DB)

T2:

- OPT9: Data Camp (challenges).
- TC2: Optimization
- OPT8: History of AI.
- TC0: Machine Learning 1.

T3:

- DS: Distributed Systems.
- TC3: Information Retrieval.
- TC1 - Machine learning 2.
- Projet A (Create a mini-challenge).

T4:

- TC6: Datacomp 2 (Databases)
- OPT 13: Information Theory
- OPT4: Deep learning
- Project B (Resolve a mini-challenge)

Language + EIT Digital I&E Courses + Research training.

Isabelle Guyon - [Chaired Professor of Big Data](#) and INRIA researcher Machine Learning and Optimization (TAU team) Laboratoire de Recherche en Informatique ([LRI](#)) University Paris-Saclay, France. Graduate of [ESPCI](#). PhD in Paris in [Gerard Dreyfus' Lab](#). Worked at [Bell Labs](#) for 7 years, then moved to Berkeley, California. Independent consultant with [ClopiNet](#). Since 2015, Full Professor at Université Paris-Saclay: [Teaching Machine Learning](#) and advising [graduate students](#). Since 2019, coordinating the [CS Artificial Intelligence master program at UPSaclay](#).

Eötvös Loránd University (ELTE), Hungary

Link to the university: <https://www.inf.elte.hu/en/Programme>

Contact: Tomáš Horváth, tomas.horvath@inf.elte.hu

FIRST SEMESTER

Compulsory courses

Introduction to Data Science (5 ECTS, 1st semester)

The course navigates through the basic concepts and principles behind the main data science models and techniques. Descriptive techniques such as clustering and frequent pattern mining are explained in more details while, in case of predictive techniques, the focus is put mainly on the concepts of a model, its parameters and hyper-parameters as well as the quality and validation of models including overfitting-underfitting and the bias-variance trade-offs. Data quality and pre-processing issues related to various data types and modelling problems are also tackled. Finally, basic recommendation techniques and the CRISP-DM methodology are contained in the course as well.

Foundations of Data Science (4 ECTS, 1st semester)

The course focuses on mathematical foundations of data science including basic univariate and multivariate statistics, basic concepts of probability theory, basic concepts from geometry, basic concepts from linear algebra and basic concepts from information theory. The purpose of the course is that students with different backgrounds in the above mentioned disciplines of mathematics receive a compact knowledge necessary for understanding the basic principles and methods in data science.

Data Models and Databases (4 ECTS, 1st semester)

The course is devoted to main concepts, models and principles behind databases. Besides a good knowledge in machine learning, familiarity with various data models and hands-on skills and experience related to database technologies are inevitable in the toolbox of a data scientist. The main topics discussed within the lecture are non-relational data models and database technologies; operational database management systems such that data lakes, data marts and data warehouses; data analytics and on-line analytical processing tools and techniques. Topics related to the efficiency of various models and technologies w.r.t. use-case applications will be also discussed during the course.

Electives courses:

Software Technology (5 ECTS, 1st semester)

Introduction to security analysis methods, including threat modelling and attack modelling both for cyber-attacks, e.g. attacks on software or communication and for physical (or field) attacks, e.g. manipulation of sensor data, GPS signals etc. in autonomous systems.

Cryptographic primitives, mathematical background and scope. Use of appropriate cryptographic tools in protocols. Overview of most important protocols used in networking, especially in the automotive industry. Overview of existing standards and recommendations on safety and security of autonomous driving systems.

<https://www.inf.elte.hu/dstore/document/916/security%20of%20autonomous%20systems.docx>

Design and Analysis of Algorithms (5 ECTS, 1st semester)

Stable matching. Gale-Shapley algorithm. Divide and conquer algorithms. Mergesort. Counting inversions. Closest pair of points. Dynamic programming. Sequence alignment. Knapsack, subset sum and change-making problems. Greedy algorithms. Scheduling problems. Clustering. Approximation algorithms. Load balancing problem. Center selection problem. Randomized algorithms. Quicksort. Quick select. Karger's global minimum cut algorithm.

<https://www.inf.elte.hu/dstore/document/903/Design%20and%20analysis.docx>

Computer Graphics (5 ECTS, 1st semester)

The basic principles and techniques for computer graphics on modern hardware, with special focus on real time applications.

