MASTER'S PROGRAMME

HUMAN-MACHINE COMMUNICATION

FACULTY OF SCIENCE AND ENGINEERING

UNIVERSITY OF GRONINGEN

QANU
Catharijnesingel 56
PO Box 8035
3503 RA Utrecht
The Netherlands

Phone: +31 (0) 30 230 3100
E-mail: support@qanu.nl
Internet: www.qanu.nl

Project number: Q0744

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This report was finalised on 11 March 2020.

REPORT ON THE MASTER'S PROGRAMME HUMAN-MACHINE COMMUNICATION OF THE UNIVERSITY OF GRONINGEN

This report takes the NVAO's Assessment Framework for the Higher Education Accreditation System of the Netherlands for limited programme assessments as a starting point (September 2018).

ADMINISTRATIVE DATA REGARDING THE PROGRAMME

Master's programme Human-Machine Communication

Name of the programme:	Human-Machine Communication
CROHO number:	60653
Level of the programme:	Master
Orientation of the programme:	Academic
Number of credits:	120 EC
Specialisations:	- Cognitive Engineering - Cognitive Language Modelling - Cognitive Modelling - Computational Cognitive Neuroscience
Location(s):	Groningen
Mode(s) of study:	Full-time
Language of instruction:	English
Submission deadline NVAO:	1 May 2020

The visit of the assessment panel Artificial Intelligence to the Faculty of Science and Engineering of the University of Groningen took place on 7 and 8 October 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	University of Groningen
Status of the institution:	Financed
Result institutional quality assurance assessment:	Positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 25 September 2019. The panel that assessed the master's programme Human-Machine Communication consisted of:

- Prof. dr. A. (Ann) Nowé. Professor at the Computer Science Department of the Faculty of Science and the Computer Science group of the Engineering Faculty at the Vrije Universiteit Brussel [chair];
- Prof. dr. C. (Cees) Witteveen. Full professor at the Algorithmics Group of the Faculty of Engineering, Mathematics and Computer Science, Delft University of Technology;
- Prof. dr. B. (Bart) de Boer. Researcher and professor at the Artificial Intelligence lab of the Vrije Universiteit Brussel;
- Dr. C.H.M. (Kees) Nieuwenhuis. Technology Manager and member of the bureau of the Chief Technology Officer at Thales Netherlands;
- M. (Maartje) Stokvis MSc. Completed the Master's programme in Data Science for Decision Making at Maastricht University [student member].

The panel was supported by Dr. B. (Barbara) van Balen, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the master's programme Human-Machine Communication at the Faculty of Science and Engineering of the University of Groningen was part of the cluster assessment Artificial Intelligence. Between October 2019 and January 2020, the panel assessed 14 programmes at 6 universities. The following universities participated in this cluster assessment: University of Groningen, Maastricht University / Transnational University Limburg, Radboud University, University of Amsterdam, Vrije Universiteit Amsterdam and Utrecht University.

On behalf of the participating universities, quality assurance agency QANU was responsible for logistical support, panel guidance and the production of the reports. Dr. Marijn Hollestelle was project coordinator for QANU. Dr. Marijn Hollestelle, Dr. Barbara van Balen, Peter Hildering MSc and Drs. José van Zwieten acted as secretaries in the cluster assessment.

During the site visit at the University of Groningen, the panel was supported by Dr. Barbara van Balen, a certified NVAO secretary.

Panel members
The members of the assessment panel were selected based on their expertise, availability and independence. The panel consisted of the following members:

- Prof. dr. A. (Ann) Nowé. Professor at the Computer Science Department of the Faculty of Science and the Computer Science group of the Engineering Faculty at the Vrije Universiteit Brussel [chair];
- Prof. dr. C. (Cees) Witteveen. Full professor at the Algorithmics Group of the Faculty of Engineering, Mathematics and Computer Science, Delft University of Technology;
- Prof. dr. B. (Bart) de Boer. Researcher and professor at the Artificial Intelligence lab of the Vrije Universiteit Brussel;
- Prof. dr. W. (Wiebe) van der Hoek. Interim Executive Pro Vice Chancellor and professor at the Department of Computer Science of the University of Liverpool;
- Prof. dr. F. (Frank) Jäkel. Principal Investigator at the Centre for Cognitive Science of the Technical University Darmstadt;
- Dr. ir. J.F.M. (Hans) Tonino. Associate Professor at the Algorithmics Group of the Faculty of Engineering, Mathematics and Computer Science and Director of Studies Embedded Systems at Delft University of Technology;
- Dr. ir. E. (Edwin) de Jong. Principal Machine Learning Scientist at ScreenPoint Medical and coach A.I. startups at RockStart;
- Dr. C.H.M. (Kees) Nieuwenhuis. Technology Manager and member of the bureau of the Chief Technology Officer at Thales Netherlands;
- Dr. A. (Annerieke) Heuvelink-Marck. Senior Scientist at the Software Concepts Department of Philips Group Innovation and Research;
- Dr. A.P. (André) Meyer-Vitali. Senior Scientist Data Science group ICT department at the Netherlands Organisation for applied scientific research (TNO);
- M. (Maartje) Stokvis MSc. Completed the Master's programme inData Science for Decision Making at Maastricht University [student member];
- F. (Florence) van der Voort BSc. Master student Artificial Intelligence and master student Philosophy: Bioethics and Health at the Vrije Universiteit Amsterdam [student member].

Preparation
On 10 May 2019, the panel chair was briefed by QANU on her role, the assessment framework, the working method, and the planning of site visits and reports. A preparatory panel meeting was organised on 28 August 2019. During this meeting, the panel members received instruction on the use of the assessment frameworks. The panel also discussed their working method and the planning of the site visits and reports.

The project coordinator composed a schedule for the site visit in consultation with the Faculty of Science and Engineering. Prior to the site visit, the Faculty selected representative partners for the various interviews. See Appendix 4 for the final schedule.

Before the site visit to the University of Groningen, QANU received the self-evaluation reports of the programmes and sent these to the panel. A thesis selection was made by the panel's chair and the project coordinator. The selection existed of 15 theses and their assessment forms for the programmes, based on a provided list of the 30 most recent theses from January 2016 till May 2019. A variety of topics and tracks and a diversity of examiners were included in the selection. The project coordinator and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses.

After studying the self-evaluation report, theses and assessment forms, the panel members formulated their preliminary findings. The secretary collected all initial questions and remarks and distributed these amongst all panel members.

At the start of the site visit, the panel discussed its initial findings on the self-evaluation report and the theses, as well as the division of tasks during the site visit.

Site visit
The site visit to the University of Groningen took place on 7 and 8 October 2019. Before and during the site visit, the panel studied the additional documents provided by the programmes. An overview of these materials can be found in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme's management, alumni and representatives of the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. No requests for private consultation were received.

The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations.

Report
After the site visit, the secretary wrote a draft report based on the panel's findings and submitted it to the project coordinator for peer assessment. Subsequently, the secretary sent the report to the panel members. After processing the panel members' feedback, the project coordinator sent the draft reports to the Faculty in order to have it checked for factual irregularities. The project coordinator discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Faculty and University Board.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of the standards:

Generic quality
The quality that, from an international perspective, may reasonably be expected from a higher education Associate Degree, Bachelor's or Master's programme.

Meets the standard
The programme meets the generic quality standard.

Partially meets the standard
The programme meets the generic quality standard to a significant extent, but improvements are required in order to fully meet the standard.

Does not meet the standard
The programme does not meet the generic quality standard.

The panel used the following definitions for the assessment of the programme as a whole:

Positive
The programme meets all the standards.

Conditionally positive
The programme meets standard 1 and partially meets a maximum of two standards, with the imposition of conditions being recommended by the panel.

Negative
In the following situations:
- The programme fails to meet one or more standards;
- The programme partially meets standard 1;
- The programme partially meets one or two standards, without the imposition of conditions being recommended by the panel;
- The programme partially meets three or more standards.

SUMMARY JUDGEMENT

The panel concluded that the final qualifications of the master's degree programme Human-Machine Communication meet the Dutch qualification framework and the international standards, as indicated by the alignment with the KION framework. They sufficiently indicate the academic master's level. The panel established that the programme has a scientific orientation and a specific profile aimed at Cognitive Neuroscience in relation to physical processes, as well as Computational Modelling and Robotics and Autonomous Systems.

The curriculum of the master's programme Human-Machine Communication enables the students to achieve the final qualifications. The panel found the curriculum to be well developed, managed and implemented, and there is a good alignment between the curriculum and the final qualifications. The panel established that the curriculum has been built along the lines of the KION frame of reference. It allows students to obtain all necessary skills and knowledge. The panel appreciates the possibility to do an internship in combination with the master's research project. Other positive elements of the programme are the introductory programme and the first year research project. Furthermore, the panel appreciates the wide range of electives available to the students.

The panel finds the study yield low and the average study duration high. One of the reasons for this long study duration is the tendency to take longer to finish the master graduation project. The panel advises to take measures to limit this duration.

The panel agrees with the policy of the University of Groningen that considering the international character of the HMC programme, and the desired balance of the national and international student and staff population, offering the programme in English and with an English programme name ensures the best fit.

The didactical approach aimed at advanced implementation of cognitive topics in projects and the used teaching forms are, according to the panel, adequate for a master's programme.

The panel has noticed that the teaching staff is highly committed. The teaching staff furthermore is in the opinion of the panel highly qualified both in teaching as well as in domain-specific research. The level of English proficiency of the teaching is good.

