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DeCAIR

# DeCAIR: Developing Curricula for Artificial Intelligence and Robotics

## *Report on Surveying International M.Sc. Programs in AI and Robotics*

## Activity Information

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| **Work Package** | WP1 – Surveys and Needs Identification |
| **Task** | 1.2 Survey and evaluation of similar AI and robotics master programs |
| **Activity Coordinator** | UJ (Ramzi Saifan) |
| **Participating Partners** | UJ, JUST, LU, UGR, UNIGE, UST, UNIPI |
| **Objective(s)** | • Surveying international AIR M.Sc. programs to identify their main attributes in terms of curriculum, syllabi, resources, faculty members' expertise and collaboration with industry. |
| **Due Date** | March 7th |

## Instructions

1. Activity coordinator is to coordinate with the focal point of JUST and LU to collect information of **eight** international AIR **M.Sc. programs**. EU partners may provide suggestions regarding the programs to survey.
2. Activity coordinator is to coordinate with EU partners to provide information about their AIR M.Sc. Programs.
3. Information to be collected for each program is the main attributes reported in Table 1.2.1, and files for the Curriculum and Syllabi.
4. Activity coordinator is responsible for gathering the collected files and store them to the ***Surveyed_MSC_Programs*** shared folder. The files for each program should be stored in a separate folder with the following syntax ***ProgramName_UniversityName***.
5. This report is to be prepared through collaboration of different partners and submitted to the WP lead by the activity coordinator. Filled tables should be added to this report.

## Summary and Recommendations

In this report, we surveyed twenty-one AIR related master programs as a step towards achieving the first work package (i.e, the surveys work package) in the DeCAIR project. The surveyed programs are from diverse countries and universities, and are scattered among wide geographical areas. Specifically, we surveyed three programs from USA, two programs from Asia, and sixteen programs from Europe. Among the sixteen programs from Europe, there were 10 programs from the partner universities as shown in Table 1.

**Table 1. List of Surveyed M.Sc. Programs**

| *No* | *Program name* | *University* | *Country* |
|---|---|---|---|
| *1* | *MSc in Artificial Intelligence* | *Radboud University* | *Netherlands* |
| *2* | *MSc in Artificial Intelligence* | *University of Groningen* | *Netherlands* |
| *3* | *MSc in Engineering - Robot Systems (Advanced Robotics Technology/ Drones and Autonomous Systems)* | *University of Southern Denmark* | *Denmark* |
| *4* | *MSc in Artificial Intelligence* | *University of Georgia* | *USA* |
| *5* | *MSc in Computer Science – Artificial Intelligence* | *University of Southern California* | *USA* |
| *6* | *MSc in Computer Science – Machine Learning* | *Columbia University* | *USA* |
| *7* | *MSC in Artificial Intelligence* | *Hong Kong university of science and technology* | *Hong Kong* |
| *8* | *MSc in Robotics and Autonomous Systems* | *Hong Kong university of science and technology* | *Hong Kong* |
| *9* | *MSc in Robotics* | *Ecole Polytechnique Fédérale de Lausanne (EPFL)* | *Switzerland* |
| *10* | *MSc in Robotics and Computation* | *University College London (UCL)* | *United Kingdom* |
| *11* | *Robotics, Cognition, Intelligence* | *Technical University of Munich* | *Germany* |
| *12* | *Master in Computer Science* | *University of Granada* | *Spain* |
| *13* | *Master in Data Science and Computer Engineering* | *University of Granada* | *Spain* |
| *14* | *Master in Industrial Electronics* | *University of Granada* | *Spain* |
| *15* | *MSc in Data Science & Engineering – Artificial Intelligence Track* | *University of Genoa* | *Italy* |
| *16* | *MSc in Artificial Intelligence and Data Engineering* | *University of Pisa* | *Italy* |
| *17* | *MSc in Robotics And Automation Engineering* | *University of Pisa* | *Italy* |
| *18* | *MSc in Autonomous Systems* | *University of Stuttgart* | *Germany* |
| *19* | *MSc in Engineering Cybernetics* | *University of Stuttgart* | *Germany* |
| *20* | *MSc in Mechatronics* | *University of Stuttgart* | *Germany* |
| *21* | *MSc in Simulation Technology* | *University of Stuttgart* | *Germany* |

Generally, the master programs are focusing on one or two areas at most. For example, among the surveyed programs some of them are focusing on artificial intelligence (AI), some are focusing on Robotics, and some are more related to data science. But, since AI is needed in data science and robotics, the master programs in data science and robotics usually require one or more courses in AI.

On the other hand, several master programs are focusing on two disciplines like master in data science and AI, or master in AI and robotics. In such programs, the students are required to register one to two fundamental courses in each discipline and one to two core courses in each discipline. Then the students may choose a minimum number of courses from one group out of two or more groups of courses. For example, the student who is enrolled in a master of AI and robotics, if he/she likes to focus more on AI, at least *x* courses from a set of AI courses must be studied. The same thing is applied on the student who studies master in AI and robotics and who would like to focus on robotics.

All of the surveyed master programs have two types of courses: mandatory and electives. Also, most of them are thesis based. Usually, the number of mandatory courses is less than the number of elective courses. Apparently, the mandatory courses are the minimum that the student must study. On the other hand, the elective courses are composed of a long list of courses, and the lists have a lot of variations among different universities. The student may choose the most suitable courses based on the pursued research and thesis. Similarly, the mandatory courses in different master programs at different universities are different. However, many programs share several mandatory courses. Also, the mandatory courses are based on whether the program is more focusing on AI, Robotics, or data science.

Table 2 summarizes the common mandatory courses among programs which are more related to AI. Also, the most frequent elective courses are shown. Table 3 shows the summary of master programs that are more related to Robotics. Regarding the data science programs, Table 4 summarizes them.

Regarding the research and teaching labs, each program at each university has several research labs and groups in the areas of AI, robotics, and/or data science. Regarding the teaching labs, the AI and data science master programs, do not have teaching labs other than a computer lab with strong and high specifications computers. But, the issue is different in robotics programs, which need robotics lab that allow the students to do their own testing and experiments.

**Table 2: Summary of Mandatory and Elective Courses in AI Master Programs**

| Mandatory Courses | Most Common Elective Courses |
|---|---|
| Machine Learning | Advanced machine learning |
| Deep Learning | Speech processing and recognition |
| Applied Machine Learning or machine learning programming | Computational vision |
| Intelligent agents | Natural language processing |
| | Multi-agents systems |
| | Advanced artificial intelligence |
| | Ethics for AI |
| | Statistical machine learning |
| | Bayesian machine learning |
| | Advanced deep learning |
| | Deep reinforcement learning |
| | Probabilistic deep learning |
| | Cognitive engineering |
| | Introduction to data science |
| | Language modelling |
| | Handwriting recognition |

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| | AI and the web |
| | Human computer interaction |
| | Knowledge based systems |
| | Decision making under uncertainty |
| | Introduction to computational learning theory |
| | Machine learning for data science |
| | Unsupervised learning |

**Table 3: Summary of Mandatory and Elective Courses in Robotics Master Programs**

| Mandatory Courses | Most Common Elective Courses |
|---|---|
| Introduction to Robotics | Intelligent Systems |
| Machine Learning | Computational Intelligence |
| Computer Vision | Mechanics of Robots |
| Robot Sensing | Basics of Mobile Robotics |
| | Industrial and Applied Robotics |
| | Human Robot Interfaces |
| | Affective Computing and Human-Robot Interaction |
| | System Theory and Control Theory, Digital Control, Process Control, Control and Identification of Uncertain Systems |
| | Guidance and Navigation Systems |
| | Vehicle Dynamics |
| | Legged Robots |
| | Controlling Behavior in Animals and Robots |
| | Machine Learning for Visual Computing |
| | Multi-Agents Artificial Intelligence |
| | Introduction to Deep Learning |
| | Probabilistic and Unsupervised Learning |
| | Reinforcement Learning |
| | Supervised Learning |
| | Robot Vision and Navigation |
| | Robotic Sensing, Manipulation and Interaction |
| | Robotic Systems Engineering |
| | Motion Planning in Robotics |
| | Humanoid Robotic Systems |
| | Robotics 3D Vision |
| | Robot Perception and Learning |
| | Introduction to Drone Technology |

**Table 4. Summary of Mandatory and Elective Courses in Data Science Master Programs**

| Mandatory Courses | Most Common Elective Courses |
|---|---|
| Database related course | Optimization methods and game theory |
| Data mining | Multimedia information retrieval and computer vision |
| Machine learning | Social media mining |
| Introduction to Data science | Data visualization |
| | Internet of things |
| | Large-scale computing |

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| | Introduction to programming for data science |
| | Data mining: pre-processing and classification |
| | Data mining: unsupervised learning and anomaly detection |
| | System modelling and time series prediction |
| | Probabilistic graphical models |
| | Feature extraction in images |
| | Time series and mining of data streams |
| | Information retrieval and recommender systems |
| | Process mining |
| | Big data ii: big data analytics |
| | Soft computing: fuzzy sets and systems |

## Surveyed M.Sc. Programs

**Table 1.2.1 Attributes of Surveyed M.Sc. Programs**

| | | | |
|---|---|---|---|
| **Number** | **1** | | |
| **Program Name** | *MSc in Artificial Intelligence* | | |
| **University** | Radboud University | | |
| **Country** | Nijmegen, Netherlands | | |
| **URL** | https://www.ru.nl/courseguides/socsci/master/artificial-intelligence/ | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☐ Robotics |
| **Credit Hours** | 120 European Credit Transfer and Accumulation System (ECTS)<br>One EC is the equivalent of 28 hours of study (preparing for/attending classes, practical, exams, groupwork etc.).<br><br>The program has two specialisations:<br>• Cognitive Computing (CC)<br>• Intelligent Technology (IT)<br><br>Year 1 (Semester 1 and Semester 2; or Periods 1 through 4)<br>• Foundation courses: 18 EC (Obligatory)<br>• Specialisation selection core courses: 18 EC<br>• Specialisation electives: 18 EC<br>• Free electives 6 EC<br>• Total 60 EC<br>Year 2 (Semester 1 and Semester 2; or Periods 1 through 4)<br>• Free electives: 15 EC<br>• Option 1: Internship (15 EC) and Research Project (30 EC)<br>• Option 2: Extended Research Project: 45 EC<br>• Total 60 EC | | |
| **AI Credit Hours** | CC: 12 EC from Obligatory courses (That can be increased by 18 EC from Specialisation selection core courses and 18 EC from Specialisation electives and 45 EC from Year 2) – **Maximum Total: 88 EC** | | |

| **Number** | **1** |
|---|---|
| **Program Name** | *MSc in Artificial Intelligence* |
| | IT: 12 EC (That can be increased by 18 EC from Specialisation selection core courses and 18 EC from Specialisation electives and 45 EC from Year 2) – **Maximum Total: 88 EC** |
| **Data Science Credit Hours** | CC: 0 EC from Obligatory courses (That can be increased by 45 EC from Year 2)<br><br>IT: 0 EC (That can be increased by 6 EC from electives and 45 EC from Year 2) |
| **Robotics Credit Hours** | CC: 0 EC from Obligatory courses (That can be increased by 6 EC from Specialisation electives and 45 EC from Year 2) – **Maximum Total: 51 EC**<br><br>IT: 0 EC (That can be increased by 6 EC from Specialisation selection core courses and 6 EC from Specialisation electives and 45 EC from Year 2) – **Maximum Total: 57 EC** |
| **AI Courses in Curriculum** | 1. Auditory Perception and Technology (Semester 1, 3 EC, IT Specialisation Elective)<br>2. Advanced Computational Neuroscience (Semester 2, 6 EC, CC Specialisation Elective)<br>3. Advanced Machine Learning (6 EC, CC Specialisation Elective,<br>4. Advanced Neuroscience Techniques (Semester 1, 6 EC, CC Specialisation Elective)<br>5. AI Research Colloquium (Semester 2, 3 EC, CC Specialisation Elective)<br>6. (The) Auditory System (3 EC)<br>7. (Automatic) Speech Recognition (Semester 2, 6 EC, IT Specialisation Elective)<br>8. Bayesian Networks (Semester 1, 6 EC, CC Specialisation Elective)<br>9. Brain Reading and Writing (Semester 2, 6 EC, IT and CC Specialisation Selection Core)<br>10. Capita Selecta AI (3 EC, Free Elective)<br>11. Capita Selecta AI (6 EC, Free Elective)<br>12. Cognition and Complexity (Semester 2, 6 EC, IT and CC Specialisation Elective)<br>13. Computational Neuroscience (3 EC, CC Specialisation Elective)<br>14. Computer Graphics and Computer Vision (Semester 2, 6 EC, IT Specialisation Selection Core, CC Specialisation Elective)<br>15. Ethics for AI (Semester 2, 6 EC, **Obligatory**)<br>16. Evolution and the Mind (Semester 1, 3 EC, CC Specialisation Elective)<br>17. Information Retrieval (Semester 1, 6 EC, IT Specialisation Elective)<br>18. Intelligent Systems in Medical Imaging (Semester 2, 6 EC, IT Specialisation Elective)<br>19. Intro to Language and Speech Technology (Semester 1, 6 EC, IT Specialisation Elective)<br>20. Machine Learning in Practice (Semester 2, 6 EC, **IT Obligatory**)<br>21. Natural Computing (Semester 2, 6 EC, CC Specialisation Elective) |

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|---|---|
| **Number** | **1** |
| **Program Name** | *MSc in Artificial Intelligence* |
| | 22. Neural Information Processing Systems (Semester 1, 6 EC, IT and CC Specialisation Elective)<br>23. Neuromorphic Computing (Semester 1, 6 EC, IT and CC Specialisation Elective)<br>24. Perception (Semester 1, 6 EC, CC Specialisation Elective)<br>25. Probabilistic Deep Learning (6 EC, IT Specialisation Elective, **CC Obligatory**)<br>26. Quantitative Brain Networks (Semester 2, 6 EC, CC Specialisation Elective)<br>27. Theoretical Foundations for Cognitive Agents (Semester 2, 6 EC, IT and CC Specialisation Elective) |
| **Robotics Courses in Curriculum** | 1. Cognitive Robotics (Semester 1, 6 EC, IT and CC Specialisation Elective)<br>2. Human-Robot Interaction (Semester 1, 6 EC, IT Specialisation Selection Core)<br>3. Motor control (Semester 1, 6 EC, CC Specialisation Elective) |
| **Other Fundamental Courses** | 1. Advanced Academic & Professional Skills (Semester 1, 6 EC, **Obligatory**)<br>2. Design of Embedded Systems (Semester 1, 6 EC, IT Specialisation Elective)<br>3. Law in Cyberspace (Semester 1, 6 EC, IT Specialisation Elective)<br>4. Mind, Technology and Music (Semester 2, 6 EC, IT Specialisation Selection Core)<br>5. Neuroimaging I (Semester 1, 6 EC, IT and CC Specialisation Elective)<br>6. Neurophilosophy (Semester 2, 6 EC, IT Specialisation Elective)<br>7. New Media Lab (Semester 2, 6 EC, IT and CC Specialisation Selection Core)<br>8. Social Neurocognition (Semester 2, 6 EC, IT Specialisation Elective)<br>9. Text and Multimedia Mining (Semester 1, 6 EC, IT Specialisation Selection Core)<br>10. Upgrading the Human? (Semester 2, 6 EC, IT Specialisation Elective) |
| **Teaching and Research Labs** | NA |
| **Research Groups** | NA |
| **Collaboration with Industry** *(List of sample projects)* | NA |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **2** | | |
| **Program Name** | *MSc in Artificial Intelligence* | | |
| **University** | University of Groningen | | |
| **Country** | Netherland | | |
| **URL** | https://www.rug.nl/masters/artificial-intelligence/#!programme | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☐ Robotics |
| **Credit Hours** | 120 European Credit Transfer and Accumulation System (ECTS)<br>Most courses are worth 5 EC.<br>One EC is the equivalent of 28 hours of study (preparing for/attending classes, practical, exams, groupwork etc.).<br><br>The Artificial Intelligence programme has the following specializations:<br>- Computational Intelligence and Robotics (CI&R)<br>- Multi-Agent Systems (MAS)<br><br>Structure:<br>- General Mandatory Courses (60 ECTS):<br>o 15 ECTS<br>o Final Research Project AI (45 ECTS, with duration of one whole year)<br>- CI&R Mandatory Courses (20 ECTS)<br>- MAS Mandatory Courses (20 ECTS)<br>- Elective Courses (40 ECTS) | | |
| **AI Credit Hours** | CI&R: 15 ECTs (That can be increased by 40 ECT from elective courses and 45 ECT from Final Research Project)<br>**Maximum Total: 100 ECT**<br><br>MAS: 35 ECTs (That can be increased by 40 ECT from elective courses and 45 ECT from Final Research Project)<br>**Maximum Total: 120 ECT** | | |
| **Data Science Credit Hours** | CI&R: 0 ECTs (That can be increased by 5 ECT from elective courses and 45 ECT from Final Research Project)<br><br>MAS: 0 ECTs (That can be increased by 5 ECT from elective courses and 45 ECT from Final Research Project) | | |
| **Robotics Credit Hours** | CI&R: 20 ECTs (That can be increased by 10 ECT from elective courses and 45 ECT from Final Research Project)<br>**Maximum Total: 75 ECT**<br><br>MAS: 0 ECTs (That can be increased by 10 ECT from elective courses and 45 ECT from Final Research Project)<br>**Maximum Total: 55 ECT** | | |
| **AI Courses in Curriculum** | 1. Design of Multi-Agent Systems (Semester 1, General Mandatory) | | |