<https://www.inf.elte.hu/dstore/document/901/computer%20graphics.docx>

Image and Signal Processing (5 ECTS, 1st semester)

Signals and systems. Fourier-, Laplace-transform. AD conversion: sampling, quantization. DA conversion, Shannon's formulae. Windowing. Analog and discrete filters, Signal processing in time domain, in frequency domain. Basic concepts and methods of image processing. Edge detection, segmentation. Image reconstruction. Noise reduction.

<https://www.inf.elte.hu/dstore/document/909/image%20and%20signal%20processing.docx>

Introduction to Vehicles and Sensors (5 ECTS, 1st semester)

Principles of autonomous vehicles, and self-driving cars. Hardware and software architectures. Sensors, interconnect networks, actuators, processing elements. Radars, LIDAR's, cameras, ultrasonic, GPS, and other sensors. CAN, LIN, MOST, FlexRay vehicle interconnect networks and architectures. Intelligent transportation systems.

<https://www.inf.elte.hu/dstore/document/911/intro%20to%20vehicles%20and%20sensors.docx>

I&E

- I&E Basics (Barbara Hegyi) – 5 ECTS
- Business Development Lab I. (Udo Bub) – 5 ECTS

SECOND SEMESTER

Compulsory courses

Machine Learning (5 ECTS, 2nd semester)

The course is concerned with deeper explanation of machine learning models and algorithms. Particular interest, besides the main principles of these algorithms and their theoretical background, will be devoted to the hyper-parameters of various algorithms such as their meaning and tuning. The pros and cons of these algorithms w.r.t. various application domains and prediction tasks will be discussed, too. Main topics of the course include decision trees, support vector machines and kernel methods, graphical and probabilistic models, neural networks, factorization techniques, semi-supervised learning, ensemble techniques, bagging, boosting, time-series and text mining.

Optimization for Data Science (4 ECTS, 2nd semester)

The course focuses on basic concepts from optimization and graph theory as well as stochastic processes. The concepts discussed in the lecture form the basis for machine learning techniques since tuning the parameters of a machine learning model is an optimization task. The purpose of the course is that students with different backgrounds in the above mentioned disciplines of mathematics receive a compact knowledge necessary for

understanding the basic principles behind various machine learning techniques and algorithms.

Electives courses

Embedded and Real-Time Systems (5 ECTS, 2nd semester)

Nowadays the usage of a real-time system more and more frequently is needed. Today all of the modern operating systems contain real-time kernel. We shall overview the features of real-time systems, the scheduling types, RT signals and timers. We shall examine its modern appearance in an operating and in an embedded system.

<https://www.inf.elte.hu/dstore/document/905/Embedded%20systems.docx>

Data Mining in Smart Systems (5 ECTS, 2nd semester)

Data pre-processing, preparation (missing value imputation, noise handling and outlier detection, data transformation); clustering techniques (k-means, hierarchical, density-based); frequent pattern and association rule mining (Apriori, Eclat, FP-Growth); prediction models (linear and logistic regression, decision trees, SVM, Bayes models, kernels, matrix factorization); building model ensembles (ensembles, bagging, boosting); model evaluation (overfitting, bias-variance, cross-validation).

<https://www.inf.elte.hu/dstore/document/902/Data%20mining.docx>

3D Computer Vision (5 ECTS, 2nd semester)

Camera models. Feature detection in images. Pattern matching. Camera calibration. Stereo vision. Monocular vision. Simultaneous localization and mapping. Case studies in several application fields of computer vision.

<https://www.inf.elte.hu/dstore/document/896/3D%20computer%20vision.docx>

Artificial Intelligence in Processes and Automation (5 ECTS, 2nd semester)

After this course, the student will (i) understand the connection between low level, i.e., network based AI and high level, i.e., rule based AI (ii) be able to develop stochastic and deterministic models from data (iii) understand control principles and (iv) understand the principles of designing optimal autonomous systems that can learn with state-of-the-art learning algorithms matching or overcoming human performance in industrial environments. Novel AI related software libraries will be introduced.

