JÖNKÖPING UNIVERSITY
School of Engineering

PROGRAMME SYLLABUS

AI Engineering (master), 120 credits

Programmestart: Autumn 2020

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Programme code:	TAAI9	**Programmestart:**	Autumn 2020
Confirmed by:	Dean 2020-03-01	**Education Cycle:**	Second-cycle level
Version:	2		

Title of qualification

Degree of Master of Science (120 credits) with a major in Product Development, specialisation in AI Engineering

Programme overview

Background

Artificial Intelligence (AI), is intelligence, in a broad sense, exhibited by machines. In computer science, an ideal intelligent machine is a flexible, yet rational, agent that perceives its environment and carries out actions that maximize the chances of success for some objective or task. Human-level machine intelligence is still in the future, but applications of deep learning and edge computing are currently transforming both industry and society. Examples of applications include medical diagnosis, personal assistants, surveillance systems, robot control, robotic manufacturing, remote sensing, machine translation, speech understanding, financial services, electronic trading, cybersecurity, combat and training simulators, mission management aids, web search, video games, code analysis, support systems for tactical decision making, product recommendations, and autonomous cars.

These and other applications rely on AI techniques to interpret data that originate from a wide range of sources and use the extracted information in an intelligent and targeted behaviour. Contemporary AI often involves self-learning systems trained on large amounts of data or interacting intelligent agents that perform distributed computing and reasoning. AI connects sensors with algorithms and human-computer interfaces and extends to large networks of intelligent devices. AI is a rapidly developing research field and it is one of the driving forces of today's economy.

By combining traditional lectures with seminars and lab sessions, the AI master programme aims to teach students the basics of theory and gains hands-on experience in each subject. The acquired knowledge is applied to practical work on real applications through the development, implementation and testing of running software code.

A master's degree in AI opens up career opportunities within companies that build the next generation of AI enhanced products; for example, smart personal assistants, opinion mining systems, customer service systems, biomedical applications, games, computers, intelligent adaptive devices, robots, intelligent planning systems and so on. The programme provides the skills needed for many positions in today’s industry or research centres.

Objectives

The Master Programme in AI Engineering aims to develop the knowledge, skills and experiences required to work in companies and organisations that develop products and services with substantial software content. The software developed and/or evaluated by the students have a focus on implementing AI solutions.
The programme also covers additional special topics such as safety and security issues related to AI software solutions. During the programme, students engage in practical work and technical research.

Post-graduation employment areas

This Master's programme focuses on the development of intelligent software products and services. Specifically, AI, machine learning, and data science are covered in detail. Applications include, but are not limited to, internet-of-things, data analytics and smart cities. The programme enables graduates to aim for the more senior roles in the development of software products aimed at solving AI related problems as well as software products based on AI techniques. Graduates will have developed the capabilities needed to work in both large corporations and smaller specialized software shops. They will be comfortable with delivering major enterprise systems or specialized embedded software components across the spectrum of software development, from back-end data processing to Internet-related front-ends.

Research

This Masters degree qualifies graduates to apply for further third-cycle education leading to a licentiate or doctoral degree.

Research supporting the Programme

Product Development, including knowledge intensive product development using AI, is a major area of research within the School of Engineering, underpinned by the Knowledge Intensive Product Realization research environment (SPARK). Within the Department of Computer Science & Informatics there is a strong focus on research related to data analytics, machine learning, and the creation and enhancement of algorithms that strengthen application effectiveness and efficiency.
The exponential growth of the digital society, particularly in the form of storage and computing power in recent decades, enables companies to accumulate vast amounts of data at moderate cost. Accompanying this technological shift is a widespread realisation that the collected data contain potentially valuable information. Exploiting this stored data, in order to extract useful and actionable information, is the overall goal of the generic activity termed data analytics. The AI research at Jönköping University focuses on developing machine learning algorithms for data analytics, when necessary utilising high performance computing. Most of the research is applied, and often co-produced with industry.