The panel finds the assessment policy of the HMC programme adequate. The procedures to assure the quality of assessments are well described. The panel is convinced that the quality assurance of the assessments in the master's degree programme HMC is sufficient. The panel is positive about the introduction of the Course Unit Assessment Overviews, in which information is stored about the second examiners, the mechanisms in place to assure the quality of the assessment, the modes of assessment and the links of the assessments to the contents of the course.

The assessment procedure of the master thesis project is well described and adequate. During the site visit it became obvious that the assessment procedure for master's theses left some room for misunderstanding about the competences of external examiners. The programme management has immediately taken measures to resolve this misunderstanding. In addition, the panel advises the programme to be transparent about the difference in assessment criteria for the master's thesis projects of 45 EC and the master's thesis project of 30 EC and 15 EC internship.

The panel concludes that the Board of Examiners is performing its legal duties and tasks. The BoE checks 10% of all theses, which is sufficient. The efficiency of the sample checks could be further improved.
The panel concludes that graduates of the master's programme in Artificial Intelligence have achieved the intended learning outcomes. Master graduates are well prepared for proceeding in a PhD trajectory or a professional career on master's level in AI related industry.

The panel assesses the standards from the *Assessment framework for limited programme assessments* in the following way:

Master's programme Human-Machine Communication

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Student assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

The chair of the panel, Prof. dr. Ann Nowé, and the secretary, Dr. Barbara van Balen, hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 11 March 2020

PANEL ADVICE CONCERNING RENAMING THE PROGRAMME

Findings
The master's programme Human-Machine Communication has filed a request for a change of the name to: Computational Cognitive Science, in order to better reflect the programme's content. The assessment panel was asked to advise on this change. The panel read the self-evaluation, the course descriptions and course materials of the master's programme. Furthermore, it studied 15 master's theses and discussed the objectives and the content of the programme with the management, teaching staff and students. The panel concluded that the name Computational Cognitive Science is a better reflection of the objectives and content of the programme than the current CROHO title Human-Machine Communication. CROHO number: 60653.

Considerations
Considering the objectives and the content of the master's programme the panel agrees with the arguments of the programme management leading to request to change the programme's name in Computational Cognitive Science.

Conclusion
The panel agrees with the proposed name change from Human-Machine Communication to Computational Cognitive Science.

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED FRAMEWORK ASSESSMENTS

The Master's degree programme Human-Machine Communication is offered by the Faculty of Science and Engineering (FSE) of the University of Groningen. It is part of the Graduate School of Science and Engineering (GSSE), which includes all master's and PhD programmes of the FSE. The school has a director who reports to the Faculty Board. The programme is supported by a faculty-wide Education Support Centre (ESC), which takes care of all student administration tasks.

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings
The goal of the master's programme Human-Machine Communication (HMC) is to deliver critical, independent and academic individuals who can professionally function in common areas of Artificial Intelligence and Cognitive Science, particularly Cognitive Modelling, Computational Cognitive Neuroscience, Cognitive Engineering and Cognitive Language Modelling. The programme has a strong focus on the formal modelling of cognition and related applications. The general context of the programme profile is formed by the KION Frame of Reference, which was compiled by the Dutch academic AI programmes. This document formulates the current Dutch consensus on a national frame of reference for Artificial Intelligence in the Netherlands.

The final qualifications indicate that the AI master graduate should have the following abilities:
- independently design a system with cognitive capacities;
- perform independent research in Artificial Intelligence/ Cognitive Science;
- analyse and test system properties and qualities and report on them at a high scientific level;
- cooperate at a similar level of professionalism with graduates from disciplines related to Artificial Intelligence and Cognitive Science.

The combined focus areas of the programme, together with the defined master abilities and the clustered final qualifications of the KION frame of reference, are elaborated in the six final qualifications for the master's programme (see Appendix 2). The programme prepares students at a scientific level. The scientific training offers the possibility for employment in the non-scientific labour market, as an individual consultant or entrepreneur, as well as the possibility to continue with a PhD trajectory in a variety of research fields.

The panel noticed that the programme has a strong scientific orientation. It prepares the students for a career in research. The orientation on professions was less clearly formulated in the self-evaluation in the panel's opinion. This issue was discussed during the site visit and recognised by the programme representatives.

The panel established that the final qualifications meet the requirements of the KION reference framework and are formulated in line with the goal of the programme. They tie in with the Dublin Descriptors for master's degree programmes and therefore sufficiently indicate what could be expected from students at a master's level. They reflect the content, level and orientation of the master's programme. The panel finds the distinction between the final qualifications of the bachelor's and the master's programmes to be clear.

Considerations
The panel concluded that the final qualifications of the master's degree programme Human-Machine Communication meet the Dutch qualification framework and the international standards, as indicated by the alignment with the KION reference framework. They sufficiently reflect the academic master's

level. The panel established that the programme has a scientific orientation and a specific profile aimed at Cognitive Neuroscience in relation to physical processes, as well as Computational Modelling and Robotics and Autonomous Systems.

Conclusion
Master's programme Human-Machine Communication: the panel assesses Standard 1 as 'meets the standard'.

Standard 2: Teaching-learning environment
The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum
The master's programme in Human-Machine Communication (HMC) teaches students advanced material on the cognitive side of Artificial Intelligence. It uses formal methods and known theories about intelligence to study both cognition in humans and formal problem-solving in general. The first year is aimed at giving students the tools they will need for research in HMC. There is a compulsory introductory course on the topics of cognition, a course on cognitive modelling and a course on relevant statistical methods. The programme consists of 15 EC of compulsory courses, 15 EC of specialisation courses and 30 EC of electives related to HMC. The students also have to perform a 15 EC first-year research project. In addition, they have to choose one specialisation out of four: Cognitive Modelling, Computational Cognitive Neuroscience, Cognitive Language Modelling and Cognitive Engineering.

The specialisations serve to tie the graduation topics together. They act as a kind of elective learning trajectory, steering toward a graduation topic, but one which is not mentioned on the diploma. The specialisations teach students the skills they need to successfully perform a large research project. This project will generally be in one of the four 'specialisation' directions. The students are able to choose their own path within Artificial Intelligence and Cognitive Science, but they require a certain knowledge base before they can graduate in a specific direction. The specialisations offer a fixed number of courses (three), which guarantee that the students will be able to work towards a master's project in one of the research groups. The Curriculum Committee, consisting of staff members from every research group, regularly interfaces with the teaching staff responsible for the specialisations, to ascertain that the specialisation stays up to date with the research in Human-Machine Communication.

In the second year, the students can continue with specialisation and elective courses (15 EC) and do their master's project (45 EC) or an internship (15 EC) and master's project (30 EC). An overview of the programme can be found in Appendix 3.

The panel noticed that it is possible for a student to compile an individual study programme which does not cover three of the five research areas required according to the final qualifications (see Appendix 2). It discussed this issue during the site visit with representatives of the programme, who pointed out that the students compile an individual study programme in consultation with a staff member / study counsellor, who will ensure that the student meets all final qualifications. In addition, each individual study programme requires formal approval by the Board of Examiners before issuing the diploma. The panel appreciates the wide range of electives available for the students, in particular those aimed at employability and the societal aspects of AI. It is positive about the first-year research project the students have to perform. This allows them to be thoroughly trained in research skills and provides a broad overview of possible research themes. The first-year project is also much appreciated by the students. Another strong aspect of the curriculum is the introductory course Formal Models of Cognition. This course provides an opportunity for students who previously did not

study the bachelor's programme AI in Groningen to get to know the professors and integrate in the community. It also enables the students to develop different skills and bring their knowledge to the same level.

The programme is part of the Faculty of Science and Engineering. In 2017 the Faculty changed its name from Faculteit der Wiskunde- en Natuurwetenschappen (FWN) to Faculty of Science and Engineering (FSE) to reflect its international character. All bachelor's degree programmes and nearly all Master's degree programmes at the Faculty of Science and Engineering (FSE) (except for the Master's programme in Pharmacy and the Education track of the Master's programme in Science Education and Communication) are taught in English, in an international environment.
In line with the educational approach of the University of Groningen and the programme itself, the bachelor's programme Artificial Intelligence is taught in English. This facilitates an international classroom in which students can engage in cross-cultural learning. In addition, the English language serves as a preparation for the very internationally oriented field of artificial intelligence, as well as the broader field of the ICT sector. For new scientific staff, proficiency in English is one of the criteria on which they are selected. International students have to pass an English language test to demonstrate their proficiency.
The panel agrees with the policy of the University of Groningen that considering the international character of the AI domain and the desired balance of Dutch and international students and staff, offering the programme in English, and with an English programme name, ensures the best fit.

Didactics
Master's students are expected to already have a strong foundation in AI topics. During the programme they work on the advanced implementation of the cognitive topics in larger projects on different aspects of linguistics, cognitive modelling or cognitive engineering. Most of the contact hours in the programme are used for lectures, practicals and presentations. In the last phase the students work more independently, spending most of their time on their final research project. The panel finds the didactical approach and the teaching forms adequate for a master's programme.

Student intake, yield and feasibility
The yearly intake of the programme has been fluctuating around 10-12 students per year. The international intake has grown to about 20%. The intake of female students is on average 30%. The study yield after three years is also fluctuating, on average it is 68%, which is below the Faculty's target of 80%. The average study duration is about 2.9 years. One of the identified reasons for delay is the tendency of students to take more than the nominal time to finish their graduation research projects. However, this conclusion has not yet resulted in measures to improve the situation. Graduation rules allow students to take longer for the master's project in order to improve its quality and grading. The duration of the project has no influence on the grading nor on the possibility to receive a 'cum laude' designation. The panel also noted that the programme has a high percentage of 'cum laude' awards, which seems to contradict the intention of this designation as being 'exceptionally good'. It advises the programme to take measures to limit the duration of the graduation project and reconsider the cum laude regulations.