<https://www.inf.elte.hu/dstore/document/899/Artificial%20intelligence.docx>

I&E

- I&E Specialisation (Barbara Hegyi) – 5 ECTS
- Business Development Lab II. (Udo Bub) – 5 ECTS

University of Twente (UT), The Netherlands

Link to the university: <https://www.utwente.nl/En/>

Programme

Contact: Dr. Maurice van Keulen: <https://people.utwente.nl/m.vankeulen>

As entry year, the following courses are offered (5 EC each):

Core:

[201200044](#) - Managing Big Data

[201400174](#) - Data Science (could also be 10 EC, with additional topics and project [201500363](#))

[201600070](#) - Basic Machine Learning

[201700080](#) - Information Theory and Statistics

[191612680](#) - Computer Ethics

Core I&E courses (shared with other EIT masters):

[201700180](#) - Innovation and Entrepreneurial Finance for EIT students

[201700119](#) - Business Development Lab I

[201700120](#) - Business Development Lab II

Advanced (at least 4):

[201600071](#) - Advanced Machine Learning

[201600076](#) - Foundations of Information Retrieval

[192652150](#) - Service-oriented Architecture with Web services

[192320111](#) - Architectures of Information Systems

[201300074](#) - Research Experiments in Databases and Information Retrieval

[201700081](#) - Probabilistic programming

University of Rennes 1 (UR1), France

Link to the university: <https://istic.univ-rennes1.fr/en>

Mandatory and elective courses

- Innovation and Entrepreneurship Basics (5 ECTS)
- Business Development Laboratory 1 (5 ECTS)
- Basics of Data Analysis (6 ECTS)
- Advanced Databases (4 ECTS)
- Operations Research (5 ECTS)
- Object Oriented Analysis and Design (5 ECTS)
- Intangible assets management (5 ECTS)
- Business Development Laboratory 2 (5 ECTS)
- Summer School (4 ECTS)
- Machine Learning I (5 ECTS)
- Semantic Web Technologies (5 ECTS)
- Database Security (5 ECTS)
- Technological Watch (5 ECTS)

Exit - 2nd year, specialisation

KTH Royal Institute of Technology (KTH), Sweden

Link to the university: <https://www.kth.se/en>

[Programme](#)

Contact: Henrik Boström; bostromh@kth.se or <https://www.kth.se/profile/henbos?l=en>

Specialisation: Distributed Systems & Data Mining for Big Data

The Distributed Systems & Data Mining for Big Data specialisation focuses on providing students with analytical and programming skills to be able to build systems that efficiently process big data. After completing the specialisation at KTH, the students will be able to effectively design and implement systems to handle data at any stage in the data mining process, from batch-oriented to real-time stream processing. Students will be able to write efficient programs that extract useful information from big data. They will acquire deep skills in subfields of data mining such as mining graphs, text and streaming data as well as scalable learning algorithms.

The students work with well-known platforms such as Hadoop, Flink, Spark, GraphLab, Mahout, and H2O. There are frequent guest lectures from the many companies that are active in data science in the Stockholm region (some of which are listed below).

For the 2nd semester, students are offered practical industrial experience in cooperation with Stockholm-based companies, such as Ericsson, Spotify AB, King.com Ltd, Scania and Oracle (MySQL), or research-oriented projects, e.g., at RISE SICS and Ericsson Research. These companies and organisations, as well as several fast-moving start-ups, already cooperate with KTH on data science projects and in the context of this master's programme.

LIST OF COURSES:

Compulsory courses:

ID2221 Data-Intensive Computing	7.5 ECTS
ID2222 Data Mining	7.5 ECTS
ME2096 ICT Innovation Study Project	6.0 ECTS

II2202 Research Methodology and Scientific Writing	7.5 ECTS
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DA258X Degree Project in Computer Science and Engineering, specialising in ICT Innovation, Second Cycle Choose one of DA258X, EA258X	30 ECTS
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EA258X Degree Project in Electrical Engineering, specialising in ICT Innovation, Second Cycle	30 ECTS
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Choose one of DA258X, EA258X

Elective courses:

DD2257 Visualization	7.5 ECTS
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DD2380 Artificial Intelligence	6.0 ECTS
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DD2418 Language Engineering	6.0 ECTS
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DD2423 Image Analysis and Computer Vision	7.5 ECTS
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DD2424 Deep Learning in Data Science	7.5 ECTS
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DD2434 Machine Learning, Advanced Course	7.5 ECTS
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DD2437 Artificial Neural Networks and Deep Architectures	7.5 ECTS
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DD2447 Statistical Methods in Applied Computer Science	6.0 ECTS
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DD2476 Search Engines and Information Retrieval Systems	9.0 ECTS
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ID2203 Distributed Systems, Advanced Course	7.5 ECTS
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ID2210 Distributed Computing, Peer-to-Peer and GRIDS	7.5 ECTS
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ID2225 Learning Machines	7.5 ECTS
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ID2223 Scalable Machine Learning and Deep Learning	7.5 ECTS
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Henrik Boström is professor of computer science - data science systems at KTH Royal Institute of Technology. His research focuses on machine learning algorithms and

applications, in particular ensemble learning, prediction with confidence (conformal prediction) and interpretable and explainable machine learning. He is action editor of the journals Machine Learning and Data Mining and Knowledge Discovery. He regularly acts as senior programme committee member of some of the most prominent conferences in the area, including SIGKDD, IJCAI, AAAI.

