Artificial Intelligence

Faculty of Social Sciences,
Radboud University Nijmegen

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This report was finalized on 3 December 2013.

Report on the bachelor's programme Kunstmatige Intelligentie and the master's programme Artificial Intelligence of Radboud University Nijmegen

This report takes the NVAO's Assessment framework for limited programme assessments as a starting point.

Administrative data regarding the programmes

Bachelor's programme Kunstmatige Intelligentie

Name of the programme:	Kunstmatige Intelligentie
CROHO number:	56981
Level of the programme:	bachelor
Orientation of the programme:	academic
Number of credits:	180 EC
Specializations or tracks:	-
Location(s):	Nijmegen
Mode(s) of study:	full time
Expiration of accreditation:	31-12-2014

Master's programme Artificial Intelligence

Name of the programme:	Artificial Intelligence
CROHO number:	66981
Level of the programme:	master
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Brain-Computer Interfacing (BCI) and Cognitive Artificial Intelligence (CAI)
Location(s):	Nijmegen
Mode(s) of study:	full time
Expiration of accreditation:	31-12-2014

The visit of the assessment panel Artificial Intelligence to the Faculty of Social Sciences of Radboud University Nijmegen took place on the 21st and 22nd May 2013.

Administrative data regarding the institution

Name of the institution:	Radboud University Nijmegen
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

Quantitative data regarding the programmes

The required quantitative data regarding the programmes are included in Appendix 5.

Composition of the assessment panel

The assessment of the bachelor's and master's programme Artificial Intelligence was part of an assessment cluster. In total, the panel assessed 14 Artificial Intelligence programmes. The panel that assessed all of these programmes consisted of eight members:

- Prof. drs. dr. L.J.M. (Leon) Rothkrantz (chairman), Associate Professor at Delft University of Technology and Professor of Intelligent Sensor-Systems at the Netherlands Defence Academy;
- Prof. dr. ir. D.K.J. (Dirk) Heylen, Professor of Socially Intelligent Computing, Department of Computer Science at the University of Twente;
- Prof. dr. T. J. Grant, Emeritus Professor of Operational ICT & Communications within the Faculty of Military Sciences at the Netherlands Defence Academy (NLDA) and founder/director Retired But Active Researchers (R-BAR);
- Dr. J. (Jimmy) Troost, Director of Thales Research & Technology, Delft;
- Drs. M.J. den Uyl, owner of SMRGroup, Senior Researcher and CEO of VicarVision, Sentient and Parabots;
- Prof. dr. L. (Luc) De Raedt, Research Professor at the Lab for Declarative Languages and Artificial Intelligence at the Department of Computer Science of the Catholic University of Leuven;
- Prof. dr. P. (Patrick) De Causmaecker, Professor of Computer Science at K.U. Leuven, Kortrijk Campus, Belgium, guest professor at KaHo St.-Lieven, Ghent, Belgium, and Head of the CODes research group, coordinator of the interdisciplinary research team itec at K.U. Leuven, Kortrijk Campus;
- R.H.M. (Rik) Claessens, BSc, student of the master's programme Artificial Intelligence of Maastricht University;
- Y. (Yfke) Dulek, student of the bachelor's programme Artificial Intelligence of Utrecht University.

For each site visit a subpanel was set up, taking into account any potential conflict of interests, expertise and availability. To ensure consistency within the cluster the chairman, prof. drs. dr. Leon Rothkranz, attended all visits.

The coordinator of the cluster visits for Artificial Intelligence was drs. Hans Wilbrink, QANU staff member. He was also the project leader for the visit to Utrecht University and the VU University Amsterdam. During the other site visits, drs. Titia Buising was the project leader. To ensure continuity, both project leaders frequently held consultations. The coordinator was also present at the final meeting of all visits within the cluster.

The panel that assessed the bachelor's programme Kunstmatige Intelligentie and the master's programme Artificial Intelligence consisted of:

- Prof. drs. dr. L.J.M. (Leon) Rothkrantz (chairman), Associate Professor at Delft University of Technology and Professor of Intelligent Sensor-Systems at the Netherlands Defence Academy;
- Prof. dr. ir. D.K.J. (Dirk) Heylen, Professor of Socially Intelligent Computing, Department of Computer Science at the University of Twente;
- Dr. J. (Jimmy) Troost, Director of Thales Research & Technology, Delft;

- Prof. dr. P. (Patrick) De Causmaecker, Professor of Computer Science at K.U. Leuven, Kortrijk Campus, Belgium, guest professor at KaHo St.-Lieven, Ghent, Belgium, and Head of the CODes research group, coordinator of the interdisciplinary research team itec at K.U. Leuven, Kortrijk Campus;
- R.H.M. (Rik) Claessens BSc, student of the master's programme Artificial Intelligence of Maastricht University.

The panel was supported by drs. H.A.T.(Hans)Wilbrink, who acted as secretary.

The Radboud University Nijmegen board and the Accreditation Organisation of the Netherlands and Flanders (NVAO) approved the composition of the assessment panel. Appendix 1 contains the CVs of the members of the panel.

Working method of the assessment panel

Preparation
To prepare for the site visits, the coordinator first checked the quality and completeness of the critical reflections produced by the programmes and forwarded them to the participating panel members. They read the reports and formulated questions about their contents. The coordinator collected the questions and arranged them according to topic and/or interview partner. As well as the critical reflections, the panel members read a total of 15 theses for each programme. The theses were randomly chosen from a list of graduates of the last two completed academic years, while covering a range of grades and supervisors. The University was requested to provide educational material such as books, lecture notes, minutes of meetings of the Examination Board etc. This material was studied by the members of the panel during the visit.

On 14 March 2013 the Artificial Intelligence panel held a preliminary meeting, during which the panel was formally installed and its tasks and working methods were discussed. The proposed Domain-Specific Reference Framework for Artificial Intelligence was also accepted (see appendix 3).

Site visit
The coordinator prepared timetables for the site visit in consultation with the panel chair and the participating institutions. The timetable for the visit for the bachelor's programme of the Radboud University Nijmegen is included as appendix 2.

Prior to the visit the panel asked the programmes to select representative interview partners. The underlying idea was to exchange thoughts with students, lecturers and supervisors of all participating programmes. Well in advance of the visit, the panel received a list of the selected interview partners for its approval. During the visit, it spoke to faculty and programme management staff, students, lecturers, members of the degree programme committee and board of examiners, and alumni.