Students find the programme to be feasible and see no major obstacles to finishing in time, but they appreciate the possibility to extend the duration of the graduation project to get a higher grade. In their view a major reason for delay is that most students are working alongside their study. Many students have already been recruited by companies before they graduate.

Teaching Staff
The self-evaluation report reports a student-staff ratio of about 23 students / 1 teaching fte. The ratio has increased during the last few years due to the growth of student numbers and decreasing input from other departments, in particular the Department of Psychology. An increase of teaching staff in the AI Department is necessary, but cannot be realised in a short time. An increase in staff numbers always lags a few years behind. During the site visit, the staff members reported that they managed to teach and guide the increasing number of students, thanks to a high commitment of the

teaching staff. During the site visit the formal and programme management presented some measures to recruit more teaching staff.

During the site visit interviews, the staff demonstrated that they are motivated and enthusiastic and dedicated to providing a high-quality teaching-learning environment. They are highly qualified, in the panel's opinion, in teaching as well as in domain-specific research. Their level of English proficiency is good.

Facilities
During the site visit, the HMC students reported that although they felt privileged because of the relatively small student numbers in the HMC programme, they also experienced pressure on the facilities, like work and study spaces, originating from increasing student numbers in other degree programmes at the FSE. They are very pleased with their own HMC students' room.

Considerations
The curriculum of the master's programme Human-Machine Communication enables the students to achieve the final qualifications. The panel found the curriculum to be well developed, managed and implemented, and there is a good alignment between it and the final qualifications. It established that the curriculum has been built along the lines of the KION frame of reference. This allows students to obtain all necessary skills and knowledge. The panel appreciates the possibility to do an internship in combination with the master's research project. Other positive elements of the programme are the introductory section and the first-year research project. The panel appreciates the wide range of electives available to the students.

The panel finds the study yield to be low and the average study duration, long. One of the reasons for this long study duration is the tendency to take longer to finish the master graduation project. The panel advises taking measures to limit this duration.

The panel agrees with the policy of the University of Groningen that considering the international character of the HMC programme and the desired balance of the national and international student and staff population, offering the programme in English and with an English programme name ensures the best fit.

The didactical approach aimed at advanced implementation of cognitive topics in projects and the teaching forms used are adequate for a master's programme, according to the panel.

The panel noted that the teaching staff is highly committed. In its opinion, they are highly qualified in both teaching and domain-specific research. Their level of English proficiency is good.

Conclusion
Master's programme Human-Machine Communication: the panel assesses Standard 2 as 'meets the standard'.

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings

Assessment procedures
The assessment procedures of the HMC master's programme are in line with the assessment policy of the FSE, which is based on the university-wide assessment policy. The programme has an assessment plan, which is an overview of all assessments and contains information about the way students are evaluated throughout the degree programme. A variety of assessment types are used, ranging from assignments and interim tests to reports, oral examinations, presentations and practical

work. Since it is a programme that combines a lot of theory with a fair amount of practice, it is assessed through both practical implementations and writing papers that show a deep understanding of the theoretical frameworks. Most of the programme elements are assessed through a combination of practical assignments and a written examination. Furthermore, the students very often have to show their presentation skills.

The programme has two elements that are designated as a research project. These projects are headed by two supervisors, with the first one being an examiner approved by the Board of Examiners. The students finish their programme by completing a 45 EC research project. They start their project by signing a contract with their supervisors, in which they make clear agreements on the deadlines, on what they expect from the project and who the second supervisor of the project will be. The students have to hand in a proposal. The project should result in a thesis that clearly outlines the relevant literature and describes the results and methods used. The supervisors and students have one or two meetings to discuss the project goals. At this point the project can be terminated if the expectations diverge too much. The students can also choose to do an internship of 15 EC plus a master's project of 30 EC. The panel did not get a clear explanation of the difference in assessment criteria used for the 45 EC master's project and the 15 EC internship and 30 EC master's project. It recommends that the programme board be more transparent about these differences.

The procedure requires both supervisors to individually assess the work of the student and come to a conclusion on the quality of his/her work using a predetermined assessment form.
The panel discussed this procedure with the Board of Examiners during the site visit. It came to the conclusion that when students do their thesis work externally, it was possible that an external supervisor who is not appointed as an examiner could be an assessor of the thesis. In reaction to the remarks on this issue, the programme management changed the assessment procedure immediately. External supervisors can advise about the quality of the student's work to an assessor, but the BoE will explicitly check if two formally appointed examiners in fact assess the theses. After checking this procedure, the panel is pleased about the measures taken and concludes that this ensures a correct and independent procedure in all cases.

Quality assurance
The examination of each course is checked by a second examiner. Assignments and examinations are graded using a pre-established answer key. The programme also makes use of grading criteria for presentations and papers.

A faculty-wide method to assure the quality of assessment is the Course Unit Assessment Overview. In the CUAO, information is stored about the second examiners, the mechanisms in place to assure the quality of the assessment, the modes of assessment and the links of the assessments to the contents of the course.

The panel studied the Quality Assurance Manual FSE, the assessment plan and several CUAOs. It is convinced that the quality assurance of the assessments in the degree programme AI is sufficient. The assessment policy is adequate. The panel is positive about the introduction of the CUAOs.

Board of Examiners
The bachelor's programme AI, the master's programme AI and the master's programme HMC share one Board of Examiners, consisting of four staff members from the Artificial Intelligence Department and an external member. The external member is an employee of the Undergraduate School of Science and Engineering. The Board of Examiners (BoE) is responsible for topics related to the qualitative assessment of the programme of individual students and the assessment quality of the degree programme itself. It deals with student requests concerning changes in their individual study programme and requests for exemptions, as well as with students who show fraudulent behaviour.

In order to be able to guarantee the quality of assessments of courses and graduation, the BoE checks the quality of a sample of theses and a sample of courses.

The panel noticed that the assessment procedures are adequately described and executed, and that the BoE checks 10% of all theses obtained the ILOs, but that the efficiency of the sample checks could be further improved by, for instance, making use of support by the ESC to perform administrative checks and asking the ESC to report to the BoE.

Considerations
The panel finds the assessment policy of the HMC programme to be adequate. The procedures to assure the quality of assessments are well described. The panel is convinced that the quality assurance of the assessments in the master's degree programme HMC is sufficient. It is positive about the introduction of the Course Unit Assessment Overviews, in which information is stored about the second examiners, the mechanisms in place to assure the quality of the assessment, the modes of assessment, and the links of the assessments to the contents of the course.

The assessment procedure of the master's thesis project is well described and adequate. During the site visit it became obvious that the assessment procedure for master's theses left some room for misunderstanding about the competences of external examiners. The programme management has immediately taken measures to resolve this misunderstanding. In addition, the panel advises the programme to be transparent about the difference in assessment criteria for the master's thesis projects of 45 EC and the master's thesis project of 30 EC plus 15 EC internship.

The panel concludes that the Board of Examiners is performing its legal duties and tasks. The BoE checks 10% of all theses, which is sufficient. The efficiency of the sample checks could be further improved.

Conclusion
Master's programme Human-Machine Communication: the panel assesses Standard 3 as 'meets the standard'.

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings
In order to establish whether the graduates of the master's programme HMC demonstrate that the final qualifications are achieved, the panel checked that all final qualifications are covered in the courses and accompanying assessments that make up the curriculum. It concluded that the curriculum ensures that the graduates have achieved the final qualifications.

The panel studied a selection of fifteen master theses and their assessment forms. It agreed with the assessments of all theses. The theses showed that the students have the ability to perform independent research in Human-Machine Communication. They utilised the acquired knowledge and skills and reported professionally on their work. They demonstrated their ability to analyse problems on an international academic level, and critically and constructively reviewed both their own and other scientific results and communicated about this. The theses showed that the students have the capability to reflect on their working methods and knowledge and to understand the scientific developments in the field of Human-Machine Communication. The graduates are well prepared for continuing in a PhD trajectory and for a position on a master's level in the work field that is in line with their expertise. The panel had an interview with alumni during the site visit. They confirmed that they felt well prepared for their function in the work field. The knowledge, skills and competences they developed during their HMC studies provided a good broad background for their present positions in a variety of companies. These reactions are in line with the results of an alumni survey presented in the self-evaluation report. These results indicated the alumni were satisfied with the programme, and they found the academic and critical thinking, programming and research abilities they learnt valuable.

The contact with alumni could be improved, since the panel is of the opinion that alumni input could be very valuable for the programme. It advises the programme to facilitate an alumni network or alumni association.

Considerations
The panel concludes that graduates of the master's programme in Artificial Intelligence have achieved the intended learning outcomes. Master graduates are well prepared for proceeding in a PhD trajectory or a professional career on a master's level in an AI-related industry.

Conclusion
Master's programme Human-Machine Communication: the panel assesses Standard 4 as 'meets the standard'.

GENERAL CONCLUSION

The panel judged that the master's programme in Human-Machine Communication offered by the University of Groningen meets all standards of the NVAO assessment framework for limited programme assessment. It therefore advises positively about the re-accreditation of the programme.

Conclusion
The panel assesses the *master's programme Human-Machine Communication* as 'positive'.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Frame of Reference: Bachelor's and Master's Programmes in Artificial Intelligence
The Dutch Perspective
[For author names and article, see:
https://pure.uva.nl/ws/files/29809664/KION_FoR_2018_Final.pdf][1]

October 16th, 2018

This document is an update of the 2013 Frame of Reference as developed by the KION[2] task force on Curricula for Artificial Intelligence, which was based on:
• Artificial Intelligence Academic Programmes in the Netherlands - A State of the Art report, Quality Assurance Netherlands Universities, 2015[3]
• Computer Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science, The Joint Task Force on Computing Curricula, Association for Computing Machinery (ACM), & IEEE Computer Society, December 20, 2013, p. 221-229[4]
• The Onderwijs- en Examenregelingen (OER) of the bachelor's and master's programmes in Artificial Intelligence administered by the Dutch Universities.
• Tuning Educational Structures in Europe[5], European project, 2000-2004.