Technical University of Madrid (UPM), Spain

Links to the university:

- www.fi.upm.es
- <http://www.fi.upm.es/?id=masterdatascience>

Contact: Marta Patiño;

Specialisation: Infrastructures for Large Scale Data Management and Analysis

The Infrastructures for Large Scale Data Management and Analysis specialisation focuses on how to use large scale data management and big data infrastructures for processing, storing and analysing huge amounts of data as well as building new applications on top of them.

Students will learn:

- How to use data streaming systems, persistent queues, batch processing for large clusters, large distributed databases among other technologies.
- How to combine these tools to build ecosystems in which applications will be able to deal with the large amount of data that is being produced today and that it is increasing at a high pace due to the number of connected devices that will be available and producing data.
- How to gain experience with data analytics in order to get new insights and value from the produced data.

Students will be able to do internships and cooperate with large companies like Telefonica, Indra, Atos and also with startups from UPM in the area of Big Data such as Localidata and LeanXcale. Localidata focuses on the value data chain. LeanXcale provides a leading-edge Real-Time Big Data Analytics platform.

(24 ECTS)

- Data Analysis (4.5 ECTS)
- Large Scale Systems Project (3 ECTS)
- Open Data and Knowledge Graphs (6 ECTS)

- Large Scale Data Management (4.5 ECTS)
- Deep Learning (3 ECTS)
- Massively Parallel Machine Learning (3 ECTS)

Marta Patiño is professor at UPM. She is Distributed Systems co-director and co-founder of LeanXscale startup on Real-Time Big Data analytics. She is also funder member of the research center for Open Middleware. She is co-inventor of 3 patent applications. She has coordinated several national projects and the EU funded projects LeanBigData, CoherentPaaS, and CumuloNimbo. She is co-author of the book Database replication and published over 100 papers in international conferences and journals such as SIGMOD, VLDB Journal, ACM Trans. On Database Systems, ACM Trans. On Computer Systems, IEEE Trans. On Parallel and Distributed Systems, etc. Her research areas include scalable transactional processing, scalable complex event processing, online analytical processing, cloud computing, big data, fault-tolerance.

Aalto University (Aalto), Finland

Link to the university: <https://into.aalto.fi/display/eneitictinno/Data+Science+2020-2022>

Contact: Wilhelmiina Hämäläinen; wilhelmiina.hamalainen@aalto.fi

Exit year, autumn semester

Aalto specialization – Machine Learning, Big Data Management and Business Analytics

Compulsory major courses (9 ECTS)

Code	Course name	Credits
SCI-E1010	Introduction course for Master's students: Career and working life skills	1 ECTS
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements	3 ECTS

Select one of the following:

CS-E4710	Machine Learning: Supervised Methods	5 ECTS
CS-E5710	Bayesian Data Analysis	5 ECTS

CS-E4650	Methods of Data Mining	5 ECTS
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Compulsory I&E Courses (6 ECTS)

Code	Course name	Credits
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CS-E5425	I&E Study Project	6 ECTS
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Optional major courses (15 ECTS)

Code	Course name	Credits	Semester
CS-E3190	Principles of Algorithmic Techniques	5 ECTS	autumn
CS-E5740	Complex Networks	5 ECTS	autumn
ELEC-E5510	Speech Recognition	5 ECTS	autumn
57E00700	Capstone: DigitalISM Challenge	6 ECTS	autumn
CS-E4830	Kernel Methods in Machine Learning	5 ECTS	spring
CS-E4002	Special Course in Computer Science	1-10 ECTS	autumn/spring
CS-C3170	Web Software Development	6 ECTS	autumn
CS-E4875	Research Project in Machine Learning, Data Science and Artificial Intelligence	5-10 ECTS	autumn/spring
CS-E4003	Special Assignment in Computer Science	1-10 ECTS	autumn/spring
CS-E4004	Individual Studies in Computer Science	1-10 ECTS	autumn/spring
CS-E4000	Seminar in Computer Science	5 ECTS	autumn/spring
CS-E4800	Artificial Intelligence	5 ECTS	spring
CS-E4840	Information Visualization	5 ECTS	spring
CS-E4580	Programming Parallel Computers	5 ECTS	spring
23E47000	Digital Marketing	6 ECTS	spring