During the visit, the panel examined material it had requested and gave students and lecturers the opportunity – outside the set interviews – to talk informally to the panel during a consultation hour. One request was received for this option.

The panel used the final part of the visit for an internal meeting to discuss the findings. The visit was concluded with a public oral presentation of the preliminary impressions and general observations by the chair.

Report
After the site visit, the project secretary wrote a draft report based on the findings of the panel. It was first read and commented upon by the panel members. Then it was sent to the Faculty to check for factual irregularities. Any comments from the Faculty were discussed with the chair of the assessment panel and, if necessary, with the other panel members. After that, the report was finalized.

Decision rules
In accordance with the NVAO's Assessment framework for limited programme assessments (as of 22 November 2011), the panel used the following definitions for the assessment of both the standards and the programme as a whole.

Generic quality
The quality that can reasonably be expected in an international perspective from a higher education bachelor's or master's programme.

Unsatisfactory
The programme does not meet the current generic quality standards and shows serious shortcomings in several areas.

Satisfactory
The programme meets the current generic quality standards and shows an acceptable level across its entire spectrum.

Good
The programme systematically surpasses the current generic quality standards across its entire spectrum.

Excellent
The programme systematically well surpasses the current generic quality standards across its entire spectrum and is regarded as an (inter)national example.

Summary judgement bachelor's programme Artificial Intelligence

This report reflects the findings and considerations of the panel on the bachelor's programme in Kunstmatige Intelligentie at Radboud University Nijmegen. The evaluation of the panel is based on information provided in the critical reflection and the selected theses, additional documentation and interviews conducted during the site visit. The panel noted both positive aspects and some which could be improved. Taking those aspects into consideration, the panel decided that the programme more than fulfils the requirements of the criteria set by NVAO which are the conditions for accreditation.

Standard 1: Intended learning outcomes
The panel compared the programme to the domain-specific reference framework. It concludes that the framework gives an adequate picture of the Artificial Intelligence (AI) domain and the basic knowledge and skills that graduates need to acquire. The intended learning outcomes are very well balanced and based on the domain-specific reference framework, especially the common core of AI as mentioned in the framework. The intended learning outcomes are furthermore clearly formulated in terms of learning objectives and learning outcomes. The panel is very pleased to see that the academic orientation of the programme is translated extensively in the intended learning outcomes.

The field of AI in Nijmegen is a practical synthesis of several established fields, with a substantiated focus on cognition and the brain. The connection between bachelor and master's programme is very good, enabling a smooth transition. The programme could be more aware of its proven quality and make use of this more vigorously in order to persuade more students to study AI in Nijmegen.

Standard 2: Teaching-learning environment
In addition to a common core curriculum, each student can customize and extend his/her individual study programme through electives. The bachelor's programme in AI is based on three pillars; Brain, Cognition and Computer. In addition to these three thematic pillars, there is a theme *Core AI courses*, a theme of *Support courses* and a theme of *Academic skills courses*. The six themes are recurring throughout the curriculum and within each theme the level of training increased from introductory to broadening, to more in-depth topics and skills. The intended learning outcomes are clearly present in the curriculum, which is shown in a matrix in the critical reflection. Staff is familiar with the intended learning outcomes. The didactic concept is *Student Activating Education* (SAE), aimed at evolving self-responsibility, teamwork and deepening of knowledge and skills. The underlying principle is to activate and challenge students, which seems to work well.

Considering the multidisciplinary character of AI and the strong involvement of staff from different affiliations, the panel was impressed by the fact that the programme maintains a stable, cohesive, integrated and well-balanced study programme. The panel was particularly impressed by the high academic and didactic qualities of staff members. A point of concern is the efficiency of the programme, on average students take too much time to complete the programme. Measures are taken and are expected to improve graduation time.

Standard 3: Assessment and achieved learning outcomes
The Board of Examiners (BoE) is in control of the quality of assessment procedures. The BoE is actively involved in the assessment of thesis work and is well aware of its formal position and responsibilities. The panel was pleased to see the way the programme was able to translate the focus on Brain, Cognition and Computer not only in the courses, but also in

the assessments and subsequently the thesis topics. The panel was impressed by the quality of the thesis work and with the choice of topics for the theses, which clearly fit the AI domain as chosen by the university.

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

Bachelor's programme Artificial Intelligence:

Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	good
Standard 3: Assessment and achieved learning outcomes	good

General conclusion	good

Summary judgement master's programme Artificial Intelligence

This report reflects the findings and considerations of the panel on the master's programme in Artificial Intelligence at Radboud University Nijmegen. The evaluation of the panel is based on information provided in the critical reflection and the selected theses, additional documentation and interviews conducted during the site visit. The panel noted both positive aspects and some which could be improved. Taking those aspects into consideration, the panel decided that the programme more than fulfils the requirements of the criteria set by NVAO which are the conditions for accreditation.

Standard 1: Intended learning outcomes
The panel compared the programme to the domain-specific reference framework. It concludes that the framework gives an adequate picture of the Artificial Intelligence (AI) domain and the advanced knowledge and skills that graduates need to acquire. The intended learning outcomes are very well balanced and based on the domain-specific reference framework, especially the common core of AI as mentioned in the framework. The intended learning outcomes are furthermore clearly formulated in terms of learning objectives and learning outcomes. The panel is very pleased to see that the academic orientation of the programme is translated extensively in the intended learning outcomes.

The field of AI in Nijmegen is a practical synthesis of several established fields, with a substantiated focus on cognition and the brain. The connection between bachelor's and master's programme is very good, enabling a smooth transition. The programme could be more aware of its proven quality and make use of this more vigorously in order to persuade more students to study AI in Nijmegen.

Standard 2: Teaching-learning environment
The curriculum of the master's programme is structured around two specializations, with the choice of courses being based on the postgraduate career ambitions in fundamental or applied research. The specializations are Cognitive Artificial Intelligence (CAI) and Brain-Computer Interfacing (BCI). The programme is designed to afford students a high degree of freedom, flexibility and responsibility in selecting courses. Nevertheless, coherence of each individual curriculum is safeguarded by the programme. The intended learning outcomes are clearly present in the curriculum, which is shown in a matrix in the critical reflection. Staff are familiar with the intended learning outcomes.