Educational concept at the School of Engineering

All degree programmes at the School of Engineering at Jönköping University (JTH) follow an education concept. The concept can be seen as consisting of a number of different aspects that have to be included in the degree programmes in order to guarantee their quality and appeal as well as their ability to produce professionally skilled, in-demand students. The concept places special emphasis on collaboration with industry and internationalisation as two essential tools in developing successful programmes attracting many applicants.

In the concept for the Master’s programmes, there are common learning outcomes regarding the areas leadership, project management, internationalisation, and sustainable development. There is also an Industrial Placement Course (IPC) included in all programmes, whereby students put their theoretical knowledge into practice. IPC is a 9 credit course (5 weeks practise at a company), and it is also possible to complete the course abroad.

Internationalisation means that, for example, the opportunity is provided to practise languages and intercultural communication through student exchanges with foreign universities. JTH has around 70 partner universities around the world, and takes part in a number of international student exchange programmes. There is an opportunity to spend part of the study period abroad and to accredit studies abroad towards the degree. All Master's programmes at JTH are given completely in English.

Objectives

After the completion of the programme, students must meet the intended learning outcomes, as described in The Higher Education Ordinance by Degree of Master (1-9), and also the intended learning outcomes, as described by JTH:

Common learning outcomeserstanding

Knowledge and Understanding

1. demonstrate knowledge and understanding in the main field of study, including both broad knowledge of the field and a considerable degree of specialised knowledge in certain areas of the field as well as insight into current research and development work
2. demonstrate specialised methodological knowledge in the main field of study

Competence and skills

3. demonstrate the ability to critically and systematically integrate knowledge and analyse, assess and deal with complex phenomena, issues and situations even with limited information
4. demonstrate the ability to identify and formulate issues critically, autonomously and creatively as well as to plan and, using appropriate methods, undertake advanced tasks within predetermined time frames and so contribute to the formation of knowledge as well as the ability to evaluate this work
5. demonstrate the ability in speech and writing both nationally and internationally to clearly report and discuss his or her conclusions and the knowledge and arguments on which they are based in dialogue with different audiences
6. demonstrate the skills required for participation in research and development work or autonomous employment in some other qualified capacity

JTH. prove ability to apply acquired knowledge in practical work

JTH. prove ability to collaborate effectively in teams, especially in the presence of a strong multicultural dimension

Judgement and Approach

7. demonstrate the ability to make assessments in the main field of study informed by relevant disciplinary, social and ethical issues and also to demonstrate awareness of ethical aspects of research and development work
8. demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used
9. demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning

JTH. prove understanding of future professional engineering roles, including a sound awareness of an engineer's ethical responsibilities towards society and the need for economic, social and ecological sustainable development

JTH. prove ability to embrace interdisciplinary approaches through the application of a system perspective

Programme-specific learning outcomes

The intended learning outcomes provided for programmes, must also be met.

Knowledge and Understanding

10. display knowledge of the fundamental tasks, methods and algorithms for data analysis,
11. display knowledge of the current state-of-the-art in AI, machine learning and data science,
12. demonstrate an understanding of the basic algorithms and methods in machine learning,
13. demonstrate an understanding of the development of software utilizing AI or machine

learning,

Competence and skills

14. demonstrate the ability to apply selective fields of mathematics and mathematical statistics to intelligent systems,
15. demonstrate the ability to design, develop and deploy machine learning software solutions,
16. demonstrate the ability to design and implement distributed software architectures supporting and utilizing edge computing,
17. demonstrate the ability to work in cross-disciplinary teams during the development of software and other products,

Judgement and Approach

18. demonstrate a skill to compare and evaluate different representations and algorithms for intelligent agents,
19. demonstrate a skill to suggest suitable AI and machine learning approaches to real-world problems.