1 | INTRODUCTION
This document is an update of the 2013 frame of reference for the Dutch University programmes included in the category Artificial Intelligence of the Dutch register of higher education programmes (CROHO)[6] This frame of reference defines the fields covered by the term Artificial Intelligence as well as the common goals and final qualifications of these programmes.

Artificial Intelligence is a relatively young field. The birth of Artificial Intelligence research is often dated in 1956, when the founding fathers of AI met at the Dartmouth Conference. The history of teaching Artificial Intelligence as a separate discipline is much shorter still, starting in the Netherlands in the early '90's. Consequently, a frame of reference for Artificial Intelligence is still actively developing both in the national and the international context. This document formulates the current Dutch consensus on a national frame of reference for Artificial Intelligence in the Netherlands.

Intelligence is often defined as the ability to reason with knowledge, to plan and to coordinate, to solve problems, to perceive, to learn and to understand language and ideas. Originally these are typical properties and phenomena associated with the human brain, but they can also be investigated without direct reference to the natural system. Both ways of studying intelligence either can or must use computational modelling. The term Artificial Intelligence as used in this document refers to the study of intelligence, whether artificial or natural, by computational means.

1.1 KION: Artificial Intelligence in the Netherlands
The current Dutch Artificial Intelligence programmes were mostly started in the nineties in an interdisciplinary context. Originally they were known under a variety of names such as Cognitive Science (Cognitiewetenschap), Applied Cognitive Science (Technische Cognitiewetenschap), Knowledge Engineering (Kennistechnologie), Cognitive Artificial Intelligence (Cognitieve Kunstmatige Intelligentie) as well as Artificial Intelligence (Kunstmatige Intelligentie).

[1] The authors like to acknowledge the authors of the 2006 and 2013 Frame of Reference for their work; major parts of this document are still built on their original vision.
[2] Kunstmatige Intelligentie Opleidingen Nederland
[3] www.qanu.nl/en/state-of-the-art-reports (last visited in March 2018)
[4] www.acm.org/education/curricula-recommendations (last visited in March, 2018)
[5] www.unideusto.org/tuning/ (last visited in February 2018)
[6] Centraal Register Opleidingen Hoger Onderwijs

In 1999, the number of recognised labels in the CROHO was reduced, and the aforementioned study programmes were united under the name Artificial Intelligence[7]. Initially, this was an administrative matter that did not influence the content of the curricula. It did mean, however, that from then on cognitive science (as the study of natural intelligence) and artificial intelligence (as a formal approach to intelligence) were shared under the heading of Artificial Intelligence. The above mentioned definition of Artificial Intelligence as the study of natural and/or artificial intelligence by computational means was then agreed upon. The KION (Kunstmatige Intelligentie Opleidingen in Nederland) was formed as a discussion and cooperation platform for the united programmes.

Starting in 2002, all university-level study programmes in the Netherlands were divided into a bachelor's and a master's phase. KION took this as an opportunity to agree upon a common kernel of subjects that would be constituent of every Dutch Artificial Intelligence bachelor's programme, with the aim of advancing an adequate fit of all Dutch bachelor's programmes to all Dutch master's requirements.

Since then, some degree programmes have changed their names for specification and/or marketing purposes. The Human-Machine Communication degree programme in Groningen joined the KION framework soon after the start, in 2004. In 2013, the VU changed the name of its bachelor's in Kunstmatige Intelligentie to Lifestyle Informatics, to better fit their human-oriented approach to AI, which helped to attract a new population of students (including a higher proportion of female students). However, from 2019 on, the bachelor's programme will be taught in English under the name Artificial Intelligence (with a track in Intelligent Systems and a track in Socially Aware Computing). Furthermore, in 2017, Maastricht renamed its bachelor's programme to Data Science & Knowledge Engineering, and changed its master's programme in Operations Research programme to Data Science for Decision Making, to enable more synergy with its master's AI programme. A full list of the degree programmes that are a member of the KION can be found in section 1.2.

During the last decade new developments in Artificial Intelligence (AI) have become increasingly visible to society and the general public. Most appealing successes like IBM's Watson performance and Google's DeepMind victory in AlphaGo, have globally drawn attention. In business, AI's impact on massive data-mining applications in consumer markets may even more revolutionise the use of AI in everyday life.

The successes in the field of AI have not gone unnoticed in the Dutch educational AI programmes. There has been a substantial increase in the intake of virtually all Dutch AI programmes, reflecting the awareness of the growing potential of AI by talented students. In addition, several Dutch programmes are now taught in English, attracting students from all over the world. At some Universities, the substantial growth has led to measures to maintain quality, e.g. by introducing a Binding Study Advice or even by imposing a Numerus Fixus (Radboud University and University of Amsterdam in September 2018; other Universities are likely to follow in 2019).

The prospects of a career in AI, directly or via business-related spin-offs, are very promising; we therefore have to be prepared to face the challenge of keeping quality of our AI programmes during upcoming years, while offering enough capacity to train professionals to fulfil the future needs of society in implementing AI-based solutions.

The following degree programmes are a member of the Kunstmatige Intelligentie Overleg Nederland:

1.2.1 Bachelor's Programmes of the KION

The following Bachelor's programmes are a part of the KION:

- B Artificial Intelligence, Radboud Universiteit Nijmegen (CROHO: 56945)
- B Data Science and Knowledge Engineering, Universiteit Maastricht (CROHO: 50300)
- B Kunstmatige Intelligentie, Rijksuniversiteit Groningen (CROHO: 56981)
- B Kunstmatige Intelligentie, Universiteit van Amsterdam (CROHO: 56981)

[7] In Dutch: Kunstmatige Intelligentie

• B Kunstmatige Intelligentie, Universiteit Utrecht (CROHO: 56981)
• B Artificial Intelligence, Vrije Universiteit Amsterdam (CROHO: 56983)

1.2.2 Master's Programmes of the KION

• The following Master's degree programmes are a part of the KION:
• M Artificial Intelligence, Radboud Universiteit Nijmegen (CROHO: 66981)
• M Artificial Intelligence, Rijksuniversiteit Groningen (CROHO: 66981)
• M Artificial Intelligence, transnationale Universiteit Limburg (CROHO: 66981)
• M Artificial Intelligence, Universiteit Utrecht (CROHO: 66981)
• M Artificial Intelligence, Universiteit van Amsterdam (CROHO: 66981)
• M Artificial Intelligence, Vrije Universiteit Amsterdam (CROHO: 66981)
• M Data Science for Decision Making, transnationale Universiteit Limburg (CROHO: 60125)
• M Human-machine Communication, Rijksuniversiteit Groningen (CROHO: 60653)

1.3 Aim of this Document

Now that the Dutch Artificial Intelligence programmes are coming up for accreditation in 2019, KION feels that the essence of the 2013 Frame of Reference is still valid, but in definite need of an update. However, this document is not intended purely as a description of the current status quo. Rather, it aims to provide an account of what an Artificial Intelligence programme should provide as a minimum (the communal requirements for every study programme called Artificial Intelligence), and how it can extend this basis to distinguish itself from other Artificial Intelligence programmes.

Agreement among the Dutch Artificial Intelligence programmes upon the contents of this document will advance both the equivalence of these programmes, and the understanding on existing and possible profiles within Artificial Intelligence programmes. Moreover, it is hoped that this document will also be a starting point for defining international standards for Artificial Intelligence programmes.

2 | PROGRAMME CHARACTERISTICS

This section describes definitions regarding the build-up of bachelor's and master's programmes.

2.1 Areas, Courses, Modules and Topics

A bachelor's programme in Artificial intelligence is organised hierarchically into three levels. The highest level of the hierarchy is the area, which represents a particular disciplinary subfield. The areas are broken down into smaller divisions called modules, which represent individual thematic units within an area. A module may be implemented as a complete course, be covered in part of a course, or contain elements from several courses. Each module is further subdivided into a set of topics, which are the lowest level of the hierarchy. The modules that implement the particular programme (or curriculum) are together referred as the 'body of knowledge'.

2.2 Core and Elective Courses

By insisting on a broad consensus in the definition of the core, we hope to keep the core as small as possible, giving institutions the freedom to tailor the elective components of the curriculum in ways that meet their individual needs. The core is thus not a complete programme. Because the core is defined as minimal, it does not, by itself, constitute a complete undergraduate curriculum. Every undergraduate programme must include additional elective courses relating to the body of knowledge. This report does not define what those courses should be, but does enumerate options in terms of modules.

2.3 Assessing the Time Required to Cover a Course

To give readers a sense of the time required to cover a particular course, a metric must be defined that establishes a standard of measurement. No standard measure is recognised throughout the world, but within the European Community agreement has been reached upon a uniform European Credit Transfer System[8] (ECTS) in which study load is measured in European Credits (ECs). One EC

[8] https://ec.europa.eu/education/resources/european-credit-transfer-accumulation-system_en (last visited on May 4, 2018)

stands for 28 hours of study time and a full year of study is standardised at 60 EC. In this document, we shall use the EC metric as the standard of measurement for study load.

2.4 Coping with Change

An essential requirement of any Artificial Intelligence degree is that it should enable graduates to cope with-and even benefit from-the rapid change that is a continuing feature of the field. But how does one achieve this goal in practice? At one level, the pace of change represents a challenge to academic staff who must continually update courses and equipment. At another level, however, it suggests a shift in pedagogy away from the transmission of specific material, which will quickly become dated, toward modes of instruction that encourage students to acquire knowledge and skills on their own.