The didactic concept is *Active Autonomy* and follows upon the didactic concept of the bachelor's programme. Students are trained in combining methodological acquisition of knowledge, theoretical insight, making judgements and practical application of the acquired knowledge.

Considering the multidisciplinary character of AI and the strong involvement of staff from different affiliations, the panel was impressed by the fact that the programme maintains a stable, cohesive, integrated and well-balanced study programme. The panel was particularly impressed by the high academic and didactic qualities of staff members.

Standard 3: Assessment and achieved learning outcomes
The Board of Examiners (BoE) is in control of the quality of assessment procedures. The BoE is actively involved in the assessment of thesis work and is well aware of its formal position and responsibilities. The panel was pleased to see the way the programme was able to translate the focus on Brain, Cognition and Computer not only in the courses, but also in

the assessments and subsequently the thesis topics. The panel was impressed by the quality of the thesis work and with the choice of topics for the theses, which clearly fit the AI domain as chosen by the university.

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

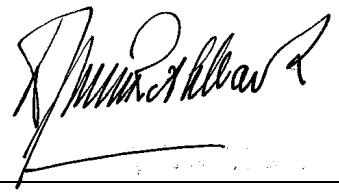
Master's programme Artificial Intelligence:

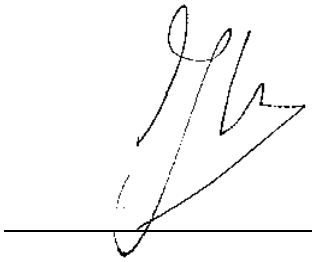
Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	good
Standard 3: Assessment and achieved learning outcomes	good

General conclusion good

The chair and the secretary of the panel hereby declare that all members of the panel 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: 3 December 2013.





Prof. drs. dr. L.J.M. Rothkrantz drs. H.A.T. Wilbrink

Description of the standards from the Assessment framework for limited programme assessments

Standard 1: Intended learning outcomes

The intended learning outcomes of the programme have been concretised with regard to content, level and orientation; they meet international requirements.

Explanation:
As for level and orientation (bachelor's or master's; professional or academic), the intended learning outcomes fit into the Dutch qualifications framework. In addition, they tie in with the international perspective of the requirements currently set by the professional field and the discipline with regard to the contents of the programme.

Findings

This standard provides insight in the domain specific frame of reference, followed by the profile and orientation of the bachelor's programme Kunstmatige Intelligentie and the master's programme Artificial Intelligence and finally the objectives and intended learning outcomes of both programmes.

Domain specific frame of reference
Traditionally, researchers in the field of artificial intelligence (AI) are concerned with the study of cognitive processes that play a role in human perception, reasoning and action, and building intelligent systems for human modelling. This implies that the field of artificial intelligence is closely related to other disciplines such as computer science, mathematics, psychology, linguistics and philosophy. In 2006, the collaborative artificial intelligence programmes in the Netherlands (KION) composed a domain-specific reference framework (hereafter: the framework) which presented the content and learning outcomes of the bachelor's and master's programmes in artificial intelligence. This framework has been revised and updated in January 2013. The framework forms the common basis for all programmes in artificial intelligence and for specifying the intended learning outcomes of the different programmes in this cluster visitation. The panel noted that in general all assessed programmes meet the intended learning outcomes described in the framework to a greater or lesser degree. For example, all programmes pay sufficient attention to the basic knowledge and skills of artificial intelligence. However, there is a variation in the extent to which the different programmes offer students deepening or broadening of the field. In addition, almost all programmes take the liberty of highlighting certain topics and adding parts of new disciplines. The panel noted that some misunderstanding arises because the different programmes give different interpretations of the concept of artificial intelligence. The concept of 'intelligence' as used in the KION framework can be interpreted in different ways. A clear operational definition, or description, is desirable according to the panel. Furthermore, the distinction in the framework between the intended learning outcomes at the bachelor's and master's level is not always clear. The gradual / incremental aspect of knowledge and skills could be elaborated on more in the framework. This could also prevent the divergence of the AI programmes on this matter.

For the Radboud University Nijmegen bachelor's and master's programme Artificial Intelligence, the panel concludes that both match the KION framework. It appreciates that the programmes cover more cognitive aspects as well as linguistic and technical aspects of AI. The focus on cognitive aspects gives the RU a unique position in the AI community in the

Netherlands. The availability of research Institutes as the Donders Centre for Cognition support this unique position. All these aspects are together part of the framework.

Profile
The critical reflection states that the bachelor's programme in Kunstmatige Intelligentie and the master's programme in Artificial Intelligence at Radboud University Nijmegen focus on the understanding and support of both natural and artificial intelligence by implementing the following profile:

- The exploration and explanation of human (neuro)cognitive phenomena and processes:
  - by means of computational models and/or
  - by means of experimentation relevant to, or involving, intelligent technologies.
- The design, implementation and evaluation of intelligent systems that:
  - perform cognitive tasks and/or
  - support the human performance of cognitive tasks in interaction.

According to the critical reflection these two approaches are in constant interaction: findings on the workings of brain and cognition lead to the design of better intelligent systems and interaction interfaces, while successful intelligent systems raise new fundamental research questions on brain and cognition. *Brain*, *Cognition* and *Computer* are therefore three prominent pillars of the bachelor's and master's programmes in Nijmegen, where in particular the focus on both brain and cognition is a distinguishing feature of the programmes. The focus on the cognitive aspects of AI is supported by the availability of the Donders Centre for Cognition which has an excellent, internationally recognised reputation. This centre provides lecturers who are experts in the field and provides an opportunity for students to perform research projects. A significant portion of the programmes develops competences in formal methods, tools and programming techniques, which are required for formalizing computational models and implementing intelligent systems. Competences in brain and cognition are trained by using courses from Psychology and cooperation with the staff of the Institute of Computing and Information Sciences provides a strong foundation for teaching competences in machine intelligence.

According to the panel, the focus on brain and cognition distinguishes Nijmegen from other AI programmes in the Netherlands and is rightfully mentioned as a unique selling point for future students. Furthermore, the panel concluded that the profile is clearly orientated on academic research.

1.3 Objectives and intended learning outcomes

Bachelor's programme Kunstmatige Intelligentie
According to the critical reflection the bachelor's programme Kunstmatige Intelligentie (KI) is an independent programme in which the integration of knowledge and skills, as well as imparting a critical and academic stance are central goals. It aims to enable a career in which AI can be practised in an academic research setting or in an applied context in the professional field. The panel agrees that the objective of the programme suits a bachelor's programme in KI.