30E03000	Data Science for Business I	6 ECTS	spring
CS-E4890	Deep Learning	5 ECTS	spring
CS-E4850	Computer Vision	5 ECTS	autumn
MS-C2128	Prediction and Time Series Analysis	5 ECTS	autumn
ELEC-E8125	Reinforcement Learning	5 ECTS	autumn

Total: 30 ECTS

Exit year, spring semester

Code	Course name	Credits
CS.thes	Master's Thesis	30 ECTS

Total: 30 ECTS

Total for the whole year: 60 ECTS

Université Côte d'Azur (UCA), France

Link to the university: <http://univ-cotedazur.fr/en/Programme>

Contact: Francoise Baude; francoise.baude@unice.fr

Specialisation: Multimedia and Web Science for Big Data

LIST OF COURSES: (all are taught in English despite the title in French).

Students need to get at least an average mark of 10/20 in a block (please see the * sign) in order to get the corresponding ECTS

COMPULSORY

- UE 1 "Unité d'enseignement 1" (course block) Total 6 ECTS, each course inside has coefficient 2)
 - Technologies for massive data
 - Compression, analysis and visualization of multimedia content
 - Analysis and indexing of images and videos in big data systems: from shallow to deep learning
- UE 3 "Unité d'enseignement Project"
 - Personal project in data science (6 ECTS)
- UE I&E (Total 6 ECTS)
 - I&E study (belongs to the I&E minor) (6 ECTS)

ELECTIVES

- UE 2 "Unité d'enseignement Options" Elective course block (Total 12 ECTS, each course inside coefficient 2 or 4)

Students can choose courses belonging to some topics structured this way:

[Frédéric Précioso](#)

Full Professor at University Nice-Sophia Antipolis

From September 2011, with University Nice-Sophia Antipolis (UNS) at Ecole Polytech Nice-Sophia, Head of MinD (Mining Data) research group in Machine Learning and Data Mining. Research Lab: I3S Laboratory, Team SPARKS.

Research interests: kernel-based SVM, Boosting, Ensemble Learning, Random Forest, Artificial Neural Networks, Deep Learning, (Inter-)Active learning, Long-term learning, Large Scale learning, Machine Learning. Hybridization, Pattern Recognition.

Research contexts: Multimedia Indexing/Classification, Content-Based Multimedia Retrieval, Text mining, Applications to Bio-Medical data, Application to environmental data, Application to sensor networks.

From September 2018, scientific programme leader at the the French National Research Agency (ANR), in the digital and mathematics department, responsible for programmes in particular, in AI.

[Lionel Fillatre](#)

Full professor at the University Nice Sophia Antipolis in the I3S laboratory ("Laboratoire d'Informatique, Signaux et Systèmes de Sophia Antipolis"), Team SIS (Signal, Images et Systèmes). His current research interests include statistical decision theory, machine learning, signal and image processing, and bio-inspired data processing.

At the Polytech Nice Sophia-Antipolis engineering school, he leads the Data Science option affiliated with both Mathématiques Appliquées et Modélisation and Sciences Informatiques departments.

[Françoise Baude](#)

Full professor at the University Nice Sophia Antipolis in the I3S laboratory ("Laboratoire d'Informatique, Signaux et Systèmes de Sophia Antipolis"), Team COMRED, SCALE group. Her research interests include distributed systems in general, parallel and distributed programming and data stream processing systems. Since 2016, she is an elected member of the academic council and research commission of the UNS.

At the Polytech Nice Sophia-Antipolis engineering school, she leads the Data Science Entry and Exit point tracks of the EIT Digital Master School.

[Fabien Gandon](#)

Research Leader

Université Côte d'Azur, Inria, CNRS, I3S, France

Senior Researcher and Research Director at Inria

Research topics: Artificial Intelligence, Knowledge Representation, Semantic Web, Linked Data, Ontologies

Leader of the Wimmics research team at Inria in the Research Center of Sophia-Antipolis and I3S CNRS,

University Côte d'Azur, Nice - Sophia Antipolis, France.

