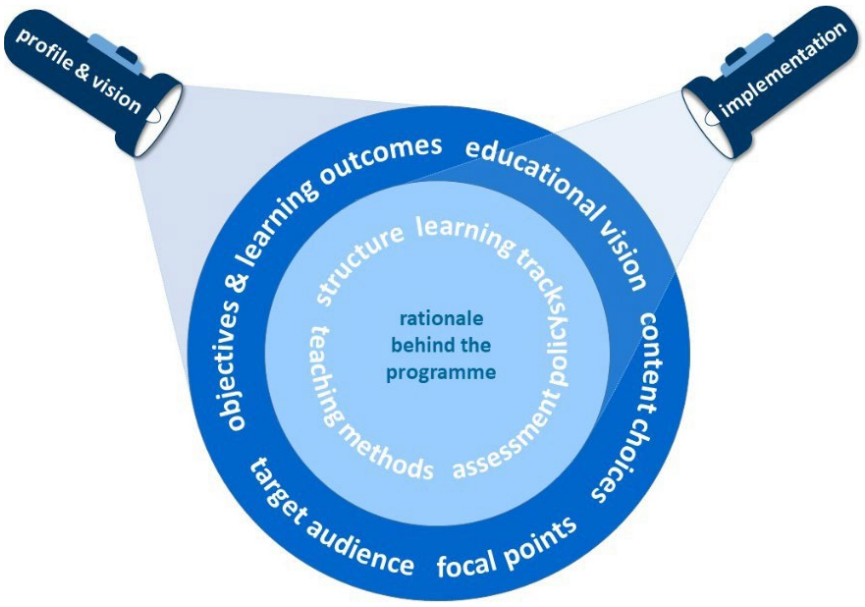
KU LEUVEN

BLUEPRINT

ADVANCED MASTER OF ARTIFICIAL INTELLIGENCE

FACULTY OF ENGINEERING SCIENCE



DECEMBER 2022

Advanced Master of Artificial Intelligence

Profile and vision

One of the most fascinating research issues today is the investigation of the true nature of intelligence: the study of learning processes, cognition and models; natural language and perception; human knowledge, representation and reasoning.

Relatedly, one of the scientific community's key research objectives is the development of an intelligent robot that perceives and communicates using natural language, collects information using vision, sensors, and movement, plans ahead and acts based on this information, assimilates new knowledge from experience and interactions with its environment and, in general, performs tasks that are typical for intelligent human beings.

The programme explores and builds on these fascinating challenges. For many years, it has provided an internationally highly reputed and advanced study programme on artificial intelligence (AI). The multidisciplinary programme trains students with a variety of backgrounds, including engineering, sciences, economics and management, psychology and linguistics, in all areas of knowledge-based technology, cognitive science and their applications. This one-year programme, entirely in English, is the result of a joint effort by a large number of internationally leading research units from seven different faculties of this university.

Depending on their backgrounds, students choose amongst three options offered:

- **Engineering and Computer Science (ECS):** Intended for students with a background in engineering or exact sciences.
- **Speech and Language Technology (SLT):** The central focus is on the processing of natural language, both in its spoken and written form.
- **Big Data Analytics (BDA):** BDA trains students in the state-of-the-art data analysis techniques, programming techniques and applications that deal with very large data collections.

Goals and learning outcomes

The programme aims to impart the most advanced knowledge to students and train them in the latest techniques in artificial intelligence, with specific focus either on 'Engineering and Computer Science' (ECS), on 'Speech and Language Technology' (SLT) or on 'Big Data Analytics' (BDA), depending on the selected option within the programme. It aims to introduce the students to the concepts, methods and tools in the field.

It aims to teach students about the achievements in a number of advanced fields of application and familiarise them with their current research directions. It aims to bring students to a level of knowledge, understanding, skills and experience that are needed to actively conduct basic or applied research on an international level. In particular, it aims to provide students with a critical scientific attitude towards the central themes of AI.