The programme has five learning objectives, which are implemented in ten intended learning outcomes for the bachelor's programme, based on the Dublin descriptors (Appendix 3). Both the learning objectives and the learning outcomes are based on the KION reference framework.

The panel studied the intended learning outcomes and concludes that they meet the requirements set by the international field. Graduates of the bachelor's programme have acquired academic research skills, and are able to develop computational models that implement aspects of artificial or natural intelligence. Furthermore, they are able to formulate research hypotheses and investigate those in the appropriate manner.

To allow students to acquire the required knowledge, insight, skills and attitudes the programme offers a formal basis rooted in mathematics and computing science, as well as courses with a broader AI perspective, including robotics, human-computer interaction, machine learning, philosophy, psychology and cognitive neuroscience. The primary aim of the bachelor's programme is to provide students with a strong foundation for further specialization via the master's programme or a related discipline. In the bachelor's programme there is a focus on teaching academic skills and fostering the right attitude in students. The panel concludes that the learning outcomes for the bachelor's programme are clearly formulated.

Master's programme in Artificial Intelligence
According to the critical reflection, the master's programme aims at educating students to be free-thinking scientific professionals capable of formally analysing and modelling aspects of natural and artificial cognition, and of solving related problems through computational means. Graduates of the master's programme should be able to function as junior researchers within an international AI and/or Cognitive Neuroscience research team or be able to perform as AI professionals within companies and research institutions. Depending on the students' interests and career ambitions, they can choose to specialize in one of two content areas of AI research: Cognitive Artificial Intelligence (CAI) or Brain-Computer Interfacing (BCI) and tailor their course work towards fundamental or applied research. With respect to the aims and objectives of the master's programme, the panel concluded that these are clearly formulated and fitting for a master's programme in Artificial Intelligence.

The critical reflection states that the intended learning outcomes of the master's programme AI build on those of the bachelor's programme and are extended with scientific research activities and specialization in at least one of the research areas of AI., e.g., cognitive neuroscience, cognitive psychology, machine learning, human-robot interaction, brain-computer interfaces, and human-computer interaction. The panel has established that there is a clear connection between the programmes. The strong link between bachelor's and master's programmes raised problems for (international) students from other universities with a different bachelor's degree joining the master. These students are to take special courses in the free elective programme.

Internationalisation is high on the agenda for the master's programme, the panel learned from the management. The programme aims to send at least 30% of its students to study abroad and is actively organizing international exchange programmes for this purpose.

In relation to the bachelor's programme, the master's programme develops higher levels of self-management, independence and critical self-reflection, so students should be able to specialize in advanced, state-of-the-art themes in AI. Each individual course contributes to the training of eleven learning outcomes for the master's programme, for both the CAI and the BCI specialization. The learning outcomes implement five AI learning objectives, which are based on the KION reference framework and operationalize the five Dublin descriptors with respect to the AI profile in Nijmegen. The panel has assessed the intended learning

outcomes and concluded that the learning outcomes well fit the KION reference framework, as well as the Dublin descriptors. For both the bachelor's and master's programme the learning outcomes provide a solid basis for an AI curriculum.

Considerations

The intended learning outcomes for the bachelor's and master's programme follow international and national standards and are clearly formulated in terms of learning objectives and learning outcomes. The panel is very pleased to see the use of an elaborate matrix in order to guarantee the objectives and learning outcomes can be used at course level. The panel has established that the academic orientation of both programmes is translated extensively in the learning outcomes. The learning outcomes are very well balanced, based on the domain-specific frame of reference, especially the common core of AI as mentioned in the framework.

The learning outcomes clearly show for both programmes that the field of Artificial Intelligence in Nijmegen is a practical synthesis of several established fields, with in this particular case a substantiated focus on cognition and brain. The panel is also pleased to note the connection between the programmes, which enables a smooth transition from the bachelor KI to the master AI, or indeed any master with connections to AI. The panel is of the opinion that the programmes should be more aware of their own proven quality and make use of it more vigorously in order to persuade more students to come and stay in Nijmegen.

Conclusion

Bachelor's programme Kunstmatige Intelligentie: the panel assesses Standard 1 as 'good'.
Master's programme Artificial Intelligence: the panel assesses Standard 1 as 'good'.

Standard 2: Teaching-learning environment

The curriculum, staff and programme-specific services and facilities enable the incoming students to achieve the intended learning outcomes.

Explanation:
The contents and structure of the curriculum enable the students admitted to achieve the intended learning outcomes. The quality of the staff and of the programme-specific services and facilities is essential to that end. Curriculum, staff, services and facilities constitute a coherent teaching-learning environment for the students.

Findings

This standard provides an insight in the curriculum of the AI programmes. Furthermore, the didactic concept is evaluated by the panel. Special attention is paid to the relation between the intended learning outcomes and the curriculum. Then, the staff, facilities, quality assurance and intake and efficiency of the programme are discussed.

Curriculum
The critical reflection explains that the *bachelor's programme* is based on the three pillars Brain, Cognition and Computer. The programme comprises of three years, of which the first year is the introductory phase, the second year a broadening phase and the third year a deepening phase. The first year starts with the Caleidoscope course, which discusses tangible research topics containing real-world problems and showing the relevance of AI in science and society. Subsequently, the first two years contain a mix of courses covering all themes relevant the aforementioned three pillars. The final year offers students the possibility to deepen their skills and knowledge. The bachelor's programme is finished with the Bachelor Thesis Project.

All courses within the first year are obligatory (60 EC). There's a limited choice of electives in the second year (6 EC). The first part of the third year consists of obligatory courses (36 EC). To encourage international student exchanges, the final semester consists mainly of electives, which can be substituted with courses from another university (12 EC thesis and 12 EC electives). The panel concludes that the structure of the bachelor's programme is clear and has a logical setup. The first year is broad and provides students with basic knowledge and understanding of the most important themes of AI. Subsequently, students specialize and deepen their knowledge in a limited number of themes. This leads to the final product, the bachelor thesis.

In addition to the structure of the curriculum, the panel studied the course materials during the site visit, and concludes that the materials show that the aspired bachelor level is obtained and that the learning outcomes are consistently and clearly translated to learning goals for each course.