| **Number** | **2** |
|---|---|
| **Program Name** | *MSc in Artificial Intelligence* |
| | 2. Machine Learning (Semester 1, General Mandatory)<br>3. Arguing Agents (Semester 1, MAS Mandatory, CI&R Elective)<br>4. Cognitive Modelling: Basic Principles and Methods (Semester 1, MAS Mandatory, CI&R Elective)<br>5. Computational Social Choice (Semester 2, MAS Mandatory, CI&R Elective)<br>6. Logical Aspects of Multi-agent Systems (Semester 2, MAS Mandatory, CI&R Elective)<br>7. Deep Learning (Semester 2, General Mandatory)<br>8. Cognitive Engineering (Semester 1, Elective)<br>9. Introduction to Data Science (Semester 1, Elective)<br>10. Language Modelling (Semester 1, Elective)<br>11. Semantic Web Technology (Semester 1, Elective)<br>12. User Models (Semester 1, Elective)<br>13. Neural Networks and Computational Intelligence (Semester 1, Elective)<br>14. Applied Cognitive Engineering (Semester 2, Elective)<br>15. Computer Vision (Semester 2, Elective)<br>16. Natural Language Processing (Semester 2, Elective)<br>17. Handwriting Recognition (Semester 2, Elective) |
| **Robotics Courses in Curriculum** | 4. Cognitive Robotics (Semester 1, CI&R Mandatory, MAS Elective)<br>5. Pattern Recognition (Semester 1, CI&R Mandatory, MAS Elective)<br>6. Robotics for AI (Semester 1, CI&R Mandatory, MAS Elective)<br>7. Handwriting Recognition (Semester 2, CI&R Mandatory)<br>8. Robotics for IEM (Semester 1, Elective)<br>9. Auditory and Visual Perception (Semester 1, Elective) |
| **Other Fundamental Courses** | 11. Introduction Science and Policy (Semester 1, Elective)<br>12. Introduction Science and Business (Semester 1, Elective)<br>13. Skills in Science Communication (Semester 1, Elective)<br>14. Advanced Computer Graphics (Semester 1, Elective)<br>15. Computational Semantics (Semester 1, Elective)<br>16. Philosophy of Neuroscience (Semester 1, Elective)<br>17. Auditory Biophysics (Semester 2, Elective)<br>18. Cognitive Modelling: Complex Behaviour (Semester 2, Elective)<br>19. Computational Simulations of Language (Semester 2, Elective)<br>20. Fundamentals of Distributed Systems (Semester 2, Elective) |

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|---|---|
| **Number** | **2** |
| **Program Name** | *MSc in Artificial Intelligence* |
| | 21. Scientific Visualization (Semester 2, Elective)<br>22. Advanced Imaging Techniques (Semester 2, Elective)<br>23. Advanced self-organisation of social systems (Semester 2, Elective)<br>24. Computational Cognitive Neuroscience (Semester 2, Elective)<br>25. Language Technology Project (Semester 2, Elective)<br>26. Neuro-ergonomics (Semester 2, Elective) |
| **Teaching and Research Labs** | NA |
| **Research Groups** | 1. Autonomous Perceptive Systems<br>2. Cognitive Modeling<br>3. Multi-Agent Systems<br>4. Robotics |
| **Collaboration with Industry** *(List of sample projects)* | NA - Only externally funded research projects by governmental programs and research foundations. |
| **Summary and Notes** | |
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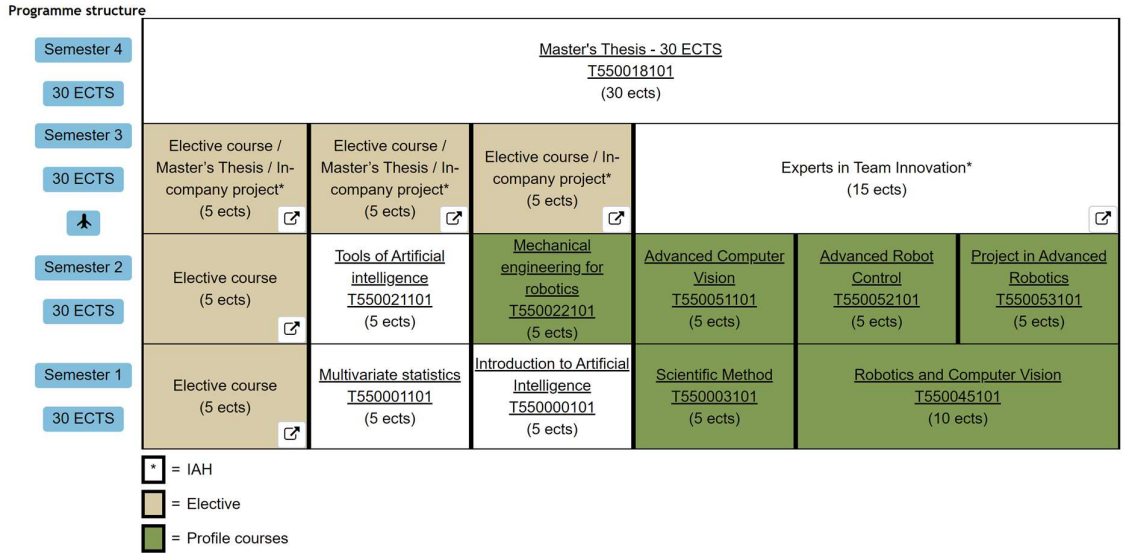
|---|---|---|---|
| **Number** | **3** | | |
| **Program Name** | *MSc in Engineering - Robot Systems (Advanced Robotics Technology/Drones and Autonomous Systems)* | | |
| **University** | University of Southern Denmark | | |
| **Country** | Odense, Denmark | | |
| **URL** | https://www.sdu.dk/en/uddannelse/kandidat/robotteknologi?utm_source=Keystone&utm_campaign=Keystone&utm_medium=KeystoneListing | | |
| **Program Focus** | ☐ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 120 European Credit Transfer and Accumulation System (ECTS); Most courses are worth 5 ECTS.<br><br>The program has the following specializations:<br>- Advanced Robotics Technology (ART)<br>- Drones and Autonomous Systems (DAS)<br><br>ART Structure:<br>  <br><br>DAS Structure: | | |

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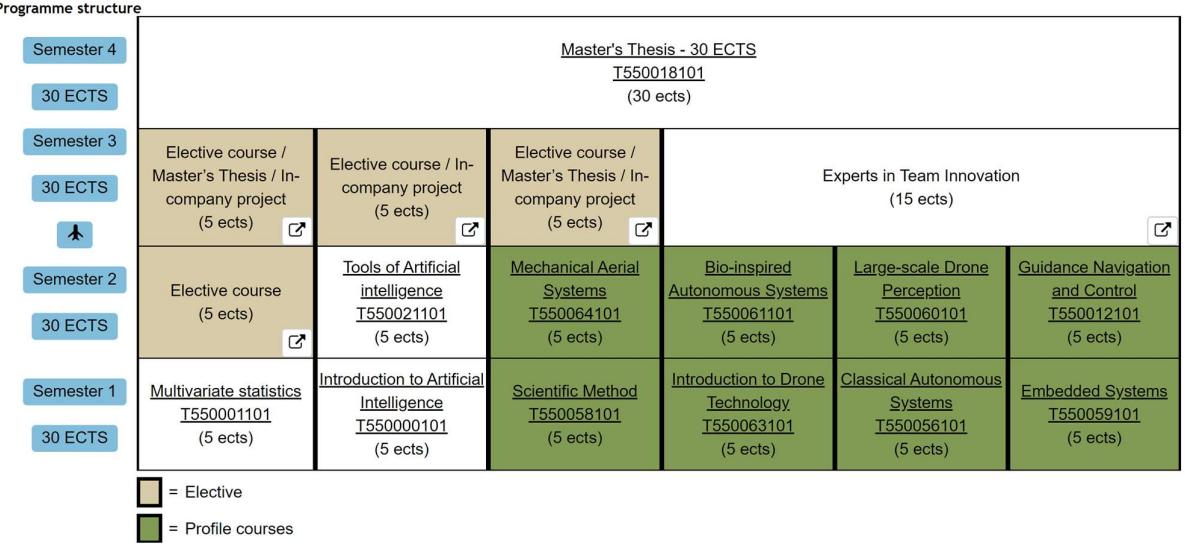
| **Number** | **3** |
| **Program Name** | *MSc in Engineering - Robot Systems (Advanced Robotics Technology/Drones and Autonomous Systems)* |
| | Programme structure<br>  <br><br>**No list of Electives is provided**. |
| **AI Credit Hours** | CAS: 10 Obligatory ECTS (That can be increased by 10 ECTS from elective courses and 15 ECTS from (elective courses OR additional Master's Thesis Credits OR In-company Project) and 15 ECTS from Experts in Team Innovation (or equivalent) and 30 ECTS from Master's Thesis.<br><br>DAS: 10 Obligatory ECTS (That can be increased by 5 ECTS from elective courses and 15 ECTS from (elective courses OR additional Master's Thesis Credits OR In-company Project) and 15 ECTS from Experts in Team Innovation (or equivalent) and 30 ECTS from Master's Thesis. |
| **Data Science Credit Hours** | CAS: 5 Obligatory ECTS<br>DAS: 5 Obligatory ECTS |

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| **Number** | **3** |
| **Program Name** | *MSc in Engineering - Robot Systems (Advanced Robotics Technology/Drones and Autonomous Systems)* |
| **Robotics Credit Hours** | CAS: 25 Obligatory ECTS (That can be increased by 10 ECTS from elective courses and 15 ECTS from (elective courses OR additional Master's Thesis Credits OR In-company Project) and 15 ECTS from Experts in Team Innovation (or equivalent) and 30 ECTS from Master's Thesis.<br><br>DAS: 35 Obligatory ECTS (That can be increased by 5 ECTS from elective courses and 15 ECTS from (elective courses OR additional Master's Thesis Credits OR In-company Project) and 15 ECTS from Experts in Team Innovation (or equivalent) and 30 ECTS from Master's Thesis. |
| **AI Courses in Curriculum** | 10. Introduction to Artificial Intelligence (Semester 1, 5 ECTS, ART and DAS Obligatory)<br>11. Tools of Artificial Intelligence (Semester 2, 5 ECTS, ART and DAS Obligatory) |
| **Robotics Courses in Curriculum** | 1. Robotics and Computer Vision (Semester 1, 10 ECTS, ART and DAS Obligatory)<br>2. Introduction to Drone Technology (Semester 1, 5 ECTS, DAS Obligatory)<br>3. Classical Autonomous Systems (Semester 1, 5 ECTS, DAS Obligatory)<br>4. Advanced Computer Vision (Semester 2, 5 ECTS, ART Obligatory)<br>5. Advanced Robot Control (Semester 2, 5 ECTS, ART Obligatory)<br>6. Project in Advanced Robotics (Semester 2,5 ECTS, ART Obligatory)<br>7. Mechanical Engineering for Robotics (Semester 2, 5 ECTS, ART Obligatory)<br>8. Guidance, Navigation, and Control (Semester 2, 5 ECTS, DAS Obligatory)<br>9. Large-scale Drone Perception (Semester 2, 5 ECTS, DAS Obligatory)<br>10. Bio-Inspired Autonomous Systems (5 ECTS, DAS Obligatory)<br>11. Mechanical Aerial Systems (Semester 2, 5 ECTS, DAS Obligatory) |
| **Other Fundamental Courses** | 12. Multivariate Statistics (Semester 1, 5 ECTS, ART Obligatory)<br>13. Scientific Method (Semester 1, 5 ECTS, ART and DAS Obligatory)<br>14. Embedded Systems (Semester 1, 5 ECTS, DAS Obligatory) |
| **Teaching and Research Labs** | NA |
| **Research Groups** | SDU Robotics (https://www.sdu.dk/en/forskning/sdurobotics) |
| **Collaboration with Industry** *(List of sample projects)* | 1. FlexDraperProduct (2018-2021) https://www.sdu.dk/en/forskning/sdurobotics/researchprojects/flexdraperproduct<br>2. Health Care Assisting Technology (2017-2020) https://www.sdu.dk/en/forskning/sdurobotics/researchprojects/health-cat<br>3. MADE Digital (2017-2020) https://www.sdu.dk/en/forskning/sdurobotics/researchprojects/made+digital<br>…more at https://www.sdu.dk/en/forskning/sdurobotics/researchprojects |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **3** | | |
| **Program Name** | *MSc in Engineering - Robot Systems (Advanced Robotics Technology/Drones and Autonomous Systems)* | | |
| **Number** | **4** | | |
| **Program Name** | *MSc in Artificial Intelligence* | | |
| **University** | University of Georgia | | |
| **Country** | USA | | |
| **URL** | https://www.ai.uga.edu/ms-artificial-intelligence | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☐ Robotics |
| **Credit Hours** | **30 Hours**<br><br>Structure:<br>• 3 hours of Master's thesis<br>• 2 hours of Master's research<br>• At least 14 hours from the following groups:<br>  ○ 8 hours selected from Group A of courses<br>  ○ 6 hours selected from Group B of courses<br>• The following courses must be included on the Program of Study unless specifically waived for a particular student by that student's Advisory Committee and by the Graduate Coordinator:<br>  ○ PHIL/LING 6510 Deductive Systems (3 hours)<br>  ○ CSCI 6380 Data Mining (4 hours) or CSCI 8950 Machine Learning (4 hours)<br>  ○ CSCI/PHIL 6550 Artificial Intelligence (3 hours)<br>  ○ ARTI 6950 Faculty Research Seminar (1 hour) | | |
| **AI Credit Hours** | 7 Hours (That can be expanded to include 8 Hours from the group electives and 3 Hours from thesis and 2 hours from research)<br>**Maximum Total: 20 Units** | | |
| **Data Science Credit Hours** | 0 Units (That can be expanded to include 8 Hours from the group electives and 3 Hours from thesis and 2 hours from research)<br>**Maximum Total: 13 Units** | | |
| **Robotics Credit Hours** | 0 Hours (That can be expanded to include 8 Hours from the group electives and 3 Hours from thesis and 2 hours from research)<br>**Maximum Total: 13 Units** | | |
| **AI Courses in Curriculum** | 28. CSCI 6380 Data Mining (4 hours) or CSCI 8950 Machine Learning (4 hours, Mandatory) | | |