Fundamentally, teaching students to cope with change requires instilling an attitude that promotes continued study throughout a career in those students. To this end, an Artificial Intelligence curriculum must strive to meet the following challenges:

- Adopt a teaching methodology that emphasises learning as opposed to teaching, with students continually being challenged to think independently.
- Assign challenging and imaginative exercises that encourage student initiative.
- Present a sound framework with appropriate theory that ensures that the education is sustainable.
- Ensure that equipment and teaching materials remain up to date.
- Make students aware of information resources and appropriate strategies for staying current in the field.
- Encourage cooperative learning and the use of communication technologies to promote group interaction.
- Convince students of the need for continuing professional development to promote lifelong learning.
- Provide students with awareness of potential ethical and legal issues the field of Artificial Intelligence.

3 | SHARED IDENTITY

3.1 Common Role

Apart from the roles academics usually perform in society students of Artificial Intelligence are educated to enrich society with the benefits a formalization of intelligence and intelligent phenomena can provide. In particular this entails that an alumnus of Artificial Intelligence can contribute to the understanding and exploitation of natural and artificial intelligence. This may lead to new technologies but it may also enrich designs, products, and services with intelligence so that they are more effective, more reliable, more efficient, safer, and often require less natural resources. This role, in combination with the interdisciplinary nature of the field, requires the Artificial Intelligence alumnus to be able to contribute to interdisciplinary teams and, in many cases function as an intermediate who facilitates the interaction of (other) domain specialists.

3.2 Common Requirements

Artificial Intelligence is a broad discipline and many approaches to the study of intelligent phenomena are justified and fruitful. Curricula are therefore often different from their siblings in emphasis, goals, and capabilities of their graduates. Yet they have much in common. Any reputable Artificial Intelligence programme should include each of the following aspects.

1. Essential and foundational underpinnings of the core aspects of intelligence. These must be founded on empirical efforts and based on a formal theory, and they may address professional values and principles. Regardless of their form or focus, the underpinnings must highlight those essential aspects of the discipline that remain unaltered in the face of technological change. The discipline's foundation provides a touchstone that transcends time and circumstances, giving a sense of permanence and stability to its educational mission. Students must have athorough grounding in that foundation.

2. A foundation in the core concepts of modelling and algorithms for implementing intelligence. The construction and use of models (simplified, abstracted and dynamic representations of some phenomenon in reality) is common to many sciences. In Artificial Intelligence, however, model building is central: the field of Artificial Intelligence may actually be defined as trying to model aspects of (formal or natural) intelligence and knowledge. Moreover, models within Artificial Intelligence have specific characteristic: they are computational and therefore necessarily mathematical or formal. Artificial Intelligence-graduates must therefore be able to work with (computational) models at different levels of abstraction and understand the recursive nature of models in Artificial Intelligence. This foundation has a number of layers:

- An understanding of, and appreciation for, many of the diverse aspects of intelligence, models of intelligent phenomena, and of algorithms that describe intelligent processes.
- Skills to model intelligent phenomena and appreciate the abilities and limitation of these models, if appropriate in comparison with a natural intelligence counterpart.
- Skills to model and implement intelligent phenomena on a computer, in particular skills to work with algorithms and data-structures in software.
- Skills to design and build systems that are robust, reliable, and appropriate for their intended audience.

3. An understanding of the possibilities and limitations of what intelligent systems can and cannot do. This foundation has a number of levels:

- An understanding of what current state-of-the-art can and cannot accomplish, if appropriate in combination with the accomplishment of the natural system that inspired it;
- An understanding of the limitations of intelligent systems, including the difference between what they are inherently incapable of doing versus what may be accomplished via future science and technology;
- The impact of deploying technological solutions and interventions on individuals, organizations, and society.

4. The identification and acquisition of non-technical skills, including interpersonal communication skills, team skills, and management skills as appropriate to the discipline. To have value, learning experiences must build such skills (not just convey that they are important) and teach skills that are transferable to new situations.
5. Exposure to an appropriate range of applications and case studies that connect theory and skills learned in academia to real-world occurrences to explicate their relevance and utility.
6. Attention to professional, legal and ethical issues such that students acquire, develop and demonstrate attitudes and priorities that honour, protect, and enhance the profession's ethical stature and standing.
7. Demonstration that each student has integrated the various elements of the (under)graduate experience by undertaking, completing, and presenting a capstone project.

3.3 Shared Background for Bachelor's Programmes

Similar to alumni of programmes such as Physics, Computer Science, and Psychology, all Artificial Intelligence bachelors are expected to share a certain amount of support knowledge, domain specific knowledge, specialised domain knowledge, and a set of skills. The content mentioned below ensures a firm common basis that enables AI bachelors of any Dutch university admission to any Dutch master's programme in AI. At the same time, it allows for a wide range of individual and/or institute specific specialisations. The list is an update (extension) of the shared programme agreed upon by the KION platform in 2013.

3.3.1 Core Modules (shared between AI Bachelor's Degree Programmes)

The following topics and skills are part of each of the bachelor's programmes, either as a dedicated course or as a substantial topic within one or more courses. The core modules define the 8 key areas of Artificial Intelligence.

3.3.1.1 Artificial Intelligence (Core) Modules

- Algorithmic Problem Solving (Search, Decision Making, Optimalisation)
- Cognitive Science
- Computational Linguistics
- Context of Artificial Intelligence (History, Philosophy, Ethics)
- Intelligent Autonomous Agents and Multi-Agent Systems
- Interaction (Perception, Human-Computer Interaction, Communication)
- Knowledge Representation and Reasoning
- Machine Learning

3.3.1.2 Support Module

- Computer Science
    - Algorithms and Data Structures
    - Programming
- Logic
    - Propositional Logic
    - Predicate Logic

3.3.1.3 Academic Skills

- Mathematics
    - Calculus
    - Discrete Mathematics
    - Linear Algebra
    - Probability Theory
    - Statistics

Apart from curriculum specific skills, the bachelor's programmes support the development of a set of general academic skills. Even though they can be topics in specific modules, they are generally addressed by the appropriate choice of work and assessment methods throughout the curriculum.

- Analytic Skills
- Empirical Methods
- Modelling
- Teamwork
- Written and Oral Communication, Argumentation and Presentation

3.3.2 Elective Modules (within Artificial Intelligence)

The following list of modules is considered as representative of the AI field at this moment. Given that the different AI programs have different priorities in selecting topics, and assigning topics to either the bachelor's or master's, each bachelor's should offer a substantial subset of the following list as part of their bachelor's programme, either as specific course, or as a substantial part of a broader course (i.e. a module).

- Architectures of Cognition and Cognitive Modelling
- Computational and Cognitive Neuroscience
- Computational Intelligence
- Computer Vision
- Data Mining
- Deep Learning
- ELSA (Ethical, Legal and Social Aspects of AI)
- Evolutionary Algorithms (Genetic Algorithms, Evolutionary Computing)
- Language and Speech Technology

- Neural Networks
- Perception (Computational and Natural)
- Reasoning under Uncertainty
- Reinforcement Learning
- Robotics
- Text Mining and Information Retrieval
- Virtual Reality and Gaming
- Web and Artificial Intelligence

4 | BACHELOR'S PROGRAMME ARTIFICIAL INTELLIGENCE

This section is divided into two parts. Section 4.1 describes the roles that a bachelor ought to be able to perform in society. Section 4.2 describes the final qualifications that bachelors in Artificial Intelligence possess in order to fulfil these roles.

4.1 Objectives

The objective of the bachelor's programme is to provide students with a suitable basis for a further career, both in education as well as in employment. The bachelor must be prepared for a number of different roles and opportunities.

4.1.1 Access to Master's Programmes

The bachelor provides the student with the specific knowledge and abilities, exemplified in the form of a bachelor's diploma that allows the bachelor to apply for any master's programme in Artificial Intelligence or other national or international master's programmes, particularly in related disciplines.

4.1.2 Professional Career

The bachelor prepares for a position in which the student can earn his or her own subsistence. In particular it prepares for:

- Supervised work on a national and international academic level;
- Positions in the modern high-tech society, such as functions in knowledge-intensive companies and knowledge intensive parts of the non-profit sector.

4.1.3 Academic Skills

The bachelor provides sufficient training in (scientific) reasoning, conduct, and communication to reach internationally accepted standards of academic skills at that level.

4.1.4 Place in Society

The bachelor's programme provides the bachelor with the knowledge and tools needed to form an informed opinion of the meaning and impact of Artificial Intelligence, and an informed notion of the responsibilities of a specialist in this area.

4.2 Final Qualifications

The objectives of the bachelor can be specified into final qualifications. To comply with international standards these qualifications are presented below in terms of the Dublin descriptors for the bachelor's profile[9]. Together these final qualifications must lead to alumni that exemplify the shared identity defined in section 3.

4.2.1 Knowledge and Understanding

The bachelor demonstrates knowledge and understanding in a field of study that builds upon and supersedes their general secondary education. Knowledge and understanding is typically at a level at which the bachelor, whilst supported by advanced textbooks, is able to include some aspects at the forefront of their field of study.

[9] "A Framework for Qualifications of the European Higher Education Area", 2005. (last visited on May 4, 2018)

We distinguish two levels of qualification: a basic understanding, corresponding to knowledge of the essentials and fundamentals of the field in question, such as knowing what the field is, knowing how to apply knowledge in said field, and knowing how to further develop oneself in the field in question, and an advanced understanding, corresponding to in-depth knowledge about a topic in question.