Besides offering students the opportunity to customize and extend their individual study programme through electives that are part of the regular bachelor curriculum, talented and motivated students who wish to broaden their competences can follow extended programmes through the Radboud Honours Academy or perform additional Capita Selecta projects. These programmes are extra-curricular and require an additional effort from participating students of 15 (extra) EC per year.

The bachelor's programme is structured in six different recurring themes (learning trajectories) along the three years of the bachelor. Within each theme the level of training

increases from introductory, via broadening, to more in-depth topics and skills. The three thematic pillars are

- the Cognition pillar (Introduction in Cognitive Psychology, Language in Action, Computational and formal Modelling and Advanced Behaviour);
- the Brain pillar (Introduction Brain, Neural networks (since 2012-13: Neurocognitive models) and Introduction BCI);
- the Computer pillar (2 programming courses, Functional Programming and Software Engineering.

Besides these three thematic pillars, there is a theme Core AI courses (Introduction AI, Search, Planning and Machine Learning, and Knowledge Representation and Reasoning), a theme of Support courses (mathematics, statistics and logic); Academic skills with courses Professional Field Orientation and Presentation Skills, a Colloquium AI (which contains scientific lectures from invited speakers) and Philosophy of Cognitive Science. The study guide describes course goals, prerequisites and qualifications of all courses. The panel concluded that the programme managed to construct a coherent curriculum revolving around carefully chosen thematic and supporting pillars.

The panel learned that to ensure balance and cohesion, staff from AI, Psychology and Cognitive Science meet on a regular basis. Plenary meetings of all AI staff are held each month. Staff members who are involved in similar themes (like in robotics, AI or mathematics) regularly discuss the goals, content and work forms of their courses. Similarly, teachers involved in courses given in the same year agree on mutual course elements. Besides these plenary and bilateral staff meetings, involvement from the Degree Programme Committee is considerable.

Considering the multidisciplinary character of AI and the involvement of staff from different affiliations who are strongly involved in the programme, the panel was convinced that the bachelor's programme AI maintains a stable, cohesive, integrated and well-balanced study programme.

The *master's curriculum* is structured around the two specializations. The choice of courses is based on the aspirations for a postgraduate career in fundamental or applied research. The set of restricted choice courses have been selected for their thematic relevance for a MSc programme in Artificial Intelligence in general, and at least one of the specializations, Cognitive Artificial Intelligence (CAI) and Brain-Computer Interfacing (BCI) in particular. The programme uses a decision tree to guide students, a useful tool according to students as the panel learned.

The master's programme is designed so as to afford students a high degree of freedom, flexibility and responsibility in selecting courses for an individual Training and Supervision Plan (TSP) that best fits their personal research- and career-interests. Students are required to choose one specialization. Within each specialization, students follow 24 EC of required core courses, 36 EC restricted choice courses and the master thesis and internship projects (together 48 EC). Each student can select a maximum of 12 EC of elective courses. Hence, although the Training and Supervision Plan provides much freedom of choice, it contains at least 90% of relevant AI modules, a fact the panel highly appreciates.

For a specialization in CAI, students are required to take at least the two courses Bayesian

and Decision models in AI and Cognition & Complexity. For a specialization in BCI, students are required to take at least the two courses Brain Reading and BCI Practical Course. For both specializations, students who aspire an academic research career are recommended to take the course Research Methods. For students who aspire an applied research or a professional career, other courses are available, e.g. Machine Learning in Practice.

Restricted choice courses (36 EC) contribute to knowledge of and insight in amongst others computing science, language technology, psychology, neuroscience and philosophy. Optional courses (12 EC) can be selected from the list of restricted choice courses, or any other course taught at the Radboud University or another academic institution. All students complete their master's programme by performing an original research project (Master internship) supervised by researchers affiliated with the Department of AI and/or external institutes and writing a scientific thesis on their research (Master thesis). In total 80% of the 2nd year (48 out of 60 EC) is devoted to the internship and thesis.

Similar to the bachelor's programme, the panel learned that to ensure balance and cohesion in the master's programme, staff from AI, Psychology and Cognitive Science meet on a regular basis. Plenary meetings of all AI staff are held each month. Staff members who are involved in similar themes (like in robotics, AI or mathematics) regularly discuss the goals, content and work forms of their courses. Similarly, teachers involved in courses given in the same year agree on mutual course elements. Besides these plenary and bilateral staff meetings, involvement from the Degree Programme Committee is considerable.

Considering the multidisciplinary character of AI and the involvement of staff from different affiliations who are strongly involved in the programme, the panel was convinced that the master's programme AI also maintains a stable, cohesive, integrated and well-balanced study programme.

Didactic concept
The critical reflection states that the *bachelor's programme* uses the didactic concept of student activating education (SAE), aiming at evolving self-responsibility, teamwork and deepening of knowledge and skills by taking on advanced assignments. During the site visit students acknowledged the fact that they are being trained under guidance towards self-responsibility and independent thinking by approachable staff. The panel established that many different work forms are used throughout the bachelor's programme, such as (interactive) lectures, working sessions, lab sessions and self-study. The guiding principle underlying these work forms is to activate and challenge the students, the panel learned from the staff. Cooperative learning and self activation is stimulated by the use of social media. Students also informed the panel about the activating element of their education and mentioned the fact that they are encouraged by regular feedback on their progress. The panel was therefore very pleased to see that the concept is put into practice.

According to the critical reflection the *master's programme* trains students in combining methodical acquisition of knowledge, theoretical insight, making judgments, and practical application of the acquired knowledge. The programme challenges students to perform these activities themselves and provides supervision, feedback and suggestions for improvement. This didactic concept of active autonomy follows upon the didactic concept of student activating education from the bachelor's programme. The critical reflection claims that this didactic concept puts a considerably greater emphasis on, and provides training in, the capacity of the students to actively engage in scientific (fundamental or

applied) research and work more independently.

The didactic concept is practised using a variety of work forms, such as giving oral presentations, both for peer and non-peers, experts and non-experts; writing research proposals; performing original research projects, individually or in teams; building and analyzing computational models and/or computer systems; writing or presenting critical commentaries on papers; doing literature research and writing research papers.

During multiple meetings the panel held during the site visit, it learned that the didactic principle is uniformly practiced in both programmes and is supported by staff. The students are clearly aware of the underlying principle of the courses they take and, as the panel learned, appreciate the gradual training towards independent thinking. Especially in the master, they appreciate the freedom of choice together with monitoring and feedback.