| Number | 3 |
|---|---|
| **Program Name** | *MSc in Engineering - Robot Systems (Advanced Robotics Technology/Drones and Autonomous Systems)* |
| | 29. CSCI/PHIL 6550 Artificial Intelligence (3 hours, Mandatory)<br>30. CSCI 6330 AI and the Web (4 hours, Group A)<br>31. CSCI 6360 Data Science II (4 hours, Group A)<br>32. CSCI/ARTI 6540 Symbolic Programming (3 hours, Group A)<br>33. CSCI 6560 Evolutionary Computing (4 hours, Group A)<br>34. CSCI 6800 Human Computer Interaction (4 hours, Group A)<br>35. CSCI 8050 Knowledge Based Systems (4 hours, Group A)<br>36. CSCI 8360 Data Science Practicum (4 hours, Group A)<br>37. CSCI 8380 Advanced Topics in Information Systems (4 hours, Group A)<br>38. CSCI/PHIL 8650 Logic and Logic Programming (4 hours, Group A)<br>39. CSCI 8920 Decision Making Under Uncertainty (4 hours, Group A)<br>40. CSCI/ENGR 8940 Computational Intelligence (4 hours, Group A)<br>41. CSCI 8945 Advanced Representation Learning (4 hours, Group A)<br>42. CSCI/ARTI 8950 Machine Learning (4 hours, Group A)<br>43. CSCI 8955 Advanced Data Analytics (4 hours, Group A)<br>44. CSCI 8960 Privacy-Preserving Data Analysis (4 hours, Group A)<br>45. FORS 8450 Advanced Forest Planning and Harvest Scheduling (3 hours, Group A)<br>46. LING 6570 Natural Language Processing (3 hours, Group A)<br>47. ARTI 8800 Directed Readings in Artificial Intelligence (Require permission of instructor)<br>48. ARTI 8000 Topics in Artificial Intelligence (Require permission of instructor) |
| **Robotics Courses in Curriculum** | 49. CSCI/ARTI 6530 Introduction to Robotics (4 hours, Group A)<br>50. CSCI 8535 Multi Robot Systems (4 hours, Group A)<br>51. CSCI 8820 Computer Vision and Pattern Recognition (4 hours, Group A) |
| **Other Fundamental Courses** | 27. PHIL/LING 6510 Deductive Systems (3 hours, Mandatory)<br>28. ARTI 6950 Faculty Research Seminar (1 hour, Mandatory)<br>29. CSCI 8860 Biomedical Informatics (4 hours, Group A)<br>30. ENGL 6885 Introduction to Humanities Computing (3 hours, Group A)<br>31. ENGL/LING 6886 Text and Corpus Analysis (3 hours, Group B)<br>32. EPSY 8130 Psycholinguistics (3 hours, Group B)<br>33. LING 6021 Phonetics and Phonology (3 hours, Group B)<br>34. LING 6022 Advanced Phonetics and Phonology (3 hours, Group B)<br>35. LING 6160 Compositional Semantics (3 hours, Group B)<br>36. LING 8120 Morphology (3 hours, Group B) |

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| **Number** | **3** |
| **Program Name** | *MSc in Engineering - Robot Systems (Advanced Robotics Technology/Drones and Autonomous Systems)* |
| | 37. LING 8150 Generative Syntax (3 hours, Group B)<br>38. LING 8160 Advanced Generative Syntax (3 hours, Group B)<br>39. LING 8180 Seminar in Phonetics/Phonology (3 hours, Group B)<br>40. PHIL/EETH 6250 Philosophy of Technology<br>41. PHIL/LING 6300 Philosophy of Language (3 hours, Group B)<br>42. PHIL 6310 Philosophy of Mind (3 hours, Group B)<br>43. PHIL 6410 Philosophy of Natural Science<br>44. PHIL/LING 6520 Model Theory (3 hours, Group B)<br>45. PHIL 6530 Philosophy of Math (3 hours, Group B)<br>46. PHIL/LING 8300 Seminar in Philosophy of Language (max of 3 hours, Group B)<br>47. PHIL 8310 Seminar in Philosophy of Mind (max of 3 hours, Group B)<br>48. PHIL 8500 Seminar in Problems of Logic (max of 3 hours, Group B)<br>49. PHIL 8600 Seminar in Metaphysics (max of 3 hours, Group B)<br>50. PHIL 8610 Epistemology (max of 3 hours, Group B)<br>51. PSYC 6100 Cognitive Psychology (3 hours, Group B)<br>52. PSYC 8240 Judgment and Decision Making (3 hours, Group B) |
| **Teaching and Research Labs**<br>**Research Groups**<br>**Collaboration with Industry**<br>*(List of sample projects)* | • Evolutionary Computation and Machine Learning Lab http://ecml.uga.edu/<br>• THINC lab http://thinc.cs.uga.edu/<br>• Heterogeneous Robotics (HeRo) Lab http://hero.uga.edu/<br>• CASPR Project https://www.ai.uga.edu/caspr-home |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **5** | | |
| **Program Name** | *MSc in Computer Science – Artificial Intelligence* | | |
| **University** | University of Southern California | | |
| **Country** | USA | | |
| **URL** | https://viterbigradadmission.usc.edu/programs/masters/msprograms/computer-science/ms-computer-science-artificial-intelligence/ | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☐ Robotics |
| **Credit Hours** | **32 Units**<br><br>12.5 hours of contact are required per unit.<br><br>Structure:<br>• Required Courses (20 units)<br>• Group Electives – take three courses, one from each group (12 units)<br>  ○ Group 1 (Machine Learning & Deep Learning)<br>  ○ Group 2 (Natural Language Processing & Speech Recognition)<br>  ○ Group 3 (Computer Vision & Robotics)<br><br>Students may use units of special topics courses CSCI 599 or CSCI 699 toward the group elective requirements with department approval. The list of available special topics include many courses that may fall under and beyond the listed groups of electives (https://www.cs.usc.edu/academic-programs/courses/special-topics-courses/) | | |
| **AI Credit Hours** | 12 Units (That can be expanded to include 8 Units from the group electives)<br>**Maximum Total: 20 Units** | | |
| **Data Science Credit Hours** | 0 Units | | |
| **Robotics Credit Hours** | 8 Units (That can be expanded to include 4 Units from the group electives)<br>**Maximum Total: 12 Units** | | |
| **AI Courses in Curriculum** | 52. CSCI 561 Foundations of Artificial Intelligence (Required Course, 4 Units)<br>53. CSCI 566 Deep learning and Its Applications (Required Course, 4 Units)<br>54. CSCI 567 Machine learning (Required Course, 4 Units)<br>55. EE 546 Mathematics of High-Dimensional Data (Group 1 Elective, 4 Units)<br>56. EE 588 Optimization for the Information and Data Sciences (Group 1 Elective, 4 Units)<br>57. ISE 633 Large-Scale Optimization for Machine Learning (Group 1 Elective, 4 Units)<br>58. CSCI 544 Applied Natural Language Processing (Group 2 Elective, 4 Units) | | |

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| **Number** | **5** |
| **Program Name** | *MSc in Computer Science – Artificial Intelligence* |
| | 59. CSCI 662 Advanced Applied Natural Language Processing (Group 2 Elective, 4 Units)<br>60. EE 519 Speech Recognition and Processing for Multimedia (Group 2 Elective, 4 Units) |
| **Robotics Courses in Curriculum** | 12. COMS W4733 Computational Aspects of Robotics (Selection Track Core Courses)<br>13. COMS W4733 Computational Aspects of Robotics (Elective)<br>14. MECS E6615 Advanced Robotic Manipulation (Elective)<br>15. CSCI 445 Introduction to Robotics (Group 3 Elective, 4 Units)<br>16. CSCI 545 Robotics (Group 3 Elective, 4 Units)<br>17. CSCI 677 Advanced Computer Vision (Group 3 Elective, 4 Units)<br>18. EE 569 Introduction to Digital Image Processing (Group 3 Elective, 4 Units) |
| **Other Fundamental Courses** | 53. CSCI 570 Analysis of Algorithms (Required Course, 4 Units)<br>54. CSCI 571 Web Technologies (Required Course, 4 Units) |
| **Teaching and Research Labs** | https://viterbischool.usc.edu/shared-research-infrastructure/<br><br>Viterbi School Core Infrastructure<br>• Center For Advanced Manufacturing (CAM)<br>• John O'Brien Nanofabrication Laboratory<br>• MOSIS VLSI Circuit Fabrication Facility<br>• Structures and Materials Research Laboratory (SMRL)<br>• USC Center for Peptide and Protein Engineering (CPPE)<br>• USC-Lockheed Martin Quantum Computing Center<br>• Investigator-Managed Viterbi School Shared Infrastructure<br>• SLA Fast Prototyping Machine<br>• UltraLab<br><br>Viterbi-Dornsife Shared Core Infrastructure<br>• Core Center of Excellence in Nano Imaging (CNI)<br>• Viterbi-Dornsife Machine Shop<br><br>Other USC Core Infrastructure:<br>• Complete Listing of USC Research Facilities<br>• Biomedical Imaging |

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| **Number** | **5** |
| **Program Name** | *MSc in Computer Science – Artificial Intelligence* |
| | • Biophysics Core<br>• Compund Semiconductor Lab<br>• Digital Archive & Media Resources<br>• Dornsife Neuroimaging Center<br>• Genomics<br>• High Performance Computing Center<br>• Medical and Biomedical Cores<br>• Statistics Cores |
| **Research Groups** | Numerous Research Centers: https://viterbischool.usc.edu/research-centers/<br>• Artificial Intelligence for Social Good<br>• Airbus Institute for Engineering Research (AIER)<br>• Arid Climate and Water Research Center (AWARE)<br>• Biomimicry for Synthesis of Smart Textiles<br>• … |
| **Collaboration with Industry**<br>***(List of sample projects)*** | https://viterbischool.usc.edu/faculty/faculty-research-resources/research-initiatives/<br>Programs:<br>• Coulter Translational Research Partnership Program<br>• Neuroscience Graduate Program<br>• Women in Science and Engineering<br><br>Funds:<br>• Collaboration Fund<br>• Zumberge Faculty and Research Innovation Fund<br>• Core Instrumentation Fund<br>• Collaborative Research in Regenerative Medicine<br><br>Institutes with Funding Opportunities:<br>• METRANS Transportation Center<br>• Ming Hsieh Institute for Research<br>• Southern California Clinical and Translational Science Institute (SC CTSI)<br>• Southern California Environmental Health Sciences Center |

| **Number** | **5** |
|---|---|
| **Program Name** | *MSc in Computer Science – Artificial Intelligence* |
| **Summary and Notes** | |
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| **Number** | **6** | | |
| **Program Name** | *MSc in Computer Science – Machine Learning – Non-Thesis* | | |
| **University** | Columbia University | | |
| **Country** | USA | | |
| **URL** | https://www.cs.columbia.edu/areas/machine/ | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☐ Robotics |
| **Credit Hours** | **30 Points (pts)**<br><br>Each point of academic credit requires a minimum of three hours work each week in a 14-week semester, typically divided into one hour of classroom instruction (with an hour of classroom instruction defined as at least 50 minutes) and two hours of independent work (which may include readings, problem sets, papers, individual or group projects, and so forth).<br><br>Machine Learning track requires:<br>• Breadth courses<br>– 1 course (3pts) from Group 1 (Systems)<br>– 1 course (3pts) from Group 2 (Theory)<br>– 1 course (3pts) from Group 3 (AI and Applications)<br>– 1 course (3pts) from either Group 1, 2, or 3<br>• Required Selection of Track courses (6pts)<br>• Track Electives (6pts)<br>• General Electives (6pts) | | |
| **AI Credit Hours** | 9pts (That can be expanded to include 3pts from the breadth courses and 6pts from track electives)<br>**Maximum Total: 18pts** | | |
| **Data Science Credit Hours** | 3pts (That can be expanded to include 6pts from track electives)<br>**Maximum Total: 9pts** | | |
| **Robotics Credit Hours** | 3pts (That can be expanded to include 6pts from track electives)<br>**Maximum Total: 9pts** | | |
| **AI Courses in Curriculum** | 61. COMS W4252 Introduction to Computational Learning Theory (Selection Track Core Courses)<br>62. COMS W4771 Machine Learning (Selection Track Core Courses)<br>63. COMS W4721 Machine Learning for Data Science (Selection Track Core Courses)<br>64. ELEN 4720 Machine Learning for Signals, Information and Data (Selection Track Core Courses)<br>65. COMS W4772 Advanced Machine Learning (Selection Track Core Courses) | | |

| **Number** | **6** |
|---|---|
| **Program Name** | *MSc in Computer Science – Machine Learning – Non-Thesis* |
| | 66. COMS 4773 Machine Learning Theory (Selection Track Core Courses)<br>67. COMS 4774 Unsupervised Learning (Selection Track Core Courses)<br>68. COMS 4775 Causal Inference (Selection Track Core Courses)<br>69. COMS W4731 Computer Vision (Selection Track Core Courses)<br>70. COMS W4705 Natural Language Processing (Selection Track Core Courses)<br>71. COMS W4701 Artificial Intelligence (Selection Track Core Courses)<br>72. COMS W4252 Introduction to Computational Learning Theory (Elective)<br>73. COMS W4772 Advanced Machine Learning (Elective)<br>74. COMS W4705 Intro to Natural Language Processing (Elective)<br>75. COMS W4731 Computer Vision (Elective)<br>76. COMS 6998 Machine Learning Personalization (Elective)<br>77. COMS W4776 Machine Learning for Data Science (Elective)<br>78. COMS E6253 Advanced Topics in Computational Learning Theory (Elective)<br>79. CSEE E6892 Bayesian Models in Machine Learning (Elective)<br>80. CSEE E6898 Large-Scale Machine Learning (Elective)<br>81. ECBM E4040 Neural Networks and Deep Learning (Elective)<br>82. ECBM E6040 Neural Networks and Deep Learning Research (Elective)<br>83. EECS E6691 Topics in Data-Driven Analysis & Comp: Advanced Deep Learning (Elective)<br>84. EECS E6699 Topics in Data-Driven Analysis and Computation: Mathematics of Deep Learning (Elective)<br>85. EECS E6720 Bayesian Models of Machine Learning (Elective)<br>86. EECS E6870 Speech Recognition (Elective)<br>87. EECS E6893 Big Data Analytics or Topics-Information Processing (Elective)<br>88. EECS E6895 Topic Adv Big Data Analytics (Elective)<br>89. EECS E6894Deep Learning for Computer Vision and Natural Language Processing (Elective)<br>90. ELEN 6885 Reinforcement Learning (Elective)<br>91. IEOR E8100 Big Data & Machine Learning (Elective)<br>92. IEOR E8100/4575 Reinforcement Learning (Elective)<br>93. STAT W4240 Data Mining (Elective)<br>94. STAT W4282 Linear Regression/Time Series Analysis (Elective)<br>95. STAT W4249 Applied Data Science (Elective)<br>96. STAT G4400 Statistical Machine Learning (Elective)<br>97. STAT W4640 Bayesian Statistics (Elective) |