As a master-after-master's programme, it is assumed that the students who enter this programme have already achieved the general skills and attitudes defined for a master programme. Nevertheless, it is also within the goals of the programme to strengthen these skills and attitudes, within the specific scientific context that AI offers.

The option 'ECS', in addition to the above, aims to instill a problem-solving attitude towards the practice of AI. Upon completion of the programme, students should be familiar with the fundamentals of AI, be aware of its reasonable expectations, have practical experience in solving AI problems and be acquainted with a number of advanced areas within the field.

The option 'SLT', in addition to the general goals, aims to provide all necessary background and skills that are required to fully understand and to actively participate in the fast developing multi-disciplinary field of language and speech. This includes a thorough understanding of the theories and models that shape the field, as well as practical experience with a variety of technologies that are used and currently developed.

The option 'BDA', in addition to the general goals, aims for the same additional goals as the option 'ECS', but specialised in big data analytics. In particular, it aims to instill a problem-solving attitude towards the practice of big data analytics. Upon completion of the programme, students should be familiar with the fundamentals of big data analytics, be aware of its reasonable expectations, have practical experience in solving BDA-problems and be acquainted with a number of advanced areas within the AI subfield of 'BDA'. The specific outcomes of the Advanced Master of Artificial Intelligence are available on this webpage:
https://onderwijsaanbod.kuleuven.be/opleidingen/e/CQ_50268936.htm#activetab=doelstellingen.

Target group

Students who enter the programme have already successfully completed a university programme of at least four years. Generally, they have already obtained a master's degree or completed an equivalent 4-year study based degree.

As such, we expect that the entering students already have the general skills and attitudes of a master graduate. The AI programme will continue to train them within the specific scientific context of artificial intelligence. On a more specific level, entering students are expected to be familiar with basic mathematical notations (sets, union, inclusion, integral, summand, etc.). Moreover, students who select the option 'ECS' are expected to master basic undergraduate level mathematics (calculus, linear algebra, discrete mathematics, probability or statistics).

All entering students are expected to be familiar with at least one high-level programming language. Students who select the option 'ECS' are expected to master at least one object-oriented programming language. All entering students are required to be proficient in English (*'Test of English as a Foreign Language':* result of at least 550).

Realisation

Structure

Understanding the principles of intelligence, the development of artificial intelligence and its many applications in different areas requires a multi-disciplinary approach.

As described earlier, within the programme, students have the choice between three options, which are designed in a similar way:

- introductory components;
- a programming component;
- advanced mandatory components;
- optional components;
- a master's thesis.

Considering this is a 1-year programme, which educates students from a wide variety of different backgrounds, an intensive knowledge and skill transfer is needed in a reduced amount of time. The **introductory components** address these issues as they intend to bring the diverse group of students to a common ground of knowledge and skills that we can build on in the remainder of the programme. The course 'Fundamentals of Artificial Intelligence', is mandatory in all options, as it handles the main specialised knowledge and skills on the topic of AI. The introductory component of 'BDA' is completed by the courses 'Data and Statistical Modelling' and 'Privacy and Big Data'. The introductory component of 'SLT' is complemented by the course 'Machine Learning and Inductive Inference'. The students of the options 'SLT' and 'ECS' additionally select a broadening course from either 'Cognitive Science', 'Philosophy of Mind and Artificial Intelligence', 'Privacy and Big Data' or 'AI Ethics & Regulation'.

All options have a **programming component**. In the programming component the options 'ECS' and 'SLT', students learn and practise programming in an AI- programming language. If an incoming student lacks the required programming skills in an object-oriented programming language, he will be required to select 'Basic Programming' as an optional course. The programming component of the option 'BDA' focuses on programming for big data analytics.

All options offer a selection of **mandatory advanced components**, corresponding to advanced topics that the students of this specific option need to be familiar with. In each option, this generally corresponds to knowledge items, listed in its learning objectives.