Translation of the intended learning outcomes into curriculum

The panel was pleased to find that the *bachelor's programme* uses a matrix to ensure the implementation of the learning outcomes throughout the obligatory courses. This matrix shows that all learning outcomes are present in the core courses, the panel concluded. Based on the monitoring of course material and interviewing staff and students the panel furthermore concluded that the two approaches to KI, understanding and supporting human cognitive functions, are taught in multiple bachelor courses. The KI learning outcomes knowledge and understanding, application of knowledge and understanding, communication skills, critical judgement and study skills are all visible in the individual courses.

The bachelor's programme offers several possibilities to train competences applicable in the non-academic professional field. From the first year onward, bachelor students learn about the professional field through dedicated courses (e.g. Professional Field Orientation) and contacts with professionals.

The *master's programme* is designed in such a way that each student fulfils all the learning outcomes within his/her own personalized curriculum. The programme also uses a matrix to safeguard the implementation of all outcomes throughout the curriculum. The panel established that the content and structure of the programme, but also the entry conditions of the master's programme enable students to fulfil the learning outcomes. The curriculum allows for quite some flexibility for the students and students can diverge in their individual educational trajectories. Yet, in the critical reflection it is claimed that the set of core courses required per specialization, the thematic relevance of all the restricted choice courses, and the criteria for master internship and thesis together, guarantee that each student completes the programme with the knowledge and skills required for a master degree in Artificial Intelligence. Furthermore, the Board of Examiners (BoE) judges whether each individual curriculum meets the requirements as specified in the EER for the master's programme. During the meeting with the BoE, the panel learned that the BoE thoroughly studies each individual curriculum and approves it only when all learning outcomes are sufficiently covered.

The panel furthermore established that despite the flexibility the programme offers to students, the programme uses multiple tools, such as a restricted choice of courses, to guarantee that all students achieve the learning outcomes during their personalized curriculum.

According to the critical reflection the curriculum supports every student in realizing the learning outcomes for the master degree in AI in Nijmegen as described in Standard 1. The core courses in the programme collectively contribute to the development of each of the learning outcomes. For example, regardless of which specialization the student chooses and whether or not the student decides to take the course Research Methods, or the course Advances in HCI respectively Machine Learning in Practice, the learning outcomes regarding research and analytical skills are achieved. Additionally, the restricted choice courses contribute to the learning outcomes as well. This allows students to diverge in terms of specialization or broaden their training.

Staff

The primary educational and organizational responsibility for the bachelor's and master's programmes lies with the staff of the Department of Artificial Intelligence. Staff from Computing Science, Psychology and the Research Masters in Cognitive Neuroscience and Behavioural Science are also involved in the programmes. According to the critical reflection, the involvement of these teachers is in accordance with the interdisciplinary character of the programmes and the panel was very happy to see that this results in a synergy of disciplines. The staff members are actively involved in research in AI and cognitive neuroscience, the panel established. The panel was also very pleased to see the clear connection between research and teaching, which was fully supported by the interviews with students.

All teaching staff members have a basic teaching qualification (BKO, Basiskwalificatie onderwijs) and the majority have the additional extended teaching qualification (UKO, Uitgebreide kwalificatie onderwijs). Students stated during the site visit that they are positive about the didactical qualities of their lecturers. The panel recognized these positive comments in the course evaluations which it studied during the site visit.

To ensure the international character and atmosphere of the master's programme, the programme actively recruits its teachers internationally for courses in the programme. The student/staff ratio is 28.4:1. The students have no complaints regarding the availability of members of staff, the panel learned during the site visit.

The panel has studied the composition of the staff and its list of publications and is very much convinced of the scientific qualities of the staff members, without exception with a PhD. Furthermore, the didactic qualities are also more than evident, according to the panel, as is shown by the teaching qualifications and positive feedback by the students. The panel learned that the staff members are highly appreciated by the students, both bachelor and master students, and compliments the staff with their approachability and level of personal involvement attributed to both the programmes and their students. The panel was pleased to hear that being an inspiration and scientific role model is also part of the professional vocation of the staff.

The panel was particularly impressed by the high academic and didactic qualities of all staff involved in both programmes. These qualities and the accompanying commitment clearly go beyond what can be expected and lead to a clear synergy of disciplines in coherent programmes. Apart from the overall high quality of the staff, the panel was particularly impressed by the fact that next to the professor with a chair in Artificial Intelligence, many highly esteemed full professors in Psychology, Cognitive Neuroscience, Computing Science and Intelligent Systems are involved in teaching courses in the programmes.

Facilities and student support
The bachelor's programme makes use of the same standard educational facilities as the master's programme (e.g. computer equipment, Blackboard and research facilities). Furthermore, the programmes can use a substantial amount of lab facilities from affiliated research institutes. A special AI computer room is available, as well as a number of specialized robots, to be used for courses and graduation projects. The panel was quite impressed by the available lab facilities and established that students make good use of these facilities for research and study.

Both programmes each have an Internship coordinator who maintains a Blackboard organization with relevant information about internships. Twice a year the Internship coordinators organize an internship fair at which students can meet with potential supervisors advertising various research projects that the students can apply for. The panel also learned that students appreciate the fact that other staff members are also involved in monitoring the internships, to guarantee that students are not merely acting as employees for the companies involved. The programmes also have an Internationalization coordinator who provides students with information about how to plan and organize visits to other universities and plans regular information sessions for students.

Besides these facilities, the master's programme also offers a Training and Supervision Plan (TSP) coordinator to facilitate students to fill in their obligatory TSP and helping them to select appropriate courses. The master's programme maintains active contacts with internship hosting institutes, ranging from research institutes within the Radboud University, to academic institutes abroad and companies.

The panel established that the study advisor is proactive and primarily concerned with students who need extra monitoring and acts as a counselor, answering questions of individual students. The advisor meets every student at least twice a year to discuss progress. Apart from the study advisor, staff is also involved as mentors, assisted by student mentors. The panel's positive opinion of viability of this monitoring system was confirmed by the students during the interviews. The panel found that exit talks are still lacking in this system. These talks could for example be very useful for the programmes to ascertain why (relatively many) students choose to go elsewhere for their master. The panel is well aware of the fact that the transfer of students to other masters than the master AI is a sign of the quality of the multidisciplinary bachelor AI, which enables and even stimulates students to go explore their talents. However, more insights into the motivation of students to choose for a different master's programme, would help the master's programme in its focus to have a stable influx of students.