Qualifications:
1. Basic understanding of the (8) key areas in Artificial Intelligence in accordance with the shared identity.
2. Advanced knowledge of at least one of the key areas in Artificial Intelligence, up to a level that without further requirements grants access to a master programme in this area.

4.2.2 Applying Knowledge and Understanding

Bachelors can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems and/or designing systems within their field of study. They are able to analyse and model prototypical Artificial Intelligence problems by using known Artificial Intelligence methods and techniques.

Qualifications:
1. The ability to understand, apply, formulate, and validate models from the domains of Artificial Intelligence.
2. The ability to apply knowledge from the key areas of Artificial Intelligence. (as outlined in 3.3.1.1)
3. The ability to apply knowledge from the support modules of Artificial Intelligence (as outlined in 3.3.1.2)
4. Analytical approach to problem solving and design:
   - Ability to comprehend (design) problems and abstract their essentials.
   - Ability to construct and develop logical arguments with clear identification of assumptions and conclusions.
5. The ability to submit an argument in the exact sciences (or humanities) to critical appraisal.
6. Analytical and critical way of thought and ability to apply logical reasoning.
7. Openness to interdisciplinary cooperation and ability to effectively participate therein as an academic professional.
8. The ability to create an effective project plan for solving a prototypical Artificial Intelligent problem in a supervised context.
9. Manage one's own learning and development, including time management and organizational skills.
10. The ability to transpose academic knowledge and expertise into (inter)national social, professional and economic contexts.
11. Readiness to address new problems in new areas, emerging from scientific and professional fields.

4.2.3 Making Judgments

The bachelor has the ability to gather and interpret relevant data (typically within the field of study) and to formulate judgments that include reflection on relevant social, academic or ethical issues.
Qualifications:
1. Ability to critically review results, arguments and problem statements from accepted perspectives in the field of Artificial Intelligence and neighbouring disciplines.
2. Initial competence in search and critical processing of professional literature in Artificial Intelligence.
3. Acquaintance with the standards of academic criticism.
4. Awareness of, and responsible concerning, the ethical, normative and social consequences of developments in science and technology, particularly resulting from Artificial Intelligence.

4.2.4 Communication

The bachelor can communicate information, ideas, problems and solutions to audiences of both domain-specialist and a general audience.

Qualifications:
Academically appropriate communicative skills; the bachelor can:

- Communicate ideas effectively in written form and through the use of Information and Communication Technology,
- Make effective oral presentations, both formally and informally,
- Understand and offer constructive critiques of the presentations of others.

4.2.5 Learning Skills

The bachelor has developed those learning skills that are necessary for a successful further study characterised by a high degree of autonomy (typically in the context of a master or a specialist profession).

Qualifications:

1. Reflection on one's own style of thought and working methods and readiness to take the necessary corrective action.
2. Recognise the need for continued learning throughout a professional career

5 MASTER'S PROGRAMME ARTIFICIAL INTELLIGENCE

This section is divided into two parts. Section 5.1 describes the roles that a master ought to be able to perform in society. Section 5.2 describes the final qualifications that masters in Artificial Intelligence possess in order to fulfil these roles.

5.1 Objectives

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

5.1.1 Access to PhD Programmes

The master programme provides the student with the specific knowledge and abilities, exemplified in the form of a master diploma that allows the master access to a PhD programme in a broad range of disciplines, especially in Artificial Intelligence related disciplines.

5.1.2 Professional Career

The master programme prepares for a position in which the student can earn his or her own subsistence. In particular, it prepares for:

- Independent work on an academic level, especially at positions where many of the problems have not been addressed before and where solutions require scientific training
- Key positions in the modern high-tech society, such as higher functions in knowledge-intensive companies and knowledge-intensive parts of the non-profit sector

5.1.3 Academic Skills

The master programme provides sufficient training in independent scientific reasoning, conduct, and communication to reach internationally accepted standards of academic skills at that level. Masters can communicate original ideas in their own language and in English to a public of specialists and non-specialists.

5.1.4 Place in Society

The programme provides the master with the knowledge and tools needed to formulate an informed opinion about the meaning and impact of Artificial Intelligence in society. Masters are able to enrich society with results from contemporary research and oversee the consequences of proposed measures to society and are aware of their responsibility towards society.

5.2 Final Qualifications

The objectives of the master can be specified into final qualifications. To comply with international standards these qualifications are presented below in terms of the Dublin descriptors for the master's profile[10]. Together these final qualifications must lead to alumni that exemplify the shared identity defined in section 3.

5.2.1 Knowledge and Understanding

The Master demonstrates knowledge and understanding in a field of study that builds upon and supersedes their bachelor's degree. Knowledge, understanding, and abilities are typically at a level at which the master is able to formulate a feasible research plan in one's own specialisation.

We distinguish three levels of qualification: a basic understanding, corresponding to the minimal level of knowledge that is expected of a Bachelor student, an advanced understanding, meaning students must have in-depth knowledge about a topic that they could easily develop to become a specialist, and specialist knowledge, meaning students are highly skilled (and specialised) in the key area in question.

Qualifications:

1. Basic understanding of all (8) key areas of Artificial Intelligence.
2. An advanced understanding in some of the key areas of Artificial Intelligence.
3. Specialist knowledge of at least one of the key areas in Artificial Intelligence, up to a level that the master can appreciate the forefront of research in that field.

5.2.2 Applying Knowledge and Understanding

Masters can apply their knowledge and understanding in a manner that indicates a scientific approach to their work or vocation. They are able to handle complex and ill-defined problems for which it is not a priori known if there is an appropriate solution, how to acquire the necessary information to solve the sub-problems involved, and for which there is no standard or reliable route to the solution.

Qualifications:

1. The ability to formulate a project plan for an open problem in a field related to Artificial Intelligence in general and the own specialisation in particular.
2. The ability to determine the feasibility of a proposal to lead to a solution or design as specified.
3. The ability to contribute autonomously and with minimal supervision to an interdisciplinary project team and to profit from the abilities, the knowledge, and the contributions of other team members.
4. The ability to choose, apply, formulate, and validate models, theories, hypotheses, and ideas from the key areas of Artificial Intelligence.
5. The ability to submit an argument in the exact sciences (or humanities) to critical appraisal and to incorporate its essence in the solution of Artificial Intelligence problems.
6. The ability to translate academic knowledge and expertise into social, professional, economic, and ethical contexts.
7. Awareness of, and responsibility concerning, the ethical, normative and social consequences of developments in science and technology, particularly resulting from original contributions.

5.2.3 Making Judgments

The master is able to formulate an opinion or course of action on the basis of incomplete, limited and in part unreliable information.

Qualifications:

1. Competence in the search and critical processing of all sources of information that help to solve an open and illdefined problem.
2. The ability to demonstrate a professional attitude conform the (international) scientific conduct in Artificial Intelligence.

[10] Framework_for_Qualifications_of_the_European_Higher_Education_Area (last visited on May 4, 2018)

3. The ability to provide and receive academic criticism conform the standards in one specialism of Artificial Intelligence-research.
4. The ability to formulate an opinion and to make judgments that include social and ethical responsibilities related to the application of one's own contributions.
5. The master is able to judge the quality of his or her work or the work of others from scientific literature.

5.2.4 Communication

The Master can communicate information, ideas, problems and solutions to audiences of specialist in (other) research areas and to a general audience.

Qualifications:
The Master has academically appropriate communicative skills; s/he can:

- Communicate original ideas effectively in written form,
- Make effective oral presentations, both formally and informally, to a wide range of audiences
- Understand and offer constructive critiques of the presentations of others.

5.2.5 Learning Skills

The master has developed those learning skills that are necessary for a successful further career at the highest professional level. The master is able to detect missing knowledge and abilities and to deal with them appropriately.

Qualifications:
1. Being able to reflect upon one's competences and knowledge and, if necessary, being able to take the appropriate corrective action.
2. The ability to follow current (scientific) developments related to the professional environment.
3. Showing an active attitude towards continued learning throughout a professional career.

6 | INTERNATIONAL PERSPECTIVE

As stated in the introduction, this frame of reference is intended not only for the Dutch national context, but also to put the Dutch Artificial Intelligence programmes into an international perspective, and possibly to serve as a starting point for an internationally agreed frame of reference. The latter possibility is of course dependent upon international debate and agreement, and at this moment it is not clear how to bring this about, or whether it will in fact be possible. What we can and will do in this document is provide a comparison between the frame of reference as developed in the previous sections and a number of known related study programmes in other countries. In doing this, we hope to show that the developed frame of reference is up to par from an international perspective as well as the Dutch national one.

Having said this, we must immediately recognise that the Dutch national context appears to be rather special in that we only know of specialised bachelor-level Artificial Intelligence study programmes at one university outside the Netherlands, namely at Edinburgh (United Kingdom), which have a rather different programme structure than the Dutch (and general European) one. In our discussion of the Dutch frame of reference in international perspective, we will therefore add to our comparison with the Edinburgh study programme by a comparison with bachelor's programmes of study programmes in a related field, notably Cognitive Science. Furthermore, we will compare the Dutch bachelor's qualifications with the requirements for enrolment in Artificial Intelligence master programmes in other countries.

A comparison of master programmes is tricky as well. Although, contrary to bachelor's programmes, there are several well-known specialised Artificial Intelligence master programmes outside the Netherlands, study programmes at the master level are much more divergent than at the bachelor's level. A comparison can therefore only be provided in global, subject-independent, terms.

We have drawn up both the bachelor's and master's degree programme comparisons based on the programme descriptions and course lists received from the involved Universities. However, for the purpose of conciseness, we have left out particular details of the programmes that are largely time-dependent and often change from year to year.