| **Number** | **6** |
|---|---|
| **Program Name** | *MSc in Computer Science – Machine Learning – Non-Thesis* |
| **Robotics Courses in Curriculum** | 19. COMS W4733 Computational Aspects of Robotics (Selection Track Core Courses)<br>20. COMS W4733 Computational Aspects of Robotics (Elective)<br>21. MECS E6615 Advanced Robotic Manipulation (Elective) |
| **Other Fundamental Courses** | 55. COMS/STAT G6509/6701 Foundations of Graphical Models (Selection Track Core Courses)<br>56. CSOR W4246 Algorithms for Data Science (Elective)<br>57. COMS W4111 Introduction to Databases (Elective)<br>58. COMS W4737 Biometrics (Elective)<br>59. COMS W4761 Computational Genomics (Elective)<br>60. COMS E6111 Advanced Database Systems (Elective)<br>61. COMS E6232 Analysis of Algorithms II (Elective)<br>62. COMS E6717 Information Theory (Elective)<br>63. COMS E6735 Visual Databases (Elective)<br>64. COMS E6737 Biometrics (Elective)<br>65. COMS E6901 Projects in Computer Science (Elective)<br>66. CSEE E6898 Sparse Signal Modeling (Elective)<br>67. APMA E4990 Modeling Social Data (Elective)<br>68. BINF G4006 Translational Bioinformatics (Elective)<br>69. ELEN E6886 Sparse Representations and Higher Dimensional Geometry (Elective)<br>70. ELEN E6899 Topics in Information Processing: Autonomous Multi-Agent Systems (Elective)<br>71. IEOR E6613 Optimization I (Elective)<br>72. IEOR E8100 Optimization Methods in Machine Learning (Elective)<br>73. STAT W4201 Probability and Statistics/Advanced Data Analysis (Elective)<br>74. STAT W4700 Probability and Statistics (Elective)<br>75. STAT G6101 Statistical Modeling and Data Analysis I (Elective)<br>76. STAT G6104 Computational Statistics (Elective)<br>77. STAT GR8101 Topics in Applied Statistics: Applied Causality (Elective) |
| **Teaching and Research Labs** | Computing Research Facilities: https://www.cs.columbia.edu/crf/ |
| **Research Groups** | NA |
| **Collaboration with Industry** *(List of sample projects)* | NA |
| **Summary and Notes** | |
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| **Number** | **7** | | |
| **Program Name** | ***MSC in Artificial Intelligence*** | | |
| **University** | The Hong Kong university of science and technology | | |
| **Country** | Hong Kong | | |
| **URL** | https://prog-crs.ust.hk/pgprog/2021-22/mphil-phd-ai | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☐ Robotics |
| **Credit Hours** | 15 | | |
| **AI Credit Hours** | | | |
| **Data Science Credit Hours** | | | |
| **Robotics Credit Hours** | 9 | | |
| **AI Courses in Curriculum** | 1. **Advanced Artificial Intelligence** (elective)<br>2. **Machine Learning** (elective)<br>3. **Statistical Machine Learning** (elective)<br>4. **Bayesian Machine Learning** (elective)<br>5. **Advanced Deep Learning** (elective)<br>6. **Deep Reinforcement Learning** (elective)<br>7. **Topics in Artificial Intelligence** (elective)<br>8. **Topics in Machine Learning** (elective)<br>• **( list of courses are attached with another file )** | | |
| **Robotics Courses in Curriculum** | | | |
| **Other Fundamental Courses** | 78. **Course Name** (Prerequisite Name) (obligatory/elective)<br>79. **Course Name** (Prerequisite Name) (obligatory/elective)<br>80. **…** | | |
| **Teaching and Research Labs** | 1. **Introduction to Teaching and Learning in Higher :** The course aims to equip all full-time research postgraduate (RPg) students with basic teaching skills before assuming teaching assistant duties for the department. Good teaching skills can be acquired through learning and practice. This 10-hour mandatory training course provides all graduate teaching assistants (GTA) with the necessary theoretical knowledge with practical opportunities to apply and build up their knowledge, skills and confidence in taking up their teaching duties. At the end of the course, GTAs should be able to (1) facilitate teaching in tutorials and laboratory settings; (2) provide meaningful feedback to their students; and (3) design an active learning environment to engage their students. Graded PP, P or F. | | |
| **Research Groups** | 1. **Cross-disciplinary Research Methods I:** This course focuses on using various approaches to perform quantitative analysis through real-world examples. Students will learn how to use different tools in an | | |

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| **Number** | 7 |
| **Program Name** | ***MSC in Artificial Intelligence*** |
| | interdisciplinary project and how to acquire new skills on their own. The course offers different modules that are multidisciplinary/multifunctional and generally applicable to a wide class of problems.<br>2. **Cross-disciplinary Research Methods II:** This course focuses on using various approaches to perform quantitative analysis through real-world examples. Students will learn how to use different tools in an interdisciplinary project and how to acquire new skills on their own. The course offers different modules that are multidisciplinary/multifunctional and generally applicable to a wide class of problems.<br>3. **Professional Development for Research Postgraduate Students:** This course aims at equipping research postgraduate students with transferrable skills conducive to their professional development. Students are required to attend 3 hours of mandatory training on Professional Conduct, and complete 12 hours of workshops, at their own choice, under the themes of Communication Skills, Research Competency, Entrepreneurship, Self-Management, and Career Development. Graded PP, P or F.<br>4. **Artificial Intelligence Seminar I:** Series of seminars presenting research problems currently under investigation, presented by faculty, students, and visiting speakers. Students are expected to attend regularly. Graded P or F.<br>5. **Artificial Intelligence Seminar II:** Series of seminars presenting research problems currently under investigation, presented by faculty, students, and visiting speakers. Students are expected to attend regularly. Continuation of AIAA 6101. Graded P or F.<br>6. **MPhil Thesis Research:** Master's thesis research supervised by co-advisors from different disciplines. A successful defense of the thesis leads to the grade Pass. No course credit is assigned. |
| **Collaboration with Industry** *(List of sample projects)* | 9.<br>10. |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **8** | | |
| **Program Name** | ***MSc in Robotics and Autonomous Systems*** | | |
| **University** | The Hong Kong university of science and technology | | |
| **Country** | Hong Kong | | |
| **URL** | https://prog-crs.ust.hk/pgprog/2021-22/mphil-phd-roas | | |
| **Program Focus** | ☐ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 15 | | |
| **AI Credit Hours** | | | |
| **Data Science Credit Hours** | | | |
| **Robotics Credit Hours** | 9 | | |
| **AI Courses in Curriculum** | 18. **Course Name** (Prerequisite Name) (obligatory/elective)<br>19. **Course Name** (Prerequisite Name) (obligatory/elective)<br>20. **…** | | |
| **Robotics Courses in Curriculum** | 22. **Introduction to Robotics** (elective)<br>23. **Autonomous Mobile Robotics** (elective)<br>24. **Cloud Robotics and Autonomous Multi-Robot Systems** (elective)<br>25. **Human-Robot Interaction** (elective)<br>26. **Robot Manipulation** (elective)<br>27. **Introduction to Aerial Robotics** (elective)<br>28. **Robot Perception and Learning** (elective)<br>• **( list of courses are attached with another file )** | | |
| **Other Fundamental Courses** | 81. **Course Name** (Prerequisite Name) (obligatory/elective)<br>82. **Course Name** (Prerequisite Name) (obligatory/elective)<br>83. **…** | | |
| **Teaching and Research Labs** | 1. **Introduction to Teaching and Learning in Higher :** The course aims to equip all full-time research postgraduate (RPg) students with basic teaching skills before assuming teaching assistant duties for the department. Good teaching skills can be acquired through learning and practice. This 10-hour mandatory training course provides all graduate teaching assistants (GTA) with the necessary theoretical knowledge with practical opportunities to apply and build up their knowledge, skills and confidence in taking up their teaching duties. At the end of the course, GTAs should be able to (1) facilitate teaching in tutorials and laboratory settings; (2) provide meaningful feedback to their students; and (3) design an active learning environment to engage their students. Graded PP, P or F. | | |
| **Research Groups** | 5. **Cross-disciplinary Research Methods I:** This course focuses on using various approaches to perform quantitative analysis through real-world examples. Students will learn how to use different tools in an interdisciplinary project | | |

| Number | 8 |
|---|---|
| **Program Name** | ***MSc in Robotics and Autonomous Systems*** |
| | and how to acquire new skills on their own. The course offers different modules that are multidisciplinary/multifunctional and generally applicable to a wide class of problems.<br>6. **Cross-disciplinary Research Methods II:** This course focuses on using various approaches to perform quantitative analysis through real-world examples. Students will learn how to use different tools in an interdisciplinary project and how to acquire new skills on their own. The course offers different modules that are multidisciplinary/multifunctional and generally applicable to a wide class of problems.<br>7. **Professional Development for Research Postgraduate Students:** This course aims at equipping research postgraduate students with transferrable skills conducive to their professional development. Students are required to attend 3 hours of mandatory training on Professional Conduct, and complete 12 hours of workshops, at their own choice, under the themes of Communication Skills, Research Competency, Entrepreneurship, Self-Management, and Career Development. Graded PP, P or F.<br>8. **Seminar in Robotics and Autonomous Systems:** Seminar topics presented by students, faculty and guest speakers. Students are expected to attend regularly and demonstrate proficiency in presentation in accordance with the program requirements. Graded P or F.<br>9. **MPhil Thesis Research:** Master's thesis research supervised by co-advisors from different disciplines. A successful defense of the thesis leads to the grade Pass. No course credit is assigned. |
| **Collaboration with Industry** *(List of sample projects)* | 1.<br>2. |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **9** | | |
| **Program Name** | *Master of Science in Robotics* | | |
| **University** | Ecole Polytechnique Fédérale de Lausanne (EPFL) | | |
| **Country** | Switzerland | | |
| **URL** | https://www.epfl.ch/education/master/programs/robotics/ | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 120 ECTS | | |
| **AI Credit Hours** | From 4 to 39 ECTS | | |
| **Data Science Credit Hours** | From 0 to 14 ECTS | | |
| **Robotics Credit Hours** | From 18 to 38 ECTS | | |
| **AI Courses in Curriculum** | 21. **Applied Machine Learning** (Linear Algebra, Probability & Statistics) (obligatory)<br>22. **Advanced Machine Learning** (Linear Algebra, Probability & Statistics) (elective)<br>23. **Deep Learning** (Linear Algebra, Differential Calculus, Python Programming, Probability & Statistics) (elective)<br>24. **Distributed Intelligent Systems** (Linear Algebra, Differential Calculus, Python Programming, Probability & Statistics, Programming Matlab, Python, C++) (elective)<br>25. **Fundamentals of Neuroengineering** (Neuroscience, Signal Processing, Machine Learning) (elective)<br>26. **Machine Learning Programming** (Applied Machine Learning) (elective)<br>27. **Intelligent Agents** (Artificial Intelligence) (elective) | | |
| **Robotics Courses in Curriculum** | 29. **Basics of Mobile Robotics** (Introduction to Automatic Control, Introduction to Signal Processing) (obligatory)<br>30. **Aerial Robotics** (elective)<br>31. **Industrial and Applied Robotics** (Basics of Robotics, Control Systems I & II, Microtechnology Components I & II, Vibratory Systems) (elective)<br>32. **Evolutionary Robotics** (Programming Python, Java, C++) (elective)<br>33. **Haptic Human Robot Interfaces** (Basics of Robotics) (elective)<br>34. **Legged Robots** (Mobile Robots, Model Predictive Control) (elective)<br>35. **Controlling Behavior in Animals and Robots** (Neuroscience II: Cellular Mechanisms of Brain function) (elective) | | |
| **Other Fundamental Courses** | 84. **Model Predictive Control** (Control Systems) (obligatory)<br>85. **Advanced Control Systems** (Control Systems, Numerical Control of Dynamic Systems) (elective)<br>86. **Industrial Automation** (Communication Networks) (elective)<br>87. **Computer Vision** (elective)<br>88. **Image Processing I** (Signals & Systems I & II) (elective)<br>89. **Image Processing II** (Image Processing I, Signals & Systems I & II, Linear Algebra, Analysis) (elective)<br>90. **Image Analysis and Pattern Recognition** (Introduction to Signal Processing, Image processing) (elective) | | |

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| **Number** | **9** |
| **Program Name** | *Master of Science in Robotics* |
| | **91. Signal Processing for Functional brain Imaging** (elective) |
| **Teaching and Research Labs** | 2. **Learning Algorithms and Systems Laboratory (LASA)** (KUKA Light Weight Robot 4+, UR5 robotic arm, iCub humanoid robot, YuMi robot)<br>3. **Laboratory of Intelligent Systems (LIS)** |
| **Research Groups** | 10. |
| **Collaboration with Industry** *(List of sample projects)* | 3. **Second Hands**<br>4. **Crowdbot** |

**Summary and Notes**

**This Robotics master's program at EPL provides education on the theory, technology and practice of intelligent robots, such as mobile robots, wearable robots, robotic manipulators, autonomous and brain-interfaced robots. In addition to classes spanning from electromechanical systems to advanced artificial intelligence, the program offers a large set of hands-on activities where students learn by designing, prototyping and validating robotic systems.**

**It extends over four semesters and is made up of individual modules that form the theoretical and methodological foundation for thorough practical training as detailed below:**

- **Basic compulsory modules (11 ECTS): Applied Machine Learning (4 ECTS), Basics of Mobile Robotics (4 ECTS), Model Predictive Control (3 ECTS).**
- **Optional courses and orientation (59 ECTS)**
- **Labs and Project I (14 ECTS): Robotics Practical (4 ECTS), Robotics Project I (10 ECTS).**
- **Project in social and human sciences (6 ECTS).**
- **Master's Thesis (30 ECTS).**

**This program is a part of the course of study of the "Learning Algorithms and Systems Laboratory (LASA)". This laboratory is organized into five research areas:**

- **Human-Robot Interaction**
- **Machine Learning with Application to Robotics**
- **Fast Adaptive Control**
- **Dexterous Manipulation and Grasping**
- **Computational Neuroscience and Cognitive Modeling**

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| **Number** | **9** |
| **Program Name** | *Master of Science in Robotics* |
| **This program gives students a well-rounded education with practical experience, and will lead to careers in a wide range of fields where robotics technologies are increasingly adopted, such as: biomedical technologies; logistics and transportation; aviation and drones; autonomous cars; industry 4.0; smart houses; environmental technology. In addition, students can benefit from EPFL's strong innovation ecosystem to invent new systems and applications, and start up their own company.** | |

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| **Number** | **10** | | |
| **Program Name** | *Robotics and Computation MSc* | | |
| **University** | University College London (UCL) | | |
| **Country** | United Kingdom | | |
| **URL** | https://www.ucl.ac.uk/prospective-students/graduate/taught-degrees/robotics-computation-msc | | |
| **Program Focus** | ☐ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 180 ECTS | | |
| **AI Credit Hours** | From 0 to 60 ECTS | | |
| **Data Science Credit Hours** | From 0 to 45 ECTS | | |
| **Robotics Credit Hours** | From 60 to 75 ECTS | | |
| **AI Courses in Curriculum** | 28. **Machine Learning for Visual Computing** (optional)<br>29. **Multi-Agents Artificial Intelligence** (Programming Python, Java, Probability, Statistics, Machine Learning, Deep Learning, TensorFlow or PyTorch or MXNet) (optional)<br>30. **Introduction to Machine Learning** (Calculus, Linear Algebra, Probability Theory, Programming Python) (elective)<br>31. **Introduction to Deep Learning** (Calculus, Linear Algebra, Probability Theory, Machine Learning, Programming Python or Julia) (elective)<br>32. **Probabilistic and Unsupervised Learning** (Calculus, Linear Algebra, Statistics, Computer Science, Programming Matlab or Octave) (elective)<br>33. **Reinforcement Learning** (Calculus, Probability, Linear Algebra, Programming Python) (elective)<br>34. **Supervised Learning** (Multivariable Calculus, Probability and Combinatorics, Linear Algebra) (elective) | | |
| **Robotics Courses in Curriculum** | 36. **Robot Vision and Navigation** (obligatory)<br>37. **Robotic Control Theory and Systems** (Linear Algebra, Calculus, Programming C) (obligatory)<br>38. **Robotic Sensing, Manipulation and Interaction** (Programming C++, ROS, Matlab, Python) (obligatory)<br>39. **Robotic Systems Engineering** (Linux, Programming ROS, Python, Linear Algebra) (obligatory)<br>40. **Affective Computing and Human-Robot Interaction** (Machine Learning, Programming Matlab, Python, Java, C++) (elective) | | |
| **Other Fundamental Courses** | 92. **Machine Vision** (Digital Imaging, Digital Image Processing) (optional)<br>93. **Numerical Optimization** (Linear Algebra, Analysis, Programming Matlab) (optional)<br>94. **Acquisition and Processing of 3D Geometry** (Linear Algebra) (optional) | | |
| **Teaching and Research Labs** | 4. | | |
| **Research Groups** | 11.<br>12. | | |

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|---|---|
| **Number** | **10** |
| **Program Name** | *Robotics and Computation MSc* |
| **Collaboration with Industry** *(List of sample projects)* | 5.<br>6. |

**Summary and Notes**

**This Robotics and Computation master's program at UCL provides an overview of robotic and computational tools for robotics and autonomous systems as well as their main computational components: kinetic chains, sensing and awareness, control systems, mapping and navigation. Optional modules in machine learning, human-machine interfaces and computer vision help students grasp fields related to robotics more closely, while the project thesis allows students to focus on a specific research topic in depth.**

**It extends over two semesters and is made up of individual modules that form the theoretical and methodological foundation for thorough practical training as detailed below:**

- **Compulsory modules (60 ECTS): Robot Vision and Navigation (15 ECTS), Robotic Control Theory and Systems (15 ECTS), Robotic Sensing, Manipulation and Interaction (15 ECTS), Robotic Systems Engineering (15 ECTS).**
- **Optional and Elective modules (60 ECTS)**
- **Master's Thesis (60 ECTS).**