Director joint research Laboratory QWANT-Inria

Advisory Committee representative of Inria at the World-Wide Web Consortium (W3C)

Representative of Inria in the Web Science Trust Network

Leader research convention French Ministry of Culture-Inria

- Data modelling and analysis:
 - Statistical learning methods (4)
 - Statistical computational methods (4)
 - Data science (challenges and industrial experiences) (2)
 - Data mining (2)
- Data processing supporting technologies:
 - Large scale distributed systems (2)
 - Middleware for the Internet of Things (2)
 - Blockchain and privacy (2)
 - Peer to peer (2)
 - Virtualized infrastructure in cloud computing (2)
- Application of data science, in particular on multimedia content and data on the web
 - Data mining for networks (2)
 - Web of data (2)
 - Semantic web (2)

- Knowledge engineering (2)
- Sécurité des applications web (in French) (2)
- Ingénierie 3D* (taught in French) (2)
- 3D engineering* (taught in French)
- Multimedia content management
- Images advanced management* (taught in French)

Eötvös Loránd University (ELTE), Hungary

Link to the university: <https://www.elte.hu/Programme>

Contact: Tomáš Horváth; eszterkiss@inf.elte.hu

Specialisation: Real-time Data Analytics

The Real-time Data Analytics specialisation focuses on state-of-the-art solutions for supporting real-time data driven decision making. The (research) areas covered by the specialisation concern stream mining, sensor data analytics, complex event processing and network analysis.

Real-time data analytics can be found in many application domains ranging from Industry 4.0 through business to healthcare, playing a crucial role in areas such as control systems of self-driving cars, prediction of assembly line malfunctions, fraud detection in financial transactions or early recognition of anomalies in health monitoring.

Students will be familiarised with:

- Large scale and in-memory databases.
- The ecosystem of distributed processing and its components with particular focus on open source development of these components.
- Business analytics and reporting tools over aggregated data from multiple sources
- Visual analytics tools and their components.
- The utilisation and adaptation of machine learning and data mining methods in real-time scenarios.

Students will learn to use and utilise open-source technologies such as Hadoop, Spark, Flink, ElasticSearch, Kibana or Tableau, just to name a few. In addition to good theoretical basics of clustering, prediction, pattern mining and pattern recognition techniques, students will have a chance to gain practical experiences during internships at our industrial partners with whom we have well-established cooperation.

Courses (25 ECTS)

Stream Mining (5 ECTS)

The course is devoted to processing and mining data streams in which data, arriving at high speed, are processed under various space and time constraints. Typically, data are processed with one pass by the algorithm taking into account that data may evolve over time. The course will cover topics of data stream clustering and classification, frequent pattern mining from data streams, change detection and forecasting in data streams, and indexing and distributed mining of data streams.

Sensor Data Analytics (5 ECTS)

The course is concerned with analysis of data originating of sensors of various types under the presence of uncertainty due to errors and noise in data collection and transmission. Often, in-network processing is required such that the data are processed in the network of sensors itself instead of utilising a centralised solution. Main topics of the course include noise reduction and data cleaning, object detection and recognition, pattern mining, prediction and forecasting, and in-network computing while considering various types of data such as time series, audio and video.

Network science (5 ECTS)

The course is devoted to investigation of complex structures such as, among others, computing, communication, transportation, social, biological or spatial networks, with particular interest in analysis, mining and visualization of networks.

Advanced Machine Learning (6 ECTS)

The course focuses on advanced machine learning approaches and their application in various areas with particular interest in deep learning architectures, kernel methods, graphical models, Bayesian techniques, reinforcement learning, scalable latent models, semi-supervised learning, ensemble techniques, transfer learning and other state-of-the-art approaches.

Open-source Technologies for Real-time Data Analytics (4 ECTS)

During the course, students will be familiarised with state-of-the-art open-source technologies suitable for real-time data analytics with particular interests in thorough analysis of their advantages and disadvantages with relation to various use-case domains and applications. After completing the course students will be able to assemble complex workflows covering tasks from large-scale data collection and storage to big data analytics.

Tomáš Horváth is the head of the Data Science and Engineering Department, established in September 2016 by Deutsche Telekom, of the Faculty of informatics of the Eötvös Loránd University in Budapest, Hungary. He received his MSc and PhD degrees at the Pavol Jozef Šafárik University in Košice, Slovak Republic, in 2002 and 2008, respectively. He was on a post-doc internship at the Information Systems and Machine Learning lab of the University in Hildesheim, Germany, from 2009 to 2012. From 2015 to 2016 he received a post-doc grant at the Department of Computer Science, University of São Paulo in São Carlos, Brazil. His research interests include relational learning, rule-based and monotone classification techniques, pattern mining, recommender systems and personalization. Recently, he is focusing his work on meta-learning techniques and automated machine learning approaches.