Contents

Programme principles

A key principle for the programme is the treatment of AI as both an integrated part in systems and products and a tool to be used for product development and decision support. The program builds upon theoretical knowledge on AI to help acquire practical skills in applying machine learning for data analysis and skills on programming machine learning as well as knowledge on how to utilize the strengths of different hardware platforms.

The AI perspective is complemented by the programme's emphasis on growing the competence of the students as professional engineers. This is manifest in several ways. The CDIO Initiative™ underpins a new vision for engineering education. By mapping to the Curriculum Guidelines for Graduate Degree Programs in AI Engineering and to the AI Engineering Body of Knowledge, the degree builds upon the work of professional software bodies. A commitment to "evidence-based AI engineering" helps students to understand the importance of sound research over hype and myth in the AI field.

Collaboration with businesses and institutions ensures that the programme reflects "real-world" product development needs while lectures from external AI software engineers provide a counterpoint to the academic view of software development. The programme embraces the Agile Manifesto philosophy which favours a flexible approach to the frequent delivery of working code over a rigid adherence to processes and plans.

Instruction is in the form of lectures, seminars, exercises, laboratory sessions and project work. All courses are held in English. All final course examinations are in English.

Programme progression

Two introductory courses start the programme. Industrial Product Realization in Collaboration provides all Master students at the School of Engineering with a shared conceptual, organizational and research framework for product realization within their individual disciplines. In parallel, the course Artificial Intelligence introduces students to the basic knowledge representation, problem solving, and learning methods of artificial intelligence. Upon completion of the course, the students should be able to develop basic intelligent systems and understand the role of knowledge representation, inference, search and learning in intelligent-system engineering. Those students that have already taken the course Artificial Intelligence (TAIK19) must select an alternative course on advanced level within the fields of computer engineering, informatics, product development or mathematics.

The core topics of the programme follow in sequence: Data Science introduces students to fundamental topics in data analysis and skills in performing data analysis. Software tools and techniques and their application to different business domains are also introduced; The Machine Learning course introduces the basics of machine learning, focusing on basic building blocks, families of machine learning algorithms and how to evaluate performance; Embedded and Distributed AI creates an overall understanding of knowledge representation and processing in AI, covering the span from the semantic web through distributed systems all the way to deep learning and edge computing. The course Mathematics for Intelligent Systems provides students with the necessary mathematical competences and tools to adequately approach problems with an AI related content. The course Software Product Quality Assurance makes students aware of the important role of requirements in ensuring successful software product development and ensures that they have a deep and sophisticated understanding of the different influences on software quality, transcending the simplistic view of testing as a final step before shipping the code.

Alongside these core topics, other courses address more specialised areas, some of the courses being possible elective courses: Safety and Security of Software Products; Development for Mobile, Wearable and Smart Device (Elective); and User Experience Design (Elective).

Project work starts with Product Development in Cross-Discipline Teams – 1. The product project is brought to completion and the results are presented in Product Development in Cross-Discipline Teams - 2. During the Industrial Placement Course (NFK) (Elective), students will gain real work place experience with a collaborating organisation. To prepare the students for the master thesis two courses are provided, Research Methods for Intelligent Systems and State-of-the-art in AI Research, the latter course provides students with a deeper knowledge within themes related to the AI research frontier Finally, students will carry out academic research in Master Thesis (Ex-jobb).

Courses

Mandatory courses

Course Name	Credits	Main field of study	Specialised in	Course Code
Artificial Intelligence	7.5	Informatics	G1F	TAIK19
Data Science	7.5	Informatics	A1N	TDSR29
Embedded and Distributed AI	7.5	Product Development	A1F	TEDS20
Final Project Work in Product Development	30	Product Development	A2E	TEUV24
Industrial Product Realization in Collaboration	6	Production Systems, Product Development	A1N	TIPR28
Machine Learning	7.5	Product Development	A1F	TMLS20
Mathematics for Intelligent Systems	6		A1N	TMIR29
Product Development in Cross-discipline Teams – 1	3	Informatics, Product Development	A1F	TP1S29
Product Development in Cross-discipline Teams - 2	6	Informatics, Product Development	A1F	TP2S20
Research Methods for Intelligent Systems	7.5	Informatics	A1F	TRIS20