**This programme prepares students to enter a robotics-related industry or any other occupation requiring engineering or analytical skills. Graduates with skills to develop new robotics solutions and solve computational challenges in automation are likely to be in demand globally.**

| | | | |
|---|---|---|---|
| **Number** | **11** | | |
| **Program Name** | *Robotics, Cognition, Intelligence* | | |
| **University** | Technical University of Munich | | |
| **Country** | Germany | | |
| **URL** | https://www.tum.de/en/studies/degree-programs/detail/detail/StudyCourse/robotics-cognition-intelligence-master-of-science-msc/ | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 120 ECTS | | |
| **AI Credit Hours** | From 23 to 50 ECTS | | |
| **Data Science Credit Hours** | From 8 to 35 ECTS | | |
| **Robotics Credit Hours** | From 11 to 38 ECTS | | |
| **AI Courses in Curriculum** | 35. **Basics of artificial Intelligence** (Basics: Algorithms and Data Structures, Discrete Structures) (obligatory)<br>36. **Machine Learning** (Linear Algebra for Computer Science, Analysis for Computer Science, Discrete Probability Theory) (obligatory)<br>37. **Human-Machine Communication I** (Boolean Algebra, Finite Automata, Mathematics I, Computer Technology, Signal Representation, Control Systems) (obligatory)<br>38. **Cognitive Systems** (obligatory)<br>39. **Reinforcement Learning for Robotics** (elective)<br>40. **Advanced Deep Learning for Computer Vision** (Analysis for Informatics, Linear Algebra for Informatics, Introduction to Deep Learning) (elective)<br>41. **Application of Knowledge-based Methods** (Techniques in Artificial Intelligence, Basic Courses in Informatics) (elective)<br>42. **Computational Intelligence** (Programming Matlab) (elective)<br>43. **Introduction to Deep Learning** (Analysis for Informatics, Linear Algebra for Informatics, Python) (elective)<br>44. **Machine Learning for Computer Vision** (Linear Algebra for Informatics, Probability Theory, statistical Modeling and Machine Learning) (elective)<br>45. **Advanced Deep Learning for Robotics** (Analysis for Computer, Linear Algebra for Computer, Introduction to Deep Learning) (elective)<br>46. **Human-Machine Communication II** (Human-Machine Communication I, Signals) (elective)<br>47. **Neural Engineering: Implants, Interfaces and Algorithms** (Computational Intelligence or Artificial Intelligence or Machine Learning) (elective) | | |
| **Robotics Courses in Curriculum** | 41. **Motion Planning in Robotics** (obligatory)<br>42. **Robotics** (Vector Algebra, Differential Calculus, Basic knowledge of physics) (obligatory)<br>43. **Object-Oriented Modeling in Mechatronic Systems** (elective) | | |

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|---|---|
| **Number** | **11** |
| **Program Name** | *Robotics, Cognition, Intelligence* |
| | 44. **Assembly, Handling and Industrial Robots** (Technical Mechanics, Advanced Mathematics) (elective)<br>45. **Robot Dynamics** (Mechanics) (elective)<br>46. **Sensor Guided Robotic Manipulation and Locomotion** (Robotics) (elective)<br>47. **Orbit Dynamics and Robotics** (Mechanics, Control Systems, Basics of Astronautics) (elective)<br>48. **Advanced Concepts of Perception for Robotic Systems** (Robotics, Image Processing, Basics of Intelligent Robots, Programming C++) (elective)<br>49. **Fundamentals of Human-Centered Robotics** (Robotics, Control Systems) (elective)<br>50. **Humanoid Robotic Systems** (elective)<br>51. **Modeling and Regulation of Humanoid Walking Robots** (Control Engineering Fundamentals) (elective)<br>52. **Introduction to Surgical Robotics** (elective)<br>53. **Multi-Sensory Based Robot Dynamic Manipulation** (Linear Algebra, Robotics, Programming C++, ROS) (elective)<br>54. **Programming and Control of Human Robot Interaction** (Robotics) (elective)<br>55. **Microtechnical sensors/actuators** (elective)<br>56. **Mechatronic Device Technology** (Control Systems, Programming) (elective)<br>57. **Autonomous Navigation for Flying Robots** (Linear Algebra, Probability Theory, 3D Geometry, Python) (elective)<br>58. **Robotics 3D Vision** (Linear algebra, Calculus, Computer Vision II) (elective)<br>59. **Control of Modern Lightweight Robots** (Control Engineering Basics) (elective) |
| **Other Fundamental Courses** | 95. **Computer Vision II: Multiple View** (Linear Algebra for Informatics, Analysis for Informatics) (obligatory) |
| **Teaching and Research Labs** | 5. **Chair of Robotics, Artificial Intelligence and Real Time Systems** (Shunck LWA 4P Robot, ABB IRB 120 Robot, KUKA LBR iiwa Robot, Automated Bicycle, BeagleBone Black, Altera DE0 FPGA board, Raspberry Pi, Freescale i.MX 6 SoCs, Sensors (Cameras, Accelerometer, Gyroscope, Laser, Wheel-Encoders, IR)) |
| **Research Groups** | 13. |
| **Collaboration with Industry** *(List of sample projects)* | 7. ***Embodied Cognition in a Compliantly Engineered Robot (*ECCEROBOT*)***<br>8. **European Clearing House for Open Robotics Development (**ECHORD**)** |
| **Summary and Notes** | |
| **The "Robotics, Cognition, Intelligence" master's program is a joint program of the Department of Informatics, Electrical Engineering, Information Technology and Mechanical Engineering of the Technical University of Munich.**<br>**It extends over four semesters and is made up of individual modules that form the theoretical and methodological foundation for thorough practical training as detailed below:**<br>• **Compulsory modules (57 ECTS): Basic knowledge in the three areas of robotics (11 ECTS), cognition (13 ECTS), intelligent autonomous systems (18 ECTS), master's seminar (5 ECTS), master's internship (10 ECTS).** | |

| Number | 11 |
|---|---|
| Program Name | *Robotics, Cognition, Intelligence* |

- **Elective modules (33 ECTS): General fundamentals (6 ECTS) and Deepening in the fields of computer science, mechanical engineering and electrical engineering (27 ECTS).**
- **Master's Thesis (30 ECTS).**

**This program is a part of the course of study of the "Chair of Robotics, Artificial Intelligence and Real-Time Systems". This chair is organized into four research areas:**

- **Human Robot Interaction and Service Robotics**
- **Medical Robotics**
- **Cognitive Robotics**
- **Cyber-Physical / Embedded Systems**

**After the completion of this program, good future employment prospects are predicted in the fields of automation technology for the aviation and aerospace industries, microelectronics industry, intelligent environments, pharmaceutical and chemical industries and large-scale research institutions. Graduates of the program will be qualified to move into employment in a range of high-level roles, including:**

- **Conception and realization of complex systems**
- **Project management and development of new software based products**
- **Conception and development of new systems from application areas such as automation technology, the automobile industry, engineering, information technology, real-time systems, web-services and infrastructures**
- **Research and teaching in research institutes, universities, and continuing education environments**
- **Consulting**

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|---|---|
| **Number** | **12** |
| **Program Name** | *Master in Computer Science* |
| **University** | University of Granada |
| **Country** | Spain |
| **URL** | https://masteres.ugr.es/ing-informatica/ |
| **Program Focus** | ☒ AI ☒ Data Science ☒ Robotics |
| **Credit Hours** | 102 ECTS offered - 72 ECTS for the Master degree |
| **AI Credit Hours** | 6 ETCS |
| **Data Science Credit Hours** | 30 ECTS |
| **Robotics Credit Hours** | 8 ETCS |
| **AI Courses in Curriculum** | 1. **Computational Intelligence** (obligatory)<br>2. **Cloud Computing: Fundamentals and Infrastructures** (obligatory)<br>3. **Cloud Computing: Services and Applications** (obligatory)<br>4. **Intelligent Systems for Management in Companies** (obligatory)<br>5. **Intelligent Data Processing** (obligatory)<br>6. **Applications of Advanced Computational Mathematics** (obligatory)<br>7. **Graphical Visualisation Techniques: Medical Applications** (elective) |
| **Robotics Courses in Curriculum** | 1. **Home Automation** (elective)<br>2. **Critical Systems** (elective) |
| **Other Fundamental Courses** | **1. Planning and Management of Computer Projects** (obligatory)<br>**2. Company Internships** (elective)<br>**3. Company Engineering Projects** (elective)<br>**4. Development of Software Systems Based on Components and Services** (obligatory)<br>**5. Development and Evaluation of Interactive Software Systems** (obligatory)<br>**6. Virtual Environments** (obligatory)<br>**7. Systems Administration and Security** (elective)<br>**8. Information Management in Mobile Devices** (elective)<br>**9. Information Management on The Web** (elective)<br>**10. Mobile Internet** (elective)<br>**11. Web-Based Software Systems** (elective)<br>**12. Master Thesis** (obligatory) |

| **Number** | **12** |
|---|---|
| **Program Name** | *Master in Computer Science* |
| **Teaching and Research Labs** | 1. **No special labs available** |
| **Research Groups** | 1. **Approximate Reasoning and Artificial Intelligence (ARAI)**<br>2. **Computer Vision Group (CVG)**<br>3. **Computational Intelligence (CI)**<br>4. **Intelligent Databases and Information Systems (IdBIS)**<br>5. **Intelligent Systems Groups (ISG)**<br>6. **Models of Decision and Optimization (MODO)**<br>7. **Soft Computing and Intelligent Information Systems (SCI2S)**<br>8. **Uncertainty Treatment in Artificial Intelligence (UTAI)**<br>9. **Visual and Information Processing (VIP)**<br>10. **Circuits and Systems for Information Processing (CASIP)**<br>11. **Concurrent Systems (SC)**<br>12. **Group of Specification, Development and Software Evolution (GEDES)**<br>13. **Graphic Computers and Virtual Reality (INGREVI)**<br>14. **Signals, Telematics and Communications (STC)**<br>15. **Smart Wireless Applications and Technologies Group (SWAT)** |
| **Collaboration with Industry** *(List of sample projects)* | 1. **None related directly with Master** |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **13** | | |
| **Program Name** | *Master in Data Science and Computer Engineering* | | |
| **University** | University of Granada | | |
| **Country** | Spain | | |
| **URL** | https://masteres.ugr.es/datcom/ | | |
| **Program Focus** | ☒ AI | ☒ Data Science | ☒ Robotics |
| **Credit Hours** | 127 ECTS offered - 60 ECTS for the Master degree | | |
| **AI Credit Hours** | 95 ETCS | | |
| **Data Science Credit Hours** | 95 ECTS | | |
| **Robotics Credit Hours** | 32 ETCS | | |
| **AI Courses in Curriculum** | 48. **Introduction to Data Science** (obligatory)<br>49. **Introduction to Programming for Data Science** (elective)<br>**50. Data mining: pre-processing and classification** (elective)<br>**51. Data Mining: Unsupervised Learning and Anomaly Detection** (elective)<br>**52. High Performance Computing for Classification and Optimisation** (elective)<br>**53. Computational biology with big data-omics and biomedical engineering** (elective)<br>**54. System modelling and time series prediction** (elective)<br>**55. Probabilistic graphical models** (elective)<br>**56. Feature Extraction in Images** (elective)<br>**57. Time Series and Mining of Data Streams** (elective)<br>**58. Information Retrieval and Recommender Systems** (elective)<br>**59. Data mining: Advanced Aspects** (elective)<br>**60. Social Media Mining** (elective)<br>**61. Process Mining** (elective)<br>**62. Big data II: Big Data analytics** (elective)<br>**63. Soft computing: Fuzzy Sets and systems** (elective)<br>**64. Soft Computing Techniques for Learning and Optimisation. Neural Networks and Metaheuristics, evolutionary and bio-inspired programming** (elective)<br>65. **Computer Vision** (elective) | | |
| **Robotics Courses in Curriculum** | 60. **Introduction to Programming for Computer Engineering** (elective)<br>61. **Embedded systems and hw/sw co-design** (elective)<br>62. **Internet of things** (elective)<br>**63. High performance architectures for vision** (elective)<br>**64. Mechatronics and aerospace systems** (elective)<br>**65. Computational neuroscience and neuroengineering** (elective) | | |

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|---|---|
| **Number** | **13** |
| **Program Name** | *Master in Data Science and Computer Engineering* |
| | **66. Bio-inspired vision systems** (elective)<br>67. **Mobile robotics and neuro-robotics** (elective) |
| **Other Fundamental Courses** | 96. **Entrepreneurship and knowledge transfer** (obligatory)<br>97. **Research Methodology** (elective)<br>98. **Secure servers** (elective)<br>**99. High Performance Computing** (elective)<br>**100. Web server engineering** (elective)<br>**101. High performance signal processing in biomedicine** (elective)<br>**102. Big data I: Cloud computing and massive data storage** (elective)<br>103. **Applications of Data Science and Intelligent Technologies** (elective)<br>104. **Master Thesis** (obligatory) |
| **Teaching and Research Labs** | 6. **No special labs available** |
| **Research Groups** | 14. **Approximate Reasoning and Artificial Intelligence (ARAI)**<br>15. **Computer Vision Group (CVG)**<br>16. **Computational Intelligence (CI)**<br>17. **Intelligent Databases and Information Systems (IdBIS)**<br>18. **Intelligent Systems Groups (ISG)**<br>19. **Models of Decision and Optimization (MODO)**<br>20. **Soft Computing and Intelligent Information Systems (SCI2S)**<br>21. **Uncertainty Treatment in Artificial Intelligence (UTAI)**<br>22. **Visual and Information Processing (VIP)**<br>23. **Circuits And Systems for Information Processing (CASIP)** |
| **Collaboration with Industry** *(List of sample projects)* | 9. **None related directly with Master** |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **14** | | |
| **Program Name** | *Master in Industrial Electronics* | | |
| **University** | University of Granada | | |
| **Country** | Spain | | |
| **URL** | https://masteres.ugr.es/electronicaindustrial/ | | |
| **Program Focus** | ☐ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 78 ECTS offered - 60 ECTS for the Master degree | | |
| **AI Credit Hours** | 0 ETCS | | |
| **Data Science Credit Hours** | 0 ECTS | | |
| **Robotics Credit Hours** | 20 ETCS | | |
| **AI Courses in Curriculum** | 1. | | |
| **Robotics Courses in Curriculum** | **1. Digital Control of Mechatronic Systems** (obligatory)<br>2. **Mobile Robotics** (obligatory)<br>3. **Design and Construction of Non-Tripulated Vehicles** (elective)<br>4. **Aerospace Electronics, Applications to Small Satellites** (elective)<br>5. **Power Electronics for Electric Traction Vehicles** (elective)<br>6. **Biomedical Electronics Systems** (elective) | | |
| **Other Fundamental Courses** | **1. Digital Control for Power Electronics** (obligatory)<br>**2. Industrial Electronics: Emerging Components, Power Systems, Market and Perspective** (obligatory)<br>**3. Modeling and Management of Energy Storage Systems** (obligatory)<br>**4. Advanced Digital Design** (obligatory)<br>**5. Systems with Integrated Processors** (obligatory)<br>**6. Development of Portable Instrumentation** (elective)<br>**7. Development of Technological Innovation** (elective)<br>**8. Tcad Design of Integrated Circuits** (elective)<br>**9. Advanced Project Management** (elective)<br>**10. Advanced Image Processing for Industrial Applications** (elective)<br>**11. Security in Electronic Systems** (elective)<br>12. **External Internships** (elective) | | |
| **Teaching and Research Labs** | **1. Advanced Electronics Laboratory**<br>2. **Basic Electronics Laboratory** | | |
| **Research Groups** | 1. **Cirtuits And Systems for Information Processing (CASIP)**<br>2. **Research Group on Electronic Devices (GRIDE)**<br>3. **Digital Techniques, Digital TECniques (DiTEC)** | | |