Quality assurance and evaluations
The panel learned that generally internal all courses are evaluated positively and only minor adaptations occurred. The primary external evaluation is the accreditation of the programmes. More frequent external evaluations are based on student assessments from university-wide surveys, from the Nationale Studenten Enquête (NSE) and evaluations from the Professional Field Committee, through which the contacts with the professional field are used for quality assurance and evaluation. The PFC evaluates the BSc/MSc-programmes and provides suggestions for improvement. The PFC contains two AI staff members, one representative from Philips research (Eindhoven), one from TNO Human Factors (Soesterberg) and one from Vicar Vision (Amsterdam) and convenes at least once every two years. The panel has established that the internal and external evaluations yield results and that issues raised are addressed.

Intake and efficiency
The bachelor's programme pursues an intake of 50 new students every year. The programme aims at a limited expansion in order to be able to have sufficient staff and facilities for the students.

Numbers provided show that, like all bachelor's programmes in AI, the bachelor's programme in Nijmegen experiences a high drop out. 48% of the gross intake resigns from the bachelor's programme during the first three years of their study. Variation in drop out is high. A BSA-threshold of 40 EC has been set for first year students of the School of Psychology and AI. Students that do not pass this threshold are not allowed to continue their education at AI in Nijmegen for the next three years. The overall efficiency of roughly 40% after 4 years is significantly lower than the nationwide target of 70%. The programme has taken several measures for improving the efficiency. The measures are focussed on preparing and informing prospective students better and by improving the monitoring and guidance of bachelor students. The panel supports these measures and shares the concern of the programme regarding the high drop out. The first results of the improvements are encouraging, the panel concluded. Especially important according to the panel is the more strict separation between the bachelor's and master's programme. New admission rules for the master sharpened the rules for initiating and performing the bachelor thesis project, aimed at a reduction of time needed to finish the thesis, which was a considerable factor in the efficiency rate. The panel underlines the importance for students to finish their thesis timely before embarking on a master's programme.

The panel learned that the master's programme intake (between 7 and 16 student a year since 2006) will grow in accordance with the growth of the bachelor's programme. The panel supports the aim of the programme to improve the international and external intake. The efficiency rates are difficult to establish, the panel established, due to the flexible transition between the bachelor's and master's programmes. The panel concluded that the overall efficiency will improve due to the measure that form the year 2012-2013 exams in master courses are only available for students with a bachelor's degree.

In the interviews the students indicated that the study load of both programmes is acceptable. The panel has verified by studying the curricula and has also established that bottlenecks were addressed by the programmes. The panel concluded that both programmes enable students to finish within the given period of time for each programme.

Considerations

Considering the multidisciplinary character of AI and the involvement of staff from different affiliations, the panel was impressed by the fact that both the bachelor's and master's programme maintain a stable, cohesive, integrated and well-balanced study programme. The intended learning outcomes are known to and used by the members of staff and there is a clear and well operationalized didactic concept. The intended learning outcomes are clearly translated into the curriculum. The panel was pleased to see that research is an integral part of both programmes, in particular that of the master's.

The panel was particularly impressed by the high academic and didactic qualities of all staff involved in both programmes. These qualities and the accompanying commitment clearly go beyond what can be expected. The wide participation of full professors in teaching in both programmes is very recommendable.

A point of concern, as mentioned by the programmes themselves, is the efficiency. The average student is taking too much time to complete the curricula. The panel is convinced that the measures already implemented by the programmes will yield the desired outcome.

Conclusion

Bachelor's programme Kunstmatige Intelligenite: the panel assesses Standard 2 as 'good'.
Master's programme Artificial Intelligence: the panel assesses Standard 2 as 'good'.

Standard 3: Assessment and achieved learning outcomes

The programme has an adequate assessment system in place and demonstrates that the intended learning outcomes are achieved.

Explanation:
The level achieved is demonstrated by interim and final tests, final projects and the performance of graduates in actual practice or in post-graduate programmes. The tests and assessments are valid, reliable and transparent to the students.

Findings

This standard provides insight in the testing and assessment system and the achieved learning outcomes of both programmes.

Testing and assessment system
The critical reflection states that different forms of assessment are used: written examinations with multiple choice questions, written examinations with open questions, essays/reports, assignments and oral presentations. In several courses there is a combination of assessment types, which together determine the final judgement. The assessment methods that are used in a course depend on the learning objectives and teaching methods of the course, as well as on practical arguments such as the number of course participants. The general policy is that, especially in the course of the bachelor's programme, assessment types evolve from more directed and specific (focused questions, small assignments) to more open and integrated (essays, reports, larger projects). For each course, the study guide describes which forms of assessment are used. Apart from these summative assessments there are also formative tests, mainly in the form of assignments that do not (or minimally) count towards the final grade. These formative tests are provided in many technical courses, and are aimed at providing feedback during the learning process in order to adjust this learning process. The panel has reviewed the different forms of assessment and established that the methods used are connected to learning objectives and level. This was also corroborated by the students the panel interviewed.

The panel was impressed by the way the Nijmegen programmes were able to translate their focus on Brain, Cognition and Computer not only in the programme, but also in the tests and assessments and subsequently in the thesis topics. It furthermore considers the Nijmegen programmes to be almost too modest about this in communication towards external stakeholders.

There is one joint *Board of Examiners (BoE)* for the bachelor's programme in Kunstmatige Intelligentie and the master's programme in Artificial Intelligence. It consists of five members. Its primary goal is to secure the quality of assessments and examinations. The role of the BoE is laid down in the Rules and Regulations for the Board of Examiners and requires on the one hand informing teachers about the procedural and substantive aspects of adequate testing (including the assessment of graduation theses), and on the other hand systematically evaluating the quality of assessments. In addition, the BoE formulates proposals to improve the quality of testing and assessment, such as the Assessment plan with guidelines for teachers. Finally, the BoE decides on individual student requests and complaints. During the site visit the panel assessed documentation with respect to the functioning of the BoE and concluded that procedural aspects and documentation are adequate.