Université Paris-Saclay (UPS) - formerly Université Paris Sud, France

Link to the university: <https://www.universite-paris-saclay.fr/en>

Contact: Isabelle Guyon

Our exit point will provide in-depth theoretical and technical skills in Natural Language Processing (NLP), image processing, and large-scale machine learning. Dedicated classes allow students to deepen their knowledge in big-data topics or in NLP, including for instance : deep learning for NLP, speech recognition for natural interaction, dialogue systems, multilingual models, image mining.

T1:

- OPT2: Image Understanding
- OPT 10: Image Mining
- TC5: Signal Processing
- TC4: Probabilistic Generative Models

T2:

- OPT 11: Deep Learning For NLP
- OPT3: Reinforcement Learning
- OPT1: Graphical Models
- OPT5: Voice Recognition and Automatic Language Processing

T3:

- OPT6: Learning theory and Advanced Machine Learning
- OPT7: Advanced optimization
- OPT 14: Multilingual Natural Language Processing
- OPT 12: Text Mining and Chatbots

T4:

4-6 months internship in one of many industrial partners in the Paris region in a research lab.

Language + EIT Digital Career seminar + seminars + EIT Digital I&E Courses

Isabelle Guyon - [Chaired Professor of Big Data](#) and INRIA researcher Machine Learning and Optimization (TAU team) Laboratoire de Recherche en Informatique ([LRI](#)) University Paris-Saclay, France. Graduate of [ESPCI](#). PhD in Paris in [Gerard Dreyfus' Lab](#). Worked at [Bell Labs](#) for 7 years, then moved to Berkeley, California. Independent consultant with [ClopNet](#). Since 2015, Full Professor at Université Paris-Saclay: [Teaching Machine Learning](#) and advising [graduate students](#). Since 2019, coordinating the [CS Artificial Intelligence master program at UPSaclay](#).

University of Trento (UNITN), Italy

Link to the university: <http://www.unitn.it>

[Programme](#)

Contact information: eitmaster@unitn.it

Specialisation: Big Data Variety and Veracity

Data Science has increasingly become an integrated approach where modern scientists analyse data collected from many different sources. Before this data can be leveraged by data analytics, it has to be cleaned, transformed and integrated. This kind of data preparation is challenging, laborious, time consuming and error-prone. It is estimated to cost data scientists 50% and 80% of their time and effort. The reason is the heterogeneity and quality issues that inherently exist in the data. It, thus, comes as no surprise that Variety and Veracity are considered two fundamental characteristics of Big Data (alongside Volume and Velocity).

The Big Data Variety and Veracity specialisation at the University of Trento aims at providing the students with all the necessary knowledge to be able to understand, use, and develop tools, techniques and methodologies for efficiently and effectively coping the variety and the veracity of big datasets. Throughout the courses the students will learn about the different kinds of challenges faced in real scenarios, the existing algorithmic approaches, the software solutions that are available, the commercial tools that one can use, and the evaluation methodologies that can be applied. At the end of the programme, they will be able to identify the data management challenges in real-world situations, select the best solution for the task at hand, and apply that solution successfully.

In the first semester, the students will take a number of technical courses that will provide them with the necessary specialisation foundations. The lectures are often enriched by external experts from industry and academia. In the second semester the students will obtain their industrial experience by performing their internship in a company and also materializing their thesis work, which may be on a separate topic than the internship or a related topic that can be seen as an extension of the internship work.

LIST OF COURSES:

1st Semester:

I&E Studies	6 ECTS
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Plus 3 courses from the following list (that have not already taken during the first year of studies):

Quantum Machine Learning	6 ECTS
Data Mining	6 ECTS
Knowledge and Data Integration	6 ECTS
Web Architectures	6 ECTS
Affective computing	6 ECTS
Privacy and Intellectual Property Rights	6 ECTS

2nd Semester:

Thesis & Internship	30 ECTS
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University of Twente (UT), The Netherlands

Link to the university: <https://www.utwente.nl/En/>

Programme

Contact: Dr. Maurice van Keulen: <https://people.utwente.nl/m.vankeulen>

Specialisation: Data Science for Persona Information.