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|---|---|
| **Number** | **14** |
| **Program Name** | *Master in Industrial Electronics* |
| | 4. **Nanoelectronics Research Group (GIN)**<br>5. **Nanostructures, quantum properties and technological applications (NPCAT)**<br>6. **Electrical and Chemical Sensing Solutions (ECSENS)**<br>7. **Pervasive Electronics advanced research laboratory (PEARL)** |
| **Collaboration with Industry** *(List of sample projects)* | 2. **None related directly with Master** |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **15** | | |
| **Program Name** | ***Master of Science - Data Science & Engineering – Artificial Intelligence Track*** | | |
| **University** | UNIGE | | |
| **Country** | Italy | | |
| **URL** | https://www.unige.it/ (a) | | |
| **Program Focus** | ■ AI | ☐ Data Science | ☐ Robotics |
| **Credit Hours** | 120 CFU = 3000 student hours (b) (c) | | |
| **AI Credit Hours** | 54 CFU = 1350 student hours | | |
| **Data Science Credit Hours** | 15 CFU = 375 student hours | | |
| **Robotics Credit Hours** | 0 | | |
| **AI Courses in Curriculum** | 1. MACHINE LEARNING - CFU 9 - Obligatory<br>2. DIGITAL SIGNAL & IMAGE PROCESSING - CFU 9 - Obligatory<br>3. ADVANCED MACHINE LEARNING - CFU 9 - Obligatory<br>4. SPEECH PROCESSING AND RECOGNITION - CFU 6 - Obligatory<br>5. COMPUTATIONAL VISION - CFU 6 – Obligatory<br>6. WELL-BEING TECHNOLOGIES - CFU 6 – Elective<br>**7.** NATURAL LANGUAGE PROCESSING - CFU 6 – Obligatory<br>**8.** MULTIAGENTS SYSTEMS - CFU 6 – Obligatory | | |
| **Data Science Courses in Curriculum** | 1. LARGE-SCALE COMPUTING - CFU 9 – Obligatory<br>2. DATA VISUALIZATION - CFU 6 – Obligatory | | |
| **Robotics Courses in Curriculum** | NONE | | |
| **Other Fundamental Courses** | 1. ADDITIONAL USEFUL KNOWLEDGE - CFU 3 – Obligatory<br>2. COMPUTATIONAL NEUROENGINEERING - CFU 6 - Elective<br>3. TOPICS IN COMPUTER SCIENCE - CFU 6 - Elective<br>4. HIGH PERFORMANCE COMPUTING - CFU 9 – Obligatory<br>**5.** DATA PROTECTION & PRIVACY - CFU 6 – Elective | | |
| **Teaching and Research Labs** | 1. Lab SW1: 32PC workstations for training at all levels (BSc and MSc)<br>2. Lab SW2: 24 PC workstations for training at all levels (BSc and MSc)<br>3. Research Group Labs: Advanced workstations and HPC facilities including NVIDIA GPUs, biosensors and wearable and ambient sensors | | |
| **Research Groups (d)** | 1. Artificial intelligence<br>2. Data Science and Engineering<br>3. Secure and Reliable Systems<br>4. Human-Computer Interaction | | |

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|---|---|
| **Number** | **15** |
| **Program Name** | ***Master of Science - Data Science & Engineering – Artificial Intelligence Track*** |
| | 5. Science and Technology for Health<br>6. Robotics and Autonomous Systems<br>7. Systems Engineering |
| **Collaboration with Industry (e)**<br>*(List of sample projects)* | 1. Company : LEONARDO - Topic: Technological support<br>2. Company : CETENA - Topic: Technological support<br>3. Company : GENOA Municipality - Topic: Technological support<br>4. Company : CAP - Topic: Technological support<br>5. Sponsor : EC - Project name: Daydream<br>6. Sponsor : CINI - Project name: ELISE<br>7. Sponsor : EC - Project name: Jemaro<br>8. Sponsor : EC - Project name: IENE<br>9. Sponsor : Union Des Partner Industries Ferroviaires - Project name: OPTIMA<br>10. Sponsor : EU ESF - Project name: SENIOR |

**Summary and Notes**

(a) Complete info available at https://courses.unige.it/10852, https://servizionline.unige.it/unige/stampa_manifesto/MF/2020/10852.html

(b) The Italian Credit system is based on the CFU (Credito Formativo Universitario) corresponding to 25 student hours. 1 CFU = 1 ECTS (European Credit Transfer and Accumulation System). Each Department decides about the number of hours of lecture corresponding to one CFU. The DIBRIS - Dept of Informatics, Bioengineering, Robotics and Systems Engineering assigns 8 hours of lecture to one CFU.

(c) The weight of the FINAL DISSERTATION is 6 CFU.

(d) The research groups at DIBRIS are informal aggregation of researchers. The reported list is not exhaustive .

(e) The technological transfer is also operated trough 10 active spin-offs of the DIBRIS: BIO3DMATRIX, LCAIR, DOCSPACE, HEALTHROPY, GERMINA, LOGNESS, SCREENNEURO FARM, TALOS, TESEO, VEGA RESEARCH LABORATORIES, ZENA BYTE.

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|---|---|---|---|
| **Number** | **16** | | |
| **Program Name** | *Artificial Intelligence and Data Engineering* | | |
| **University** | University of Pisa | | |
| **Country** | Italy | | |
| **URL** | https://computer.ing.unipi.it/aide-lm | | |
| **Program Focus** | ☒ AI | ☒ Data Science | ☐ Robotics |
| **Credit Hours** | 120 | | |
| **AI Credit Hours** | 30-40 | | |
| **Data Science Credit Hours** | 24-34 | | |
| **Robotics Credit Hours** | 6 | | |
| **AI Courses in Curriculum** | 66. **Data Mining and Machine Learning** (None) (obligatory)<br>67. **Computational Intelligence and Deep Learning** (None) (obligatory)<br>68. **Process Mining and Intelligence** (None) (obligatory)<br>69. **Symbolic and Evolutionary Artificial Intelligence** (None) (obligatory)<br>70. **Process Mining and Intelligence ng** (None) (obligatory) | | |
| **Robotics Courses in Curriculum** | 68. **Robotica e Macchine Intelligenti** (None) (elective) | | |
| **Other Fundamental Courses** | 105. **Cloud Computing** (None) (obligatory)<br>106. **Large-Scale and Multi-Structured Databases** (None) (obligatory)<br>107. **Business and Project Management** (None) (obligatory)<br>108. **Optimization Methods and Game Theory** (None) (obligatory)<br>109. **Multimedia Information Retrieval and Computer Vision** (None) (obligatory)<br>110. **Performance Evaluation of Computer Systems and Networks** (None) (elective)<br>**111. Mobile and Social Sensing Systems** (None) (elective)<br>**112. Distributed Systems and Middleware Technologies** (None) (elective)<br>113. **Internet of Things** (None) (elective) | | |
| **Teaching and Research Labs** | 7. **Networking and Cloud Computing Lab** (List of major equipment, if available)<br>8. **CyberSecurity Lab** (List of major equipment, if available)<br>**9. Data Science and Engineering Lab**<br>10. L**ab Cloud Computing, Big Data & Cybersecurity** | | |
| **Research Groups** | 24.<br>25. | | |
| **Collaboration with Industry** *(List of sample projects)* | 10.<br>11. | | |

| **Number** | **16** |
|---|---|
| **Program Name** | *Artificial Intelligence and Data Engineering* |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **17** | | |
| **Program Name** | *Robotics And Automation Engineering* | | |
| **University** | University of Pisa | | |
| **Country** | Italy | | |
| **URL** | http://www.aut.ing.unipi.it/index.php | | |
| **Program Focus** | ☐ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 120 | | |
| **AI Credit Hours** | 0-12 | | |
| **Data Science Credit Hours** | | | |
| **Robotics Credit Hours** | 66-84 | | |
| **AI Courses in Curriculum** | 71. **Intelligent Systems** (None) (elective)<br>72. **Computational Intelligence** (None) (elective) | | |
| **Robotics Courses in Curriculum** | 69. **Mechanics of Robots** (None) (obligatory)<br>**70. System Theory and Control Theory** (None) (obligatory)<br>**71. Digital Control** (None) (obligatory)<br>**72. Process Control** (None) (obligatory)<br>73. **Control and Identification of Uncertain Systems** (None) (obligatory)<br>**74. Robotics** (None) (obligatory)<br>**75. Aerospace Robotics** (None) (elective)<br>**76. Underwater Systems** (None) (elective)<br>**77. Cybernetic and Physiological Systems** (None) (elective)<br>**78. Guidance and Navigation Systems** (None) (obligatory) | | |
| **Other Fundamental Courses** | 114. **Probability and Stocastic Processes** (None) (obligatory)<br>115. **Electronic Systems for Robotics and Automation** (None) (elective)<br>116. **Real Time Systems** (None) (elective)<br>117. **Control of energy systems** (None) (elective)<br>118. **Mechanics and Mechatronics Laboratory** (None) (elective)<br>119. **Vehicle Dynamics** (None) (elective)<br>120. **Modelling and simulation of discrete event systems** (None) (elective) | | |
| **Teaching and Research Labs** | 11. **Advanced Manufacturing** (1 Franka Panda Robot, 1 UR10, Universal Robot, 1 LGV forklift, 1 XL Steel Robotnik)<br>12. **Aerial Robotics Lab** (4 Drones, Vicon Motion Tracking System with 10 cameras, 2 Camera Stabilizing gimbal)<br>**13. Manipulation and Grasping Lab** (2 LWR-II Kuka arms, 2 Franka Panda Emika, 3 Pisa IIT soft hands)<br>**14. Hands and Haptics Lab** (2 Pisa IIT soft hands, 1 DLR hand, Phantom and Delta Robots, Wearable devices) | | |

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| **Number** | **17** |
| **Program Name** | *Robotics And Automation Engineering* |
| | 15. **Underwater Robotics Lab** (Zeno Underwater robot, sensors for underwater communication)<br>16. **Soft Robotics Lab** (Variable Stiffness Actuators, soft robots, soft materials) |
| **Research Groups** | 26.<br>27. |
| **Collaboration with Industry**<br>***(List of sample projects)*** | 12.<br>13. |
| **Summary and Notes** | |
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|---|---|---|---|
| **Number** | **18** | | |
| **Program Name** | *Autonomous Systems, M.Sc.* | | |
| **University** | University of Stuttgart | | |
| **Country** | Germany | | |
| **URL** | https://www.uni-stuttgart.de/en/study/study-programs/Autonomous-Systems-M.Sc./ | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 3600 | | |
| **AI Credit Hours** | (in total 3780h offered) | | |
| **Data Science Credit Hours** | (in total 5130h offered) | | |
| **Robotics Credit Hours** | (in total 3330h offered) | | |
| **AI Courses in Curriculum** | 1. **Laboratory Big Data Machine Learning** 3CP<br>2. **Aspects of Autonomous Systems** (obligatory) 6CP<br>3. **Concepts of Automatic Control** 6CP<br>4. **Detection and Pattern Recognition** 6CP<br>5. **Distributed Systems** 6CP<br>6. **Distributed Systems II** 6CP<br>7. **Intelligent cyber-physical Systems** 6CP<br>8. **Machine Learning** 6CP<br>9. **Smart Cities and Internet of Things** 6CP<br>10. **Dependability intelligent distributed automation systems** 6CP<br>11. **Reinforcement Learning**() 6CP<br>12. **Deep learning** 6CP<br>13. **Concepts of Automatic Control** 6CP<br>14. **Deep Learning Applications for Communications** 3CP<br>15. **Project Automatic Control** 3CP<br>16. **Internship System Dynamics** 3CP<br>17. **Optimal Control** 6CP<br>18. **Robust Control** 6CP<br>19. **Nonlinear Control** 6CP<br>20. **Model Predictive Control** 6CP<br>21. **Numerical Optimization and Optimal Control** 6CP<br>22. **Flat Systems** 6CP<br>23. **Statistical Learning and Stochastic Control** 6CP | | |

| **Number** | **18** |
|---|---|
| **Program Name** | *Autonomous Systems, M.Sc.* |
| **Robotics Courses in Curriculum** | 1. **Control Technology of Machine Tools and Industrial Robots** 6CP<br>2. **Applications of Robot Systems** 6CP<br>3. **Design of robot systems** 3CP<br>4. **Modeling, Analysis and Design of Advanced Kinematics** 6CP<br>5. **Computational Dynamics for Robotics** 6CP<br>6. **Trajectory Generation** 3CP<br>7. **Probabilistic Planning** 6CP<br>8. **Robots – Applications in Service Robotics** 6CP<br>9. **Practical Laboratory Automation**() 3CP<br>10. **Laboratory Project Computer Vision for Robotics** 3CP<br>11. **Laboratory Project Service Robotics** 3CP<br>12. **Automation Engineering II** 6CP<br>13. **Basic Principles of Modeling and Simulation** 6CP<br>14. **Robotics I** 6CP<br>15. **Modeling and Analysis of Automation Systems** 6CP<br>16. **Modeling and Identification of Dynamical Systems** 6CP<br>17. **Machine Dynamics** 6CP<br>18. **Modeling and Simulation in Mechatronics** 6CP<br>19. **Robotics I** 6CP<br>20. **Dynamics of Mechanical Systems** 6CP<br>21. **Nonlinear Dynamics of mechanical Systems** 6CP |
| **Other Fundamental Courses** | 1. **Automated and Connected Driving I + II** 6CP<br>2. **Systems Engineering II** 6CP<br>3. **Digital Signal Processing** 6CP<br>4. **Discrete Optimization** 6CP<br>5. **Optimization** 6CP<br>6. **Communications II** 6CP<br>7. **Computer architecture and computer organisation** 6CP<br>8. **Real-time Concepts for Embedded Systems** 6CP<br>9. **Laboratory Course Software Engineering** 6CP<br>10. **Statistical and Adaptive Signal Processing** 6CP<br>11. **Computer Vision** 6CP<br>12. **Correspondence Problems in Computer Vision** 6CP |

| Number | 18 |
|---|---|
| **Program Name** | *Autonomous Systems, M.Sc.* |
| | 13. **Optical Sensor Engineering for Autonomous Systems** 6CP<br>14. **Advanced Mathematics for Signal and Information Processing** 6CP<br>15. **Automotive radar systems for autonomous driving** 3CP<br>16. **Computer Engineering II** 6CP<br>17. **Communications III** 6CP<br>18. **Embedded Controller and Data Networks in Vehicles** 6CP<br>19. **Data Engineering** 6CP<br>20. **Software Engineering for Real-Time Systems** 6CP<br>21. **Industrial Automation Systems** 6CP<br>22. **Technologies and methods of software systems II** 6CP<br>23. **Cloud Computing: Concepts and Technologies** 6CP<br>24. **Design of Digital Systems** 6CP<br>25. **Software System Safety** 3CP<br>26. **Digital Image processing** 3CP<br>27. **Distributed Parameter Systems** 6CP<br>28. **Convex Optimization** 6CP<br>29. **Dynamic Filtering** 6CP<br>30. **Uncertainty Quantification** 6CP |
| **Teaching and Research Labs** | 17. **Laboratory – Institute of Engineering and Computational Mechanics**<br>18. **Laboratory – Institute for Systems Theory and Control**<br>19. **Practical Trainings – Institute for System Dynamics**<br>20. **Laboratory – Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>21. **Laboratory – Institute for Nonlinear Mechanics**<br>22. **Machine Learning & Robotics Lab – IPVS**<br>23. **SOLA – Software Lab University of Stuttgart** |
| **Research Groups** | 28. **Institute of Engineering and Computational Mechanics**<br>29. **Institute for Systems Theory and Control**<br>30. **Institute for System Dynamics**<br>31. **Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>32. **Institute for Nonlinear Mechanics**<br>33. **Institute for Parallel and Distributed Systems**<br>34. **Fraunhofer IPA** |

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|---|---|
| **Number** | **18** |
| **Program Name** | *Autonomous Systems, M.Sc.* |
| **Collaboration with Industry** *(List of sample projects)* | Only exemplarily:<br>ZF Friedrichshafen, Bosch, Porsche, Daimler, Trumpf, Rexroth, Festo, … |

**Summary and Notes**

The master's program Autonomous Systems was newly developed and started in the winter semester 2019/2020, so there are no graduates yet. The program can be seen as mixture of the other three programs mentioned above, i.e., it offers more AI courses than e.g. the Mechatronics program, but on the other hand it is less research-oriented than the Simulation Technology program, i.e., it considers more practical aspects. There are no compulsory courses in this program, but thematic blocks from which the students chose their elective courses.