6.1 Comparison of Bachelor's Programmes

6.1.1 The Artificial Intelligence Bachelor's Programme in Edinburgh

Edinburgh University (United Kingdom) offers a range of bachelor's degrees related to Artificial Intelligence, one of them in Artificial Intelligence as such, the others in combination with other disciplines (AI & Computer Science, Cognitive Science). An ordinary bachelor's degree consists of 4 years. In order to compare this system with the European standard of a 3-year bachelor's and a 2-year master's programme, we will take the fourth year of the Edinburgh bachelor's programme to be equivalent to the first year of a 2-year master's degree in other European countries, and base our comparison of bachelor's programmes on the first three years.

It should be pointed out that the (first three years of the) AI-related bachelors in Edinburgh show a large variation between them, and an extensive amount of (usually restricted) choices for particular courses within them. In fact, the commonality between the Edinburgh Artificial Intelligence bachelors is smaller than commonality within the Dutch framework. It seems that the wide variation in Edinburgh Artificial Intelligence related bachelor's degrees actually means that the degrees themselves are much more specialised than the Dutch framework proposes, some of them having little or no (cognitive) psychology, others having no mathematics, etcetera.

6.1.2 The Cognitive Science Bachelor's Programme in Osnabrück

The University of Osnabrück (Germany) offers a three-year (180 EC) bachelor's programme in Cognitive Science. The discipline of Cognitive Science is related to Artificial Intelligence, and may in fact be seen as a flavour of Artificial Intelligence, focused somewhat more towards Cognitive Psychology, and somewhat less towards Engineering. The same key knowledge and skills apply in Artificial Intelligence and in Cognitive Science.

Based on studying both programmes, we conclude that the Dutch frame of reference recognises the same AI-specific areas as both Cognitive Science programmes outside the Netherlands. The Dutch frame of reference devotes as much or more attention to any of these areas as any of those Cognitive Science programmes, with the exception of Cognitive Psychology in Linköping. Moreover, the recognition, in the Dutch frame of reference, that each individual study programme has a specific profile in addition to the communal areas appears to hold for both inspected study programmes outside the Netherlands as well.

6.1.3 The Symbolic Systems Bachelor's Programme in Stanford

The University of Stanford offers a programme in Symbolic Systems that has a variant in Artificial Intelligence. The list of core requirements of this programme includes, but is not strictly limited to: single and multivariable calculus, probability theory and statistics, discrete fundamentals, programming, philosophy, cognition and neuroscience, natural language and computation and cognition. Students in Artificial Intelligence should also take courses from the topics of knowledge representation and reasoning, natural language processing, learning and robotics and vision. They offer several courses in these topics. They offer a more in-depth application of numerous of these topics as non-core cognate courses, such as machine learning, motion planning, modal logic, automated reasoning, and more advanced levels of philosophy/linguistics (in reality, they offer a wide variety of supplemental courses).

The course units that are denoted are the core of Symbolic Systems and are supplemented by their Artificial Intelligence variant are very similar to the Dutch framework of reference - all of the topics in the core list of Stanford's programme + variant are reflected in our common core to some degree. There seems to be a slightly bigger focus on Philosophy (3/12th of the Symbolic Systems bachelor's

core consists of philosophical foundations). The nature of the setup of compulsory core courses in Stanford does allow students to 'somewhat' skip topics that are important in the eyes of the Dutch framework - for example, the framework in Stanford calls for knowledge on 'Computation and Cognition', which ask of the student to take one course from a list ranging from Theoretical Neuroscience to Neural Networks and Machine Learning. All in all, the frameworks are similar, but the core of Symbolic Systems appears to be a bit less technical than the Dutch framework.

6.1.4 The Bachelor's Programme Artificial Intelligence at Carnegie Mellon

The Carnegie Mellon University in Pittsburgh has introduced in Fall 2018 the first full Artificial Intelligence bachelor programme of the USA. Their curriculum consists of three cores: a mathematical, computer science and artificial intelligence core. The artificial intelligence core consists of Introductions in AI Representations, Problem Solving, Machine Learning, Natural Language Processing and/or Computer Vision. As electives, one course has to be selected from four clusters: Decision Making & Robotics, Machine Learning, Perception & Language and Human-AI Interaction.

The main difference with the Dutch Framework is the role of Logic; in this framework Propositional Logic and Predicate Logic are explicitly mentioned as support modules, in Pittsburgh logic is part of the Decision Making & Robotics cluster, with courses as Strategic Reasoning for AI and Planning Techniques for Robotics. This is a far more practical approach compared to the theoretical approach of the Dutch Framework.

6.2 Comparison of Master's Programmes

6.2.1 The Artificial Intelligence Master's Programme in Edinburgh

The Artificial Intelligence master programme in Edinburgh spans a full 12-month period and consists of two parts: taught and research. During the taught part (8 months), lectures, tutorials and group practicals are followed. The research part (4 months) consists of a major individual research project on which a dissertation is written. There is also the option of completing only the taught part, in which case, a Diploma will be awarded. MSc courses in Artificial Intelligence in Edinburgh are grouped in four major areas of specialisation:

- Intelligent robotics
- Agents, Knowledge and Data
- Machine Learning
- Natural language processing

Comparing the Edinburgh programmes to the Dutch frame of reference, we can draw the following conclusions:

- The main Artificial Intelligence topics that are in the Dutch framework are also represented in the Edinburgh programmes (as shown in the four different identified areas of specialisation).
- The Edinburgh programmes are 1-year, whereas most Dutch Artificial Intelligence master programmes are 2-year programmes. However, the Edinburgh master programme requires a 4-year honours bachelor's degree.
- The Edinburgh programme knows relatively little study load for practical work. Whereas the minimum length of a Dutch master-thesis ('afstudeerproject') is 30 ECs (half a year), the Edinburgh programme has 4 months for doing practical assignments.
- However, the practical work seems to be more research oriented, whereas in the Dutch programme there is also the option to do a final project in industry.
- The Edinburgh program has an entry requirement on mathematics (During the bachelor degree 60 credits have completed of mathematics.)

6.2.2 The Machine Learning and Machine Intelligence Master's Programme in Cambridge

At the University of Cambridge the master is called Machine Learning and Machine Intelligence. It is a very selective (20 places) two year programme (120 ECTS credits). To apply, the applicants should have a UK First class Honours Degree (equivalent with overall grade of 8/10).

Their programme includes courses such as:

- Deep Learning and Structured Data
- Probabilistic Machine Learning
- Speech Recognition
- Weighted Automata
- Computer Vision

Comparing the Cambridge study programme to the Dutch frame of reference, we can draw the following conclusions:

- the programme has clear programme objectives (9 in total)
- the programme only covers 3 of the 8 core areas (Computational Linguistics, Perception, Machine Learning)
- There is not much choice: the programme consists of eleven core modules
- the programme has only two optional modules: Computer Vision or Natural Language Processing
- As elective the students can pick one elective module from 4th year undergraduate

6.2.3 The Symbolic Systems and Computing Science Master's Programmes in Stanford

Stanford offers two variants that are similar to Artificial Intelligence in the Netherlands: the Symbolic Systems Master and an Artificial Intelligence variant in the Computer Science degree programme. Symbolic Systems is an interdisciplinary programme that combines Computer Science, Psychology, Philosophy, and Linguistics in order to better understand cognition in both humans and machines. Viewing people and computers as symbol processors, the Symbolic Systems programme explores the ways computers and people reason, perceive, and act. Within the Symbolic Systems major, there is a core set of required classes with respect to the aforementioned fields; beyond this core, students choose an area of concentration in order to gain depth.[11]

The variant that is actually named Artificial Intelligence offers a subset of the disciplines in the Dutch framework, mostly those related to Computer Science. This master´s programme focuses on solving problems using computers, and as such mainly contains course units that address topics in Machine Learning, Computer Vision, Natural Language Processing, Data Mining, Robotics and Bioinformatics. There is a framework of courses students can choose from, but this framework is fairly loosely defined (with only very few guidelines), making it hard to distinguish a core beyond the specific attention for the applied computational side of Artificial Intelligence.

Comparing the Stanford study programme to the Dutch frame of reference can only be done by evaluating both the Symbolic Systems Master and the Computer Variant at the same time:

1. The Dutch framework has more formal subjects (such as a stronger focus explicit focus on logic and computer science related topics) than the Symbolic Systems programme. The Dutch framework has more topics related to Cognitive Science and the context of Artificial Intelligence than the Computer Science AI variant.
2. It has already been mentioned that there is much variety between the master programmes
    - Both in the Netherlands and abroad. This is also the case for the programmes at Stanford.
    - The Stanford programmes seem to have a lot of freedom in their choice for electives. In other words, the core of compulsory courses is limited and students have to select many elective courses - thus rejecting the idea behind a broad common core of the programme.

6.2.4 The Cognitive Science Master's Programme in Osnabrück

The university of Osnabrück offers a two-year (120 ec) master of science programme in Cognitive Science. Apart from a 30 ec individual thesis project and a 22 ec team project, students take predominantly elective courses in Cognitive Psychology, Artificial Intelligence, (Computational) Linguistics, Robotics, Neuroscience, Neuroinformatics and Philosophy of Mind and Cognition. The choice of courses largely follows the research group structure. The programme offers a double degree option together with the Cognitive Science programme in Trento.

[11] http://symsys.stanford.edu/courses (last visited on May 4, 2018)

The Osnabrück programme has a similar focus on cognitive (and neuroscience) aspects of AI as Nijmegen. Nijmegen has a tradition of attracting graduated bachelor students from Osnabrück who are typically directly admitted to the master programme in Nijmegen; in addition, several graduated master students from Osnabrück found a PhD position at the Radboud University. Student mobility thus suggests that the programmes are relatively comparable in content and quality to the Dutch Framework.