Main topics in courses as well as in final projects are covered such as: health and sports, wellbeing, biometrics and privacy.

With this master program, the students will get acquainted with and work on the following topics: big data, data analytics, information inference, machine learning, context-aware applications, smart services. With data science, one learns how to dig for value in data by analysing various data sources. With service engineering, one learns how to design services that effectively use system capabilities to satisfy user needs and requirements. Information systems that can use the results of data science to get more value out of data and become context-aware may turn traditional services into smart services. Applications of this in various domains such as pervasive health, well-being, intelligent transportation, logistics, and business intelligence.

The variety of subjects arises from the fact the program has different flavours and hence allows the students to have an orientation towards each of them, being a mathematical, a computer science, an electrical engineering and a business information flavour.

The exit point will provide, in-depth theoretical and technical skills for becoming:

- a) specialist in specific kinds of data, such as natural language text, image data, geographic data, sensor data, networked data
- b) designer of smart services
- c) designer of data science algorithms
- d) multi-disciplinary.

Apart from the final project, elective courses are available such as:

[201600028](#) - Telemedicine and Data Analysis for Monitoring

[201500222](#) - Technology for Health

[201500132](#) - Remote Monitoring and coaching

[201400353](#) - Signals with Information

[201500040](#) - Introduction to Biometrics

[191210910](#) - Image Processing and Computer Vision

[201100254](#) - Adv. Comp. Vision & Pattern Recognition

[201700075](#) - Internet of Things

Remote Monitoring and Coaching

I&E minor thesis

Data Science group

Education and research in this setting of Data Science requires a fundamental interdisciplinary approach bridging fields like computational statistics, machine learning, image and signal processing, information retrieval, and data processing and management. Therefore a group was formed to focus on this. The mission of the group is to work on explainable data science by developing methods for autonomous, reliable and robust gathering, preparation, and analysis of the data, to enable relevant, trustworthy and explainable results.

<https://www.utwente.nl/en/eemcs/ds/>

University of Rennes 1 (UR1), France

Specialisation: Artificial Intelligence & Data Mining for Business Intelligence

Our exit year focuses on artificial intelligence methods in general, and data mining in particular, to address the challenges of business intelligence. Those challenges include numerous tasks that are covered by our courses, such as pre-processing and storing decisional data in data ware-houses, managing Big Data in the cloud, learning models and perform inferences, mining knowledge out of data, and visualizing both data and learned knowledge. The focus is put on the data science methodology rather on the arcane details of specific methods, although the courses will bring fundamental knowledge about the main AI & data mining methods.

The students will learn to analyse a business intelligence problems, and to make the appropriate choices among the numerous existing methods and tools. They will also learn to conduct the data science workflows, and to analyse the results in cooperation with domain experts. At Univ. Rennes 1, we have already built for decades a strong enterprise culture where students acquire competencies for communicating with non-IT domain experts, especially in business. Those competencies are highly valued and recognized by companies, who are also involved in the continuous improvement committee of the existing cursus on which this master is founded.

Our specialisation is backed by IRISA, one of the biggest computer science research lab in France with 800 people. Two research departments and 12 research groups are related to

data science. Most teachers in the master are also researchers in one of those groups, ensuring quickly evolving course contents.

Mandatory and elective courses

- I&E study (6ECTS)
- Machine Learning II (5 ECTS)
- Data Mining (5 ECTS)
- Indexing and Visualization (3 ECTS)
- Datawarehouses (3 ECTS)
- Cloud and Big Data Management (3 ECTS)
- Case Study in Data Science (5 ECTS)
- Master Thesis (30 ECTS)



EIT Digital

We believe in making and shaping a competitive digital Europe that is inclusive, fair and sustainable and aim at global impact through European innovation fueled by entrepreneurial talent and digital technology.

We embody the future of innovation by mobilizing a pan-European multi-stakeholder open-innovation ecosystem of top European corporations, SMEs, startups, universities and research institutes, where students, researchers, engineers, business developers and investors address the technology, talent, skills, business and capital needs of digital entrepreneurship.

We build the next generation of digital ventures, digital products and services, and breed digital entrepreneurial talent, helping business We build the next generation of digital ventures, digital products and services, and breed digital entrepreneurial talent, helping business and entrepreneurs to be at the frontier of digital innovation by providing them with technology, talent, and growth support:

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