The University of Stuttgart mainly offers four Master of Science programs in AI and robotics. Their main features are summarized in the following table and further information about the courses in AI and robotics is provided. Note that the official teaching language for all four programs is German, although some courses are offered in English. There are virtually no obligatory courses in any of the four programs, meaning that each student can choose specialization subjects and courses according to their interests. Therefore, it is not possible to give an explicit number of credit hours in the following tables since this depends heavily on the subjects chosen. Thus, we have rather indicated the number of all credit hours of subjects that are offered. Of course, students cannot take all subjects.

It is assumed that the students have a strong theoretical background in mathematics, programing and modeling. Typically, most master students have obtained their bachelor's degree at the University of Stuttgart such that the master courses build on the corresponding bachelor's degree. However, since the programs we are dealing with have many similarities, students have the opportunity to change from one bachelor's program to another master's program without any additional effort.

In general, the Mechatronics program and the Engineering Cybernetics program belong to the engineering science programs. However, in a broader sense, both programs are also categorized as applied mathematics programs, especially the Engineering Cybernetics program. In both programs, students choose two different specialization subjects, giving them the opportunity to take courses in AI and robotics. Note that there is a lot of overlap with respect to the specialization subjects. Usually, one specialization subject is offered by one institute. Thus, each institute can teach its corresponding research expertise. In addition, this structure provides an incentive for institutes to attract highly qualified students to their research through exceptional teaching.
In order to strengthen the practical knowledge of the students, the courses are complemented by mandatory practical trainings, e.g., in the laboratories. In addition, the curriculum includes a minimum twelve-week industrial internship, often extended to six months as this is common practice in industry.

The Autonomous Systems program and the Simulation Technology program are cross-faculty programs. Therefore, students can choose a wide range of specialization subjects which include AI and robotics, but also, for instance, physics. Especially in the Simulation Technology program, a strong theoretical background is required since the program is research-oriented. Both programs focus on theoretical aspects which are complemented by

| Number | 18 |
|---|---|
| **Program Name** | *Autonomous Systems, M.Sc.* |

technical trainings. However, an industrial internship, as obligatory in the Mechatronics and Engineering Cybernetics program, is not required in these programs.

For general robotic studies, the Mechatronics M.Sc. program at the University of Stuttgart is recommended, as it covers a wide range of robotics problems based on fundamental knowledge in mathematics, programming and modeling. In addition, various practical trainings complement the theoretical courses. If a special focus is placed on general system dynamics and control engineering problems, the Engineering Cybernetics program is recommended. In this program, specialization subjects and additional courses in AI can also be chosen.

If the student's interests lie in the field of AI, the Simulation Technology or Autonomous Systems program is recommended. These study programs offer many specialization subjects and courses in AI, but also in robotics. The Simulation Technology program in particular is very research-oriented and therefore offers fewer practical aspects. The study program Autonomous Systems is newly developed, it started in the winter term 2019/2020.

Note that all possible elective courses are considered below in terms of credit hours, although a student obviously cannot choose all of them within his or her program. Furthermore, many of the courses listed below are part of a specialization subject such that not every course can be combined with every other. As noted above, we would like to iterate that the programs have many courses in common.

It is worth pointing out that that international studies are generally encouraged. There are additional double degree programs (e.g., with Chalmers University of Technology and Toyohashi University of Technology) which cover similar courses in AI and robotics. Students can also spend a semester abroad at the university's or institute's partners.

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|---|---|---|---|
| **Number** | **19** | | |
| **Program Name** | *Engineering Cybernetics, M.Sc.* | | |
| **University** | University of Stuttgart | | |
| **Country** | Germany | | |
| **URL** | https://www.uni-stuttgart.de/en/study/study-programs/Engineering-Cybernetics-M.Sc./ | | |
| **Program Focus** | ☒ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 3600 | | |
| **AI Credit Hours** | in total 4050h offered | | |
| **Data Science Credit Hours** | in total 5490h offered | | |
| **Robotics Credit Hours** | in total 3960h offered | | |
| **AI Courses in Curriculum** | 1. **Machine Learning** 6CP<br>2. **Introduction to Distributed Artificial Intelligence** 3CP<br>3. **Reinforcement Learning** 6CP<br>4. **Statistical Learning and Stochastic Control** 6CP<br>5. **Deep learning** 6CP<br>6. **Concepts of Automatic Control** (obligatory) 6CP<br>7. **Optimal Control** 6CP<br>8. **Robust Control** 6CP<br>9. **Nonlinear Control** 6CP<br>10. **Numerical Optimization and Optimal Control** 6CP<br>11. **Flat Systems** 6CP<br>12. **Machine Learning in System Dynamics** 3CP<br>13. **Model Predictive Control** 6CP<br>14. **Topics in Autonomous Systems and Control** 6CP<br>15. **Theoretical and Methodological Foundations of Autonomous Systems** 6CP<br>16. **Introduction to Adaptive Control** 3CP<br>17. **Networked Control Systems** 6CP<br>18. **Analysis and Control of Multi-agent Systems** 3CP<br>19. **Advanced Methods in Systems and Control Theory** 3CP<br>20. **Optimization and Optimal Control** 6CP<br>21. **Human-Computer Interaction** 6CP<br>22. **Detection and Pattern Recognition** 6CP<br>23. **Basic Principles of Artificial Intelligence** 6CP | | |

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|---|---|
| **Number** | **19** |
| **Program Name** | *Engineering Cybernetics, M.Sc.* |
| | 24. **Seminar – Computer Science 1** 3CP<br>25. **Similarity Mechanics Engineering and Artificial Intelligence** 3CP<br>26. **Matrix Computations in Signal Processing and Machine Learning** 3CP<br>27. **Deep Learning Applications for Communications** 3CP |
| **Robotics Courses in Curriculum** | 1. **Modeling and Simulation in Mechatronics** 6CP<br>2. **Dynamics of Mechanical Systems** 6CP<br>3. **Computational Dynamics for Robotics** 6CP<br>4. **Non-linear Dynamics** 6CP<br>5. **Modeling and Identification of Dynamical Systems** 6CP<br>6. **Dynamics of Discrete-Event Systems** 6CP<br>7. **Vehicle Dynamics** 3CP<br>8. **Flexible Multibody Systems** 6CP<br>9. **Optimization of Mechanical Systems** 3CP<br>10. **Practical Laboratory Applied Dynamics** 3CP<br>11. **Selected Problems of Dynamics** 3CP<br>12. **Selected Problems of Mechanics** 3CP<br>13. **Control Technology of Machine Tools and Industrial Robots** 6CP<br>14. **Control Engineering** 6CP<br>15. **Applications of Robot Systems** 3CP<br>16. **Practical Laboratory Automation** 3CP<br>17. **Hydraulics and Pneumatics in Control Technology** 3CP<br>18. **Control Architecture and Communication Technology** 3CP<br>19. **Applied Control Systems in Manufacturing Facilities** 3CP<br>20. **Robots – Applications in Service Robotics** 3CP<br>21. **Robots – Application in Industry** 3CP<br>22. **Design of robot systems** 3CP<br>23. **Modeling, Analysis and Design of Advanced Kinematics** 6CP<br>24. **Automation Engineering** 3CP<br>25. **Object-oriented modeling and simulation** 6CP<br>26. **Internship System Dynamics** 3CP<br>27. **Trajectory Generation** 3CP<br>28. **Robotics I** 6CP<br>29. **Robotics II** 6CP |

| Number | 19 |
|---|---|
| **Program Name** | *Engineering Cybernetics, M.Sc.* |
| | 30. **Flight Mechanics** 3CP<br>31. **Flight Control** 3CP<br>32. **Nonlinear Dynamics of mechanical Systems** 6CP<br>33. **Nonsmooth Dynamics** 6CP<br>34. **Workshop Nonlinear Mechanics** 3CP<br>35. **Miscellaneous Topics in Mechanics** 3CP<br>36. **Nonlinear Structural Dynamics** 6CP<br>37. **Computational Dynamics for Robotics** 6CP<br>38. **Dynamics and Control of Legged Locomotion** 3CP<br>39. **Electrical Machines I** 6CP<br>40. **Automation Engineering II** 6CP<br>41. **Practical Course Robotics** 6CP |
| **Other Fundamental Courses** | 1. **Distributed Parameter Systems** (obligatory) 6CP<br>2. **Model Reduction of Mechanical Systems** 3CP<br>3. **Uncertainty Quantification** 6CP<br>4. **Control Architecture and Communication Technology** 6CP<br>5. **Dynamic Filtering** 6CP<br>6. **Convex Optimization** 6CP<br>7. **Stochastic processes and modeling** 6CP<br>8. **Introduction into Chaostheory** 6CP<br>9. **Dynamics of non-smooth models** 3CP<br>10. **Nonlinear Programming** 3CP<br>11. **Methods of System Simulation and Analysis** 3CP<br>12. **Estimation Methods** 3CP<br>13. **Discretization Methods** 3CP<br>14. **Mechanics of Nonlinear Continua** 6CP<br>15. **Higher Analysis** 9CP<br>16. **Functional Analysis** 9CP<br>17. **Dynamics Systems** 9CP<br>18. **Partial Differential Equations (Modeling, Analysis, Simulation)** 9CP<br>19. **Introduction to Optimization** 9CP<br>20. **Stochastic Processes** 9CP<br>21. **Differential Geometry** 9CP |

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|---|---|
| **Number** | **19** |
| **Program Name** | *Engineering Cybernetics, M.Sc.* |
| | 22. **Nonlinear Partial Differential Equations** 9CP<br>23. **Linear Matrix Inequalities in Control** 9CP<br>24. **Functional Analysis 2** 9CP<br>25. **Data Science in Production Technology** 3CP<br>26. **Automated and Connected Driving I+II** 6CP<br>27. **Computer Vision** 6CP<br>28. **Higher Mathematics IV for Cyberneticists** 6CP<br>29. **Efficient Programming** 6CP |
| **Teaching and Research Labs** | 1. **Laboratory – Institute of Engineering and Computational Mechanics**<br>2. **Laboratory – Institute for Systems Theory and Control**<br>3. **Practical Trainings – Institute for System Dynamics**<br>4. **Laboratory – Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>5. **Laboratory – Institute for Nonlinear Mechanics**<br>6. **Machine Learning & Robotics Lab - IPVS** |
| **Research Groups** | 1. **Institute of Engineering and Computational Mechanics**<br>2. **Institute for Systems Theory and Control**<br>3. **Institute for System Dynamics**<br>4. **Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>5. **Institute for Nonlinear Mechanics**<br>6. **Institute for Parallel and Distributed Systems**<br>7. **Fraunhofer IPA** |
| **Collaboration with Industry** *(List of sample projects)* | Only exemplarily:<br>ZF Friedrichshafen, Bosch, Porsche, Daimler, Trumpf, Rexroth, Festo, … |
| **Summary and Notes** | |
| As in the Mechatronics program, students choose two specialization subjects (18CP each). Many of the specialization subjects, especially in robotics, are similar to the subjects offered in the Mechatronics program. However, there are some additional subjects that have their focus more on a strong theoretical and research background of engineering problems. Thus, there are more AI courses offered than in the Mechatronics program.<br>Note that in total only two explicit courses are mandatory (Concepts of Automatic Control and Distributed Parameter Systems). All other courses are chosen from various prescribed thematic blocks, for example, Advanced Control. | |

| **Number** | **19** |
|---|---|
| **Program Name** | *Engineering Cybernetics, M.Sc.* |

The University of Stuttgart mainly offers four Master of Science programs in AI and robotics. Their main features are summarized in the following table and further information about the courses in AI and robotics is provided. Note that the official teaching language for all four programs is German, although some courses are offered in English. There are virtually no obligatory courses in any of the four programs, meaning that each student can choose specialization subjects and courses according to their interests. Therefore, it is not possible to give an explicit number of credit hours in the following tables since this depends heavily on the subjects chosen. Thus, we have rather indicated the number of all credit hours of subjects that are offered. Of course, students cannot take all subjects.

It is assumed that the students have a strong theoretical background in mathematics, programing and modeling. Typically, most master students have obtained their bachelor's degree at the University of Stuttgart such that the master courses build on the corresponding bachelor's degree. However, since the programs we are dealing with have many similarities, students have the opportunity to change from one bachelor's program to another master's program without any additional effort.

In general, the Mechatronics program and the Engineering Cybernetics program belong to the engineering science programs. However, in a broader sense, both programs are also categorized as applied mathematics programs, especially the Engineering Cybernetics program. In both programs, students choose two different specialization subjects, giving them the opportunity to take courses in AI and robotics. Note that there is a lot of overlap with respect to the specialization subjects. Usually, one specialization subject is offered by one institute. Thus, each institute can teach its corresponding research expertise. In addition, this structure provides an incentive for institutes to attract highly qualified students to their research through exceptional teaching.
In order to strengthen the practical knowledge of the students, the courses are complemented by mandatory practical trainings, e.g., in the laboratories. In addition, the curriculum includes a minimum twelve-week industrial internship, often extended to six months as this is common practice in industry.

The Autonomous Systems program and the Simulation Technology program are cross-faculty programs. Therefore, students can choose a wide range of specialization subjects which include AI and robotics, but also, for instance, physics. Especially in the Simulation Technology program, a strong theoretical background is required since the program is research-oriented. Both programs focus on theoretical aspects which are complemented by technical trainings. However, an industrial internship, as obligatory in the Mechatronics and Engineering Cybernetics program, is not required in these programs.

For general robotic studies, the Mechatronics M.Sc. program at the University of Stuttgart is recommended, as it covers a wide range of robotics problems based on fundamental knowledge in mathematics, programming and modeling. In addition, various practical trainings complement the theoretical courses. If a special focus is placed on general system dynamics and control engineering problems, the Engineering Cybernetics program is recommended. In this program, specialization subjects and additional courses in AI can also be chosen.

| **Number** | **19** |
|---|---|
| **Program Name** | *Engineering Cybernetics, M.Sc.* |

If the student's interests lie in the field of AI, the Simulation Technology or Autonomous Systems program is recommended. These study programs offer many specialization subjects and courses in AI, but also in robotics. The Simulation Technology program in particular is very research-oriented and therefore offers fewer practical aspects. The study program Autonomous Systems is newly developed, it started in the winter term 2019/2020.

Note that all possible elective courses are considered below in terms of credit hours, although a student obviously cannot choose all of them within his or her program. Furthermore, many of the courses listed below are part of a specialization subject such that not every course can be combined with every other. As noted above, we would like to iterate that the programs have many courses in common.

It is worth pointing out that that international studies are generally encouraged. There are additional double degree programs (e.g., with Chalmers University of Technology and Toyohashi University of Technology) which cover similar courses in AI and robotics. Students can also spend a semester abroad at the university's or institute's partners.