Students finalise their programme by completing a master's thesis throughout the year or a company project of three months which normally takes place during the second semester. The project needs to be carried out in a research lab or a company with research and development activities in a field of Artificial Intelligence.

The learning environment

The three main delivery modes (lecture, practical and assignment) are characterised by the role of the lecturer and the student, respectively. Other, more specific delivery modes are the master's thesis and company project. The programme combines the most appropriate delivery modes for each course and a proper balance over the entire curricula is envisaged. The general objective is to activate students, stimulate them to work independently or in a group, and to have a good balance between the different delivery modes.

For the introductory components and some of the knowledge-intensive advanced components, a classical ex cathedra approach is being used. For such components (as well as for most of the courses in the programme), the teaching activities are complemented with guided practical sessions and exercise sessions.

For programming components, the role of the practical and exercise sessions is very important. For these components, much more time and attention is devoted to practical experimentation and skill training. The lecture part of the programming components can either take the form of guided reading with interactive discussion sessions or can take a more classical lecture-based form. In the advanced components of the programme, a broad range of delivery modes is applied, e.g. individual readings, discussions, seminars, etc.

During the final stage of the programme, the students complete a master's thesis. They take an active part in research-related questions within one of the subdomains of AI. Students select one of the research projects, offered by the involved research units. They work independently, but are guided by the staff of the research unit to perform the research that is required for the selected project. The thesis project should involve the development of or the experimentation with a small-scale AI system. The thesis should result in a scientific text and must be defended during an oral presentation before a jury, consisting of the thesis adviser and two readers.

It is recommended that students explicitly study the relations between their thesis project and related themes in AI. This will allow students to get a broader and better view of the field as a whole. It will also help to reach our goal of providing students with a multidisciplinary view and attitude towards the field.

The students also have the opportunity to do a company project of 15 weeks in a company or a research institute. During the project, students become familiar with the technological and scientific concerns, addressed within companies or research centres. Students work for a period of 10 weeks in a company or research centre to study the technology that is used and developed and take part in the activities of the centre. More specifically, students develop a project in which they undertake a critical scientific investigation of the technology, applied and developed at the centre and its relations to the state of the art in current research. They report on this project in the form of a publishable paper and present their activities during a public defence. The oral defence takes place in the presence of a jury, consisting of the scientific adviser and two readers.

The Faculty and its programmes recognise the importance of a high-quality assessment. High-quality evaluation is therefore fully embedded in the learning environment: it is aligned with the objectives, uses the appropriate evaluation formats, and is adapted to fit the characteristics of the students concerned, who also receive feedback in a timely and appropriate manner. The policy document 'Tests and Assessments' describes the policy of assessment at the Faculty:

- alignment with programme and learning outcomes,
- feedback,
- quality assurance, transparency and the ombuds service,
- evaluation of master's theses,
- organisation of assessments, including special provisions for students with a disability.

The implementation of the Faculty's examination regulations, the development of the programmes, the choice of assessment modes, the specific learning outcomes, etc. In short, internal quality assurance is the primary responsibility of the Educational Committee.

Learning pathways

The expert in artificial intelligence

As mentioned earlier, the programme welcomes a very diverse student population with a wide variety in backgrounds. Students are brought to a common ground of knowledge and skills related to AI by the introductory components. This introduction in AI, combined with the students' academic background, allows students to proceed in one of the three options:

- **Engineering and Computer Science (ECS):** intended for students with a background in engineering or exact sciences. After an introduction to the basic AI concepts, tools and specific fields of application include advanced programming languages, knowledge-based systems, artificial neural networks and deep learning, robotics, computer vision, machine learning, datamining, support vector machines, bioinformatics, genetic algorithms and evolutionary computation, reinforcement learning, and others.
- **Speech and Language Technology (SLT):** The central focus is on the processing of natural language, both in its spoken and written form. The programme offers a solid linguistic basis, covering the fields of syntax, semantics, morphology, phonetics and lexicography, and continues with advanced courses in natural language processing, speech recognition, speech synthesis and language engineering.
- **Big Data Analytics (BDA):** BDA trains students in state-of-the-art data analysis techniques, programming techniques and applications that deal with very large data collections. The option is oriented towards graduates in computer science. It trains students in the central concepts of statistical data analysis, machine learning and data mining. It trains them in program learning and data mining techniques that need to cope with big data collections. It conducts deeper studies into a number of applications regarding big data and advanced analysis techniques.

The researcher

Research and education are closely related in the Faculty as it is the Faculty's policy to support programmes with strong research activities. The departments of the Faculty have an excellent research record and run many research projects, both with national and international partners.

As the incoming students have already obtained an initial master's degree, it is assumed that they should already be able to formulate research goals, determine trajectories that achieve these goals, collect and select information, relevant to achieve the research goals and interpret collected information in a critical research attitude. During this advanced master, the students will continue to train these research-related skills within the specific scientific context of AI. Especially through completing a master's thesis as a final component of the programme. To support students in this process, the Educational Development Unit of the Faculty, in co-operation with the Campus Library Arenberg, organises master's thesis workshops about information literacy, intellectual integrity and plagiarism and academic writing.

Besides the master's thesis, a part of the advanced courses provide a narrow overview of the area in question and offer experience in research, often through projects or critical evaluation, comparison and discussion on advanced research papers. Another part of the advanced courses give a broader and more complete overview of their area, leaving less or no room for research in that area of the field.

The problem solver and designer

All programmes of the Faculty of Engineering Science, put strong emphasis on transferable and transversal skills such as written and oral communication, group work, leadership, project management, responsibility and norms of engineering

practice, taking initiative, and entrepreneurship, information literacy, intellectual integrity and plagiarism and academic writing. As this concerns an advanced master's programme, a general achievement of all these skills is expected from incoming students. Similar to the general research skills, students will continue to train these research-related skills within the specific scientific context of artificial intelligence.

The professional

One of the most important goals of the programme is to prepare students for research and PhD studies. However, the industrial relevance of AI technology has grown very much over the past decades. As such, for many students, the professional ambition related to their study in AI is to complement their previous studies with state-of-the-art knowledge, skills and attitudes in AI technology. Within each of the three options (ECS/BDA/SLT), there is the possibility to do a company project.

Knowledge and skills are obtained and trained during the programme to evaluate or develop novel techniques in the field of their prior studies. Students learn to apply data mining techniques, natural language processing or advanced search or problem solving techniques to key problems in their own technological fields.

In an international context

This master's programme is imbedded in the Faculty of Engineering, a faculty with a strong international reputation that aims at developing an international open policy and atmosphere. The Faculty is not only encouraging its (master's) students, researchers and scholars to have an international experience but is also home to a vibrant community of international students, staff and researchers. Hence, the Faculty's and the programme's international activities are extensive and diverse, allowing all its students to profit from the international atmosphere at the Faculty.

Some examples of international activity:

- The Faculty is a member of several distinguished networks of technical universities in Europe such as CLUSTER, CESAER, and ATHENS.
- The Faculty does not only participate in an Erasmus Mundus programme and EIT-KIC programmes, but also provides several English master's programmes for incoming students.
- The Faculty offers (master's) students mobility and staff exchange on a European (Erasmus) and intercontinental level. By having good contacts with a selected number of international universities, the high-level quality of the education, taken abroad, is assured. Furthermore, students and researchers get the opportunity to participate in international research projects, international internships and development cooperation projects.

KU Leuven
Faculty of Engineering Science

Kasteelpark Arenberg 1 box 2200
B-3001 LEUVEN
tel. + 32 16 32 13 50

KU LEUVEN

FACULTY OF
ENGINEERING SCIENCE