7 | NATIONAL PERSPECTIVE

At its core, the framework of reference serves as a foundation for every Artificial Intelligence degree programme in the Netherlands. This is also what differentiates the degree programmes that are a member of the KION from similar degree programmes: at its very heart, the KION programmes aim to provide a broad foundation that respects the roots of the field, rather than merely offer a specialistic application of Artificial Intelligence. With the growing popularity and diversity of Artificial Intelligence as a field, the need for programmes to adhere to a framework founded in both history and modern-day application is more important than ever.

We have drawn up an analysis that compares AI-related degree programmes in the Netherlands, to see whether they fit the frame of reference. In this way, we hope to highlight the unique position the KION degree programmes hold in the field of Artificial Intelligence: both with respect to delivering broadly educated Artificial Intelligence students, but also with respect to the consistency of the quality and background future employers can expect.

7.1 Bachelor's Programmes

Tilburg University and TU Eindhoven offer a joint BSc degree in Data Science. The focus of this bachelor's degree is on mathematical tools for dealing with big data; there is less emphasis on programming and no broad introduction in Artificial Intelligence. Tilburg University also offers a bachelor in Cognitive Science and Artificial Intelligence; this is part of the School for Humanities. Currently, the programme is under development; the relationship with the KION frame of reference is still open at the time of writing. Finally, TU Delft offers a bachelor Computer Science & Engineering (intelligent data analysis variant). This programme does not offer the broad introduction in Artificial Intelligence that the KION degree programmes do.

7.2 Master's Programmes

Several universities offer a specialisation in Data Science as part of the Computer Science or Information Studies MSc degree. Tilburg University and TU Eindhoven offer a joint MSc degree Data Science and Entrepreneurship. TU Delft offers a MSc degree in Data Science & Technology. These master programmes do not offer the broad overview on AI that the KION degree programmes do, but focus specifically on data science. Tilburg University also offers a one-year MSc degree (in contrast to the two-year KION programmes) in Cognitive Science and Artificial Intelligence.

8 | CONCLUDING REMARKS

Artificial Intelligence is a rapidly developing field. The term Artificial Intelligence does not have the stature of Physics, Psychology, or even Computer Science, due to its relatively recent start as a coherent field of research. Despite this, the recent attention for the successes of the field have ascertained that the field of Artificial Intelligence has made its mark. Internationally, the study of natural and artificial intelligence with computational means is firmly embedded in the fabric of modern Universities.

Modern topics such as gaming, ambient intelligence, ambient awareness, and believable-agent systems are fashionable manifestations of Artificial Intelligence and these and future fashionable spin-offs of Artificial Intelligence will increasingly affect humans. A particularly popular focus of Artificial Intelligence can currently be found in the field of Machine Learning, where possibilities for data analysis provide the world with useful patterns in all sorts of data. These possibilities have helped popularise Artificial Intelligence in the media, but have also raised ethical and legal questions about the field. Future challenges will force products, services, and societies to react faster but

remain reliable, to be both flexible and effective, be both efficient and versatile, and to utilise natural resources with maximal benefit. The biggest challenge of all is making the most of this combination of conflicting demands, a challenge that lies very much at the core of in the concept of intelligence.

The Dutch situation is special because of the existence of Artificial Intelligence bachelor's and master's programmes on most of the general universities. This offers the Netherlands a competitive advantage, consistent with its main economic strategy to remain one of the leading "knowledge intensive" economies. This frame of reference explicates how the bachelor's and master's programmes in Artificial Intelligence of Dutch universities contribute to educate alumni that will take a leading role in meeting these future challenges.

APPENDIX 2: INTENDED LEARNING OUTCOMES

1. The master demonstrates knowledge, understanding and the ability to evaluate, analyze and interpret relevant data, all on a level that builds on and surpasses the level of the bachelor Artificial Intelligence, in at least three of the research areas below. In one research area of Human Machine Communication the master has specialised knowledge at a forefront level:
   a. Computational theories and models of cognitive processes
   b. Multivariate statistics
   c. Cognitive ergonomics
   d. Application of formal models of cognition in human-computer interaction and education
   e. Linguistics and language technology
   f. Cognitive neuroscience
2. The master demonstrates knowledge and understanding, on a level that builds on and surpasses the level of the bachelor Artificial Intelligence, in the empirical sciences (Psychology, Biology and Physics) and has experience applying and analyzing results thereof.
3. The master demonstrates relevant knowledge and the ability to apply methods and techniques from mathematics and logic used in Human Machine Communication.
4. The master demonstrates relevant knowledge and the ability to use programming languages used in Human Machine Communication.
5. The master has the ability to, on an international academic level, analyze problems, critically and constructive review both one's own and other scientific results, even if incomplete, and communicate about this both individually as in a group, both oral and in written form, also in a broader societal context, for both specialists and non-specialists.
6. The master has the ability to critically reflect on one's own working methods and knowledge and to recognise the need for continued learning on a high degree of autonomy, and is able to understand the scientific developments within the field of Human Machine Communication.

The level at which the final qualifications are met, provides the successful master HMC with:

- the ability to independently design a system having cognitive capacities
- the ability to perform independent research in Artificial Intelligence/Cognitive Science
- the ability to analyze and test system properties and qualities and to be able to report on this at a high (scientific) level
- the ability to cooperate at a similar level of professionalism with graduates from disciplines related to Artificial Intelligence and Cognitive Science

Specifically with the final master's project, the master has shown to utilise the acquired knowledge and skills to professionally report on their work, and has also demonstrated this in a final graduation 69 colloquium for a professional audience. The above indicated level should also ensure that graduates are on par with collaborators in an international context. The required level is also reflected and in accordance with the following section in which the Dublin Descriptors are related to the final qualifications.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

An overview of the compulsory elements of the programme (each course field represents 5 EC)

Year 1			
Term 1	**Term 2**	**Term 3**	**Term 4**
Formal Models of Cognition	Advanced Statistical Modelling	First-year Research Project	First-year Research Project
Elective / Spec. Course	Cognitive Modelling: Basic Principles and Methods	Elective / Spec. Course	First-year Research Project
Elective / Spec. Course	Elective / Spec. Course	Elective / Spec. Course	Elective / Spec. Course
Year 2			
Elective / Spec. Course	Internship / Master's Project	Master's Project	Master's Project
Elective / Spec. Course	Internship / Master's Project	Master's Project	Master's Project
Elective / Spec. Course	Internship / Master's Project	Master's Project	Master's Project

An overview of the specialisation elements of the programme (each course field represents 5 EC)

Term 1	**Term 2**	**Term 3**	**Term 4**
Cognitive Modelling Specialisation			
User Models		Cognitive Modelling: Complex Behaviour	Computational Cognitive Neuroscience
Cognitive Engineering Specialisation			
Cognitive Engineering			Neuro-ergonomics
User Models			
Computational Cognitive Neuroscience Specialisation			
	Machine Learning	Cognitive Modelling: Complex Behaviour	Computational Cognitive Neuroscience
Cognitive Language Modelling Specialisation			
Language Modelling		Computational Simulations of Language	Language Technology Project

APPENDIX 4: PROGRAMME OF THE SITE VISIT

7 October 2019	
08.30 – 09.00	Arrival panel and welcome by the programme management
09.00 – 10.00	Preparatory panel consultation
10.00 – 10.45	Interview programme management
10.45 – 11.00	Break / panel consultation
11.00 – 11.45	Interview students bachelor
11.45 – 12.00	Break / panel consultation
12.00 – 12.45	Interview teachers bachelor
12.45 – 13.30	Lunch + open consultations
13.30 – 14.00	Tour of the robot-lab
14.00 – 14.45	Break / panel consultation
14.45 – 15.30	Interview students master AI
15.30 – 15.45	Break / panel consultation
15.45 – 16.30	Interview students master HMC
16.30 – 16.45	Break / panel consultation
16.45 – 17.30	Interview alumni bachelor, master AI & HMC

8 October 2019	
08.30 – 09.30	Arrival of the panel and preparation for day 2
09.30 – 10.15	Teachers Master AI and HMC
10.15 – 10.30	Break / panel consultation
10.30 – 11.15	Interview board of examiners
11.15 – 11.30	Break / panel consultation
11.30 – 12.00	Interview formal responsible management
12.00 – 14.00	Panel composes their findings & lunch
14.00 – 14.15	Public verbal feedback of the preliminary findings by the panel chair
14.15 – 15.00	Break
15.00 – 15.45	Development dialogue
15.45 – 16.00	End of the site visit

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 theses of the master's programme Human-Machine Communication. Information on the selected theses is available from QANU upon request.

During the site visit, the panel studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):

- Self-evaluation Report - Artificial Intelligence and Human-Machine Communication
- Assessment plan BSc Artificial Intelligence
- KION frame of reference
- Staff overview
- Minutes meetings:
    - Heidag
    - Curriculum Committee
    - Staff Meetings
    - Raad van Advies
- FSE Quality Assurance Manual
- Programme Committee Handbook
- Manual Board of Examiners
- Quality Assurance Board of Examiners
- Rules and Regulations by the Board of Examiners
- Education Primer
- FSE Quality Assurance Manual 2017-2017
- Instellingstoets Kwaliteitszorg RUG 2014
- Teaching and Examination Regulations + appendices Master Artificial Intelligence
- NSE results 2016 and 2017
- Annual reports Board of Examiners
- Annual reports Programme Committee
- Education Monitor
- Minutes Midterm
- Publications (co-)authored by bachelor- and/or master students
- master courses Deep Learning / Robotics for AI