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|---|---|---|---|
| **Number** | **20** | | |
| **Program Name** | *Mechatronics, M.Sc.* | | |
| **University** | University of Stuttgart | | |
| **Country** | Germany | | |
| **URL** | https://www.uni-stuttgart.de/en/study/study-programs/Mechatronics-M.Sc-00001./ | | |
| **Program Focus** | ☐ AI | ☐ Data Science | ☒ Robotics |
| **Credit Hours** | 3600 | | |
| **AI Credit Hours** | in total 2700h offered | | |
| **Data Science Credit Hours** | in total 5040h offered | | |
| **Robotics Credit Hours** | in total 4860h offered | | |
| **AI Courses in Curriculum** | • **Concepts of Automatic Control** 6CP<br>• **Optimal Control** 6CP<br>• **Robust Control** 6CP<br>• **Nonlinear Control** 6CP<br>• **Model Predictive Control** 6CP<br>• **Networked Control Systems** 6CP<br>• **Analysis and Control of Multi-agent Systems** 3CP<br>• **Statistical Learning and Stochastic Control** 6CP<br>• **Multivariable Control** 3CP<br>• **Introduction to Adaptive Control** 3CP<br>• **Advanced Methods in Systems and Control Theory** 3CP<br>• **Numerical Optimization and Optimal Control** 6CP<br>• **Flat Systems** 6CP<br>• **Machine Learning in System Dynamics** 3CP<br>• **Dependability intelligent distributed automation systems** 6CP<br>• **Detection and Pattern recognition** 6CP<br>• **Deep learning** 6CP<br>• **Matrix Computations in Signal Processing and Machine Learning** 3CP | | |
| **Robotics Courses in Curriculum** | 1. **Flexible Multibody Systems** 6CP<br>2. **Control Technology of Machine Tools and Industrial Robots** 6CP<br>3. **Modeling and Simulation in Mechatronics** 6CP<br>4. **Optimization of Mechanical Systems** 3CP<br>5. **Modeling and Identification of Dynamical Systems** 6CP | | |

| Number | 20 |
|---|---|
| **Program Name** | *Mechatronics, M.Sc.* |
| | 6. **Simulation Engineering** 6CP<br>7. **Design and manufacturing of micro- and nanoelectronic systems** 6CP<br>8. **Control Engineering** 6CP<br>9. **Applications of Robot Systems** 6CP<br>10. **Applied Control Systems in Manufacturing Facilities** 6CP<br>11. **Modeling, Analysis and Design of Advanced Kinematics** 6CP<br>12. **Robots – Applications in Service Robotics** 6CP<br>13. **Control Architectures and Communication Technology** 3CP<br>14. **Design of robot systems** 3CP<br>15. **Vehicle Dynamics** 3CP<br>16. **Dynamics of Discrete-Event Systems** 6CP<br>17. **Selected Problems of Mechanics** 3CP<br>18. **Automation Engineering** 3CP<br>19. **Object-oriented modeling and simulation** 3CP<br>20. **Trajectory Generation** 3CP<br>21. **Dynamics of Mechanical Systems** 6CP<br>22. **Nonlinear Dynamics of Mechanical Systems** 6CP<br>23. **Nonsmooth Dynamics** 6CP<br>24. **Computational Dynamics for Robotics** 6CP<br>25. **Dynamics and Control of Legged Locomotion** 6CP<br>26. **Discretization Methods** 3CP<br>27. **Electrical Machines I** 6CP<br>28. **Electrical Machines II** 6CP<br>29. **Electronic Motor** 6CP<br>30. **Practical Laboratory Automation** 3CP<br>31. **Project Automatic Control** 3CP<br>32. **Practical Laboratory Applied Dynamics** 3CP<br>33. **Internship System Dynamics** 3CP<br>34. **Workshop Nonlinear Mechanics** 3CP |
| **Other Fundamental Courses** | 1. **Parallel Systems** 6CP<br>2. **Numerical Methods for Dynamics** 6CP<br>3. **Uncertainty Quantification** 6CP<br>4. **Model Reduction of Mechanical Systems** 3CP |

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|---|---|
| **Number** | **20** |
| **Program Name** | *Mechatronics, M.Sc.* |
| | 5. **Embedded Systems Engineering** 6CP<br>6. **Technologies and methods of software systems II** 6CP<br>7. **Computer architecture and computer organisation** 6CP<br>8. **Digital Signal Processing** 6CP<br>9. **Communications Transmission I** 6CP<br>10. **Design of Digital Systems** 6CP<br>11. **Convex Optimization** 6CP<br>12. **Stochastic processes and modeling** 6CP<br>13. **Electrical Signal Processing** 6CP<br>14. **Real-Time Data Processing** 6CP<br>15. **Distributed Parameter Systems** 6CP<br>16. **Dynamic Filtering** 6CP<br>17. **Mechanics of Nonlinear Continua** 6CP<br>18. **Basics of Micro Technology** 6CP<br>19. **Electronic Components in Microsystems Technology** 3CP<br>20. **Computer Engineering** 6CP<br>21. **Automation Engineering** 6CP<br>22. **System Concept and System Programming** 6CPa.<br>23. **Communication Networks Architecture and Design** 6CP<br>24. **Performance Modeling and Simulation** 6CP<br>25. **Network Security** 3CP<br>26. **Mobile Network Architecture Evolution** 3CP<br>27. **Statistical and Adaptive Signal Processing** 6CP<br>28. **Advanced Mathematics for Signal and Information Processing** 6CP<br>29. **Communications Transmission I** 6CP<br>30. **Communications III** 6CP |
| **Teaching and Research Labs** | 1. **Laboratory – Institute of Engineering and Computational Mechanics**<br>2. **Laboratory – Institute for Systems Theory and Control**<br>3. **Practical Trainings – Institute for System Dynamics**<br>4. **Laboratory – Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>5. **Laboratory – Institute for Nonlinear Mechanics** |
| **Research Groups** | **1. Institute of Engineering and Computational Mechanics**<br>**2. Institute for Nonlinear Mechanics** |

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|---|---|
| **Number** | **20** |
| **Program Name** | *Mechatronics, M.Sc.* |
| | **3. Institute for Systems Theory and Control**<br>**4. Institute for System Dynamics**<br>**5. Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>**6. Fraunhofer IPA** |
| **Collaboration with Industry**<br>***(List of sample projects)*** | Only exemplarily:<br>ZF Friedrichshafen, Bosch, Porsche, Daimler, Trumpf, Rexroth, Festo, … |

**Summary and Notes**

This study program is interdisciplinary in nature to prepare students to master any complex technological process. In addition to in-depth modules which also deal with AI and robotic topics, students choose two out of over twenty specialization subjects. It is important to highlight that there is no mandatory course in the program. However, there is a strong emphasis on robotics in most of the specialization subjects. The specialization subjects are supplemented by practical trainings. In addition, a minimum twelve-week industrial internship is part of the curriculum. The master's thesis and another student research project are completed in both specialization subjects.

The University of Stuttgart mainly offers four Master of Science programs in AI and robotics. Their main features are summarized in the following table and further information about the courses in AI and robotics is provided. Note that the official teaching language for all four programs is German, although some courses are offered in English. There are virtually no obligatory courses in any of the four programs, meaning that each student can choose specialization subjects and courses according to their interests. Therefore, it is not possible to give an explicit number of credit hours in the following tables since this depends heavily on the subjects chosen. Thus, we have rather indicated the number of all credit hours of subjects that are offered. Of course, students cannot take all subjects.

It is assumed that the students have a strong theoretical background in mathematics, programing and modeling. Typically, most master students have obtained their bachelor's degree at the University of Stuttgart such that the master courses build on the corresponding bachelor's degree. However, since the programs we are dealing with have many similarities, students have the opportunity to change from one bachelor's program to another master's program without any additional effort.

In general, the Mechatronics program and the Engineering Cybernetics program belong to the engineering science programs. However, in a broader sense, both programs are also categorized as applied mathematics programs, especially the Engineering Cybernetics program. In both programs, students choose two different specialization subjects, giving them the opportunity to take courses in AI and robotics. Note that there is a lot of overlap with respect to the specialization subjects. Usually, one specialization subject is offered by one institute. Thus, each institute can teach its corresponding research expertise. In addition, this structure provides an incentive for institutes to attract highly qualified students to their research through exceptional teaching.
In order to strengthen the practical knowledge of the students, the courses are complemented by mandatory practical trainings, e.g., in the laboratories. In addition, the curriculum includes a minimum twelve-week industrial internship, often extended to six months as this is common practice in industry.

| **Number** | **20** |
|---|---|
| **Program Name** | *Mechatronics, M.Sc.* |

The Autonomous Systems program and the Simulation Technology program are cross-faculty programs. Therefore, students can choose a wide range of specialization subjects which include AI and robotics, but also, for instance, physics. Especially in the Simulation Technology program, a strong theoretical background is required since the program is research-oriented. Both programs focus on theoretical aspects which are complemented by technical trainings. However, an industrial internship, as obligatory in the Mechatronics and Engineering Cybernetics program, is not required in these programs.

For general robotic studies, the Mechatronics M.Sc. program at the University of Stuttgart is recommended, as it covers a wide range of robotics problems based on fundamental knowledge in mathematics, programming and modeling. In addition, various practical trainings complement the theoretical courses. If a special focus is placed on general system dynamics and control engineering problems, the Engineering Cybernetics program is recommended. In this program, specialization subjects and additional courses in AI can also be chosen.

If the student's interests lie in the field of AI, the Simulation Technology or Autonomous Systems program is recommended. These study programs offer many specialization subjects and courses in AI, but also in robotics. The Simulation Technology program in particular is very research-oriented and therefore offers fewer practical aspects. The study program Autonomous Systems is newly developed, it started in the winter term 2019/2020.

Note that all possible elective courses are considered below in terms of credit hours, although a student obviously cannot choose all of them within his or her program. Furthermore, many of the courses listed below are part of a specialization subject such that not every course can be combined with every other. As noted above, we would like to iterate that the programs have many courses in common.

It is worth pointing out that that international studies are generally encouraged. There are additional double degree programs (e.g., with Chalmers University of Technology and Toyohashi University of Technology) which cover similar courses in AI and robotics. Students can also spend a semester abroad at the university's or institute's partners.

| | | | |
|---|---|---|---|
| **Number** | **21** | | |
| **Program Name** | *Simulation Technology, M.Sc.* | | |
| **University** | University of Stuttgart | | |
| **Country** | Germany | | |
| **URL** | https://www.uni-stuttgart.de/en/study/study-programs/Simulation-Technology-M.Sc./ | | |
| **Program Focus** | ☒ AI | ☒ Data Science | ☒ Robotics |
| **Credit Hours** | 3600 | | |
| **AI Credit Hours** | (in total 4950h offered) | | |
| **Data Science Credit Hours** | (in total 8640h offered) | | |
| **Robotics Credit Hours** | (in total 3600h offered) | | |
| **AI Courses in Curriculum** | 1. **Basic Principles of Artificial Intelligence** 6CP<br>2. **Introduction to Feedback Control Systems** 6CP<br>3. **Multivariable Control** 3CP<br>4. **Feedback Control Systems and Control Engineering** 6CP<br>5. **Concepts of Automatic Control** 6CP<br>6. **Optimal Control** 6CP<br>7. **Robust Control** 6CP<br>8. **Nonlinear Control** 6CP<br>9. **Detection and Pattern Recognition** 6CP<br>10. **Machine Learning** 6CP<br>11. **Model Predictive Control** 6CP<br>12. **Numerical Optimization and Optimal Control** 6CP<br>13. **Flat Systems** 6CP<br>14. **Statistical Learning Theory** 9CP<br>15. **Linear Control Theory** 9CP<br>16. **Multivariable Control** 3CP<br>17. **Reinforcement Learning** 6CP<br>18. **Theoretical and Methodological Foundations of Autonomous Systems** 6CP<br>19. **Robust Control** 9CP<br>20. **Networked Control Systems** 6CP<br>21. **Control and System Design** 6CP<br>22. **Matrix Computations in Signal Processing and Machine Learning** 3CP<br>23. **Statistical Learning and Stochastic Control** 6CP | | |

| Number | 21 |
|---|---|
| **Program Name** | *Simulation Technology, M.Sc.* |
| | 24. **Deep learning for NLP** 3CP<br>25. **Deep learning** 6CP<br>26. **Deep Learning for Speech and Language Processing** 6CP<br>27. **Analyzing Software using Deep Learning** 6CP |
| **Robotics Courses in Curriculum** | 1. **Basic Principles of Modeling and Simulation** 6CP<br>2. **Advanced Mechanics I** 6CP<br>3. **Advanced Mechanics II** 6CP<br>4. **Machine Dynamics** 6CP<br>5. **Modeling and Simulation in Mechatronics** 6CP<br>6. **Flexible Multibody Systems** 6CP<br>7. **Optimization of Mechanical Systems** 6CP<br>8. **Non-linear Dynamics** 6CP<br>9. **Modeling and Identification of Dynamical Systems** 6CP<br>10. **Biorobotics** 6CP<br>11. **Robotics I** 6CP<br>12. **Stochastic and Statistical Topics in Modeling and Simulation** 6CP<br>13. **Dynamic Systems** 9CP<br>14. **Dynamics of Mechanical Systems** 6CP<br>15. **Nonlinear Dynamics of mechanical Systems** 6CP<br>16. **Design of robot systems** 3CP<br>17. **Modeling, Analysis and Design of Advanced Kinematics** 6CP<br>18. **Computational Dynamics for Robotics** 6CP<br>19. **Dynamics and Control of Legged Locomotion** 6CP<br>20. **Advanced Topics in Machine Learning** 6CP |
| **Other Fundamental Courses** | 1. **Numerical Simulation**(obligatory) 6CP<br>2. **Databases and Information Systems** 6CP<br>3. **Parallel Systems** 6CP<br>4. **Numerical Mathematics 1** 9CP<br>5. **Higher Analysis** 9CP<br>6. **System Dynamics** 3CP<br>7. **Data Structures and Algorithms** 9CP<br>8. **Numerical Methods for Dynamics** 6CP<br>9. **Functional Analysis** 9CP |

| Number | 21 |
|---|---|
| **Program Name** | *Simulation Technology, M.Sc.* |
| | 10. **Partial Differential Equations (Modeling, Analysis, Simulation)** 9CP<br>11. **Introduction to Optimization** 9CP<br>12. **Stochastic Processes** 9CP<br>13. **Software Engineering** 6CP<br>14. **Discrete Optimization** 6CP<br>15. **Computer Vision** 6CP<br>16. **Distributed Parameter Systems** 6CP<br>17. **Convex Optimization** 6CP<br>18. **Numerics for High Performance Computing** 3CP<br>19. **Dynamic Filtering** 6CP<br>20. **Virtual Engineering** 6CP<br>21. **Linear Matrix Inequalities in Control** 9CP<br>22. **Programming Paradigms** 6C<br>23. **Nonlinear Programming** 3CP<br>24. **System Dynamics** 3CP<br>25. **Optimization** 6CP<br>26. **Fundamentals of Scientific Computing** 6CP<br>27. **High Performance Computing** 6CP<br>28. **Selected Topics of Scientific Computing** 6CP<br>29. **Efficient Programming** 6CP<br>30. **Advanced Seminar Computer Science** 3CP<br>31. **Practical Course Visual Computing** 6CP<br>32. **Functional Analysis 2** 9CP<br>33. **Introduction to Scientific Programming** 6CP<br>34. **Seminar: Mathematical Modelling**(elective) 6CP<br>35. **Advanced Simulation Methods** 6CP<br>36. **Computer Science Selection VI: Concepts of Programming Languages, Operating Systems** 9CP<br>37. **Discretization Methods** 3CP<br>38. **Parallel Numerics** 6CP<br>39. **Scientific Computing** 9CP<br>40. **Introduction to model order reduction of mechanical systems** 6CP<br>41. **Cloud Computing: Concepts and Technologies** 6CP<br>42. **Methods in Simulation Technology** 3CP |

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|---|---|
| **Number** | **21** |
| **Program Name** | *Simulation Technology, M.Sc.* |
| | 43. **Automated and Connected Driving I+II** 6CP<br>44. **Cognitive Computing** 3CP<br>45. **Uncertainty Quantification** 6CP<br>46. **Mathematical Image Processing** 9CP |
| **Teaching and Research Labs** | 1. **Laboratory – Institute of Engineering and Computational Mechanics**<br>2. **Laboratory – Institute for Systems Theory and Control**<br>3. **Practical Trainings – Institute for System Dynamics**<br>4. **Laboratory – Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>5. **Laboratory – Institute for Nonlinear Mechanics**<br>6. **Machine Learning & Robotics Lab – IPVS**<br>7. **SOLA – Software Lab University of Stuttgart** |
| **Research Groups** | 1. **Institute of Engineering and Computational Mechanics**<br>2. **Institute for Systems Theory and Control**<br>3. **Institute for System Dynamics**<br>4. **Institute for Control Engineering of Machine Tools and Manufacturing Units**<br>5. **Institute for Nonlinear Mechanics**<br>6. **Institute for Parallel and Distributed Systems**<br>7. **Fraunhofer IPA** |
| **Collaboration with Industry** *(List of sample projects)* | Only exemplarily:<br>ZF Friedrichshafen, Bosch, Porsche, Daimler, Trumpf, Rexroth, Festo, … |

**Summary and Notes**

The Simulation Technology program is very interdisciplinary and free-form, as it is cross-faculty. Thus, students can choose from a wide range of courses and thus take courses which cover robotics and AI topics. Notice that this program is very research oriented, but offers more courses in AI than, for instance, the Mechatronics program.

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