Safety and Security for Software Products	7.5	Product Development	A1N	TSSR20
Software Product Quality Assurance	9	Product Development	A1N	TSPR20
State-of-the-Art in AI Research	7.5	Informatics	A1F	TSAS20

Elective courses

Course Name	Credits	Main field of study	Specialised in	Course Code
Development for Mobile, Wearable and Smart Devices[2]	7.5	Informatics	A1N	TDWR29
Industrial Placement Course in Product Development[2]	7.5	Product Development	A1F	TNFS20
User Experience Design[2]	7.5	Informatics	A1N	TUER29

Programme overview

Year 1

Semester 1		Semester 2	
Period 1	Period 2	Period 3	Period 4
Artificial Intelligence, 7.5 credits	Data Science, 7.5 credits	Machine Learning, 7.5 credits	Embedded and Distributed AI, 7.5 credits
Industrial Product Realization in Collaboration, 6 credits	Mathematics for Intelligent Systems, 6 credits	Product Development in Cross-discipline Teams - 2, 6 credits	
	Product Development in Cross-discipline Teams – 1, 3 credits	Software Product Quality Assurance, 9 credits	

Year 2

Semester 3		Semester 4	
Period 1	Period 2	Period 3	Period 4
Research Methods for Intelligent Systems, 7.5 credits	State-of-the-Art in AI Research, 7.5 credits	Final Project Work in Product Development, 30 credits	
Safety and Security for Software Products, 7.5 credits	*Development for Mobile, Wearable and Smart Devices [2], 7.5 credits*		
	Industrial Placement Course in Product Development [2], 7.5 credits		
	User Experience Design [2], 7.5 credits		

Teaching and examination

Throughout the academic year, typically, two courses are taken in parallel. Examination forms and grades are given by each course module, respectively. The programme overview shows the programme structure for both years and may be changed during the programme. For updated programme overview visit http://www.ju.se

Prerequisites

The applicant must hold the minimum of a bachelor's degree (i.e the equivalent of 180 ECTS credits at an accredited university) with at least 90 credits in computer engineering, electrical engineering (with relevant courses in computer engineering), or equivalent. The bachelor's degree should comprise a minimum of 15 credits in mathematics. Proof of English proficiency is required.

Continuation Requirements

In order to begin the second year, at least 30 credits from the programme's first year must be completed.

Qualification Requirements

To obtain a Degree of Master of Science (120 credits) with a major in Product Development, specialisation in AI Engineering, students must complete a minimum of 120 higher education credits in accordance with the current programme syllabus, at least 60 of which must be in the main field of study Product Development and 21 credits in Mathematics.
In addition a Degree of Bachelor of Science in Engineering/Degree of Bachelor of Science or an equivalent Swedish or foreign qualification is required.

Quality Development

The School of Engineering's quality assurance process involves continuous development and quality assurance of degree programmes and courses. This means, among other things, that great importance is attributed to student feedback and that a proactive approach is taken to the development of degree programmes and courses. The quality assurance process is carried out following applicable steering documents.

Other Information

If formal competence is missing, the applicant's substantial competence is tested if the applicant has acquired equivalent knowledge in some other way. The aim is to assess the collective competence and if the applicant has the opportunity to meet selected training. Substantial competence can be about knowledge and experience from working life, long-term mobility or other courses.

Course included in the programme can be read as a separate course, subject to availability. Prerequisites are stated in the syllabus.
Admission is under "Admission arrangements for first and second level" at Jönköping University.

This syllabus is based on "Regulations and guidelines for education at undergraduate, postgraduate and doctoral studies at Jönköping"