The panel established that in some aspects the BoE is proactive For example, it monitors

actively the quality of theses and assessments. Twice a year (since 2009) the BoE checks a sample of at least 20% of the bachelor and master graduation theses for adequate substantive assessment; theses having grades below 7 or above 8.5 are always included in the sample, the rest is randomly drawn. In addition, all theses assessments over the last six months are checked for correct procedures (multiple assessors, use of appropriate assessment checklists). Also twice a year (since 2010) a sample of five courses is checked for the quality of their assessment(s), including the suitability of the assessment forms for the course objectives. Since 2011, teachers of selected courses have to fill in an 'assessment report' which is sent to the BoE together with the assessment materials of the latest course edition. From 2012, such an assessment report has to be filled in yearly (and not just for checks by the BoE) for every course that is provided by the degree programme itself, and added to the course file. Intermediate checks of course assessments are being held whenever there are negative signals about the quality of a respective assessment, such as student complaints or an exceptionally low or high failing percentage.

The panel established that the testing and assessment system is more than suitable for good quality assurance of tests and theses and has been functioning properly. The panel was also pleased to learn that the course objectives are assessed in relation to the learning objectives of the programmes as a whole, using the aforementioned matrix and paying attention to the soft skills as well. The panel was informed by students that objectives and assessment forms are known to them through the study guide and Blackboard. Additionally, the panel suggests making the course assessment reports also available to students.

Achieved learning outcomes
The assessment procedures for *bachelor theses* are described in detail in the Rules and Regulations for bachelor theses. The thesis is reviewed by the thesis advisor and a second independent assessor. Since December 2012, each thesis is checked for plagiarism using *Ephorus* by default. After the thesis has been approved, the student must defend the thesis before the two assessors for about 20 minutes. Each assessor independently completes a standardized assessment form with separate evaluations for the relevant aspects of the thesis (clearly motivated research question, adequate methods, language use, etc.) and a proposed overall grade. These evaluations are based on (1) the thesis text, (2) the defence and (3) process information as provided by the daily supervisor. The assessment of process information is regularly monitored by the internal supervisor and is discussed at the regular progress meetings. The actual final grade is established through deliberation between the assessors, who compare the separate thesis assessments forms and decide on a mutually accepted grade. Although this has not happened until now, when the assessors cannot agree on a grade, the BoE is asked to rule. The overall grade for the thesis contains rating elements for the progress and quality of the research.

The panel assessed the achieved learning outcomes by reading a selection of 15 theses together with the associated assessment forms. Consideration in selecting the theses was given to the grading (low, average, high). The panel members assessed problem definition (especially its relation to the field of AI), review of literature, methods and justification, conclusion and discussion, structure, legibility and verification. It was impressed by the general high quality of the bachelor theses and fully agrees with the scores given by the assessors. The panel sees the high quality of thesis work confirmed by the fact that the results from several thesis projects are already published in peer-reviewed journals and conference proceedings.

The assessment procedures follow the Rules and Regulations for *master theses*. The thesis is based on an internship followed by the writing of a thesis and reviewed by the two thesis supervisors and an additional, independent assessor. Since December 2012 all theses are checked using Ephorus. Next, the student must defend the thesis before the three assessors, for about 45 minutes. Prior to the defence, the student gives a public presentation, which is also assessed.

Immediately following the defence, each assessor independently completes an assessment form with partial evaluations for different aspects of the thesis and the internship, and a proposed final grade. Evaluation pertains both to the thesis and the internship. The panel finds that assessment procedure is thorough and guarantees a valid assessment of the theses. During the site visit, students confirmed that the thesis procedure and assessment is clear to them.

Since 2010-2011 the master's programme has used an improved English evaluation form, which includes separate columns for the assessment of the theses and the internship respectively. The assessment form describes the dimensions on which the quality of the thesis and the internship are assessed and provides a means to establish uniform assessments across different theses and internships.

The panel assessed the achieved learning outcomes by reading a selection of 15 theses together with the associated assessment forms. The panel members assessed problem definition (especially its relation to the field of AI), review of literature, methods and justification, conclusion and discussion, structure, legibility and verification and was very much impressed by the overall high academic quality. In particular, the panel was pleased to establish the thorough way students are supervised in choosing their subject within a wide range of possible topics. The theses all clearly fit into the realm of Artificial Intelligence and pay attention to their position in the field of AI. The generic quality is also proven by the fact that the results of many graduation projects are published at conferences and in journals.

Regarding *career perspectives,* the panel recommends the bachelor's programme to prepare students to be able to pursue their master's programme outside Nijmegen. Even more strongly, the panel feels that the bachelor's programme deserves to persuade more of its own bachelor graduates to stay and carry on with the master's programme in AI.

The panel established that the majority of master students perform their internship research at an external institution or company. Students are successful in obtaining good positions in the professional field after graduation. On average one out of four graduates pursues his PhD in Nijmegen or abroad. The panel was very pleased to learn from alumni that in most cases a suitable job is found immediately after graduation, or their own company is started.

Considerations

The panel concluded that the assessment procedures and monitoring by the BoE is of good quality. In addition, the exams the panel was able to assess during the site visit, confirmed this conclusion.

The Board of Examiners is actively involved in the assessment of thesis work and is aware of its formal position and responsibilities.

The panel was very impressed by the quality of the thesis work, both regarding bachelor and master's programme. It compliments the programmes that the topics of the theses clearly fit the AI domain as chosen by the university.

Finally, the panel has established that graduates from both programmes are well capable of finding a fitting master's programme or a suitable job.

Conclusion

Bachelor's programme Kunstmatige Intelligentie: the panel assesses Standard 3 as 'good'.
Master's programme Artificial Intelligence: the panel assesses Standard 3 as 'good'.

General conclusion

For all three standards and almost all aspects that were part of these standards, the panel was very impressed with and enthusiastic about both programmes. It has no doubt that both bachelor and master's programme exceed the basic requirements according to the NVAO framework.

Conclusion

The panel assesses the *bachelor's programme Kunstmatige Intelligentie* as 'good'.
The panel assesses the *master's programme Artificial Intelligence* as 'good'.

Appendices

Appendix 1: Curricula vitae of the members of the assessment committee

Prof. dr. Leon Rothkrantz studied Mathematics at the University of Utrecht from 1967-1971. Next he started his PhD study at the University of Amsterdam under supervision of Prof Freudenthal and Prof. Van Est. He finished his PhD study in 1980. In the meantime he worked as a teacher Mathematics at "de Nieuwe Lerarenopleiding" at Delft. From 1980 he worked as a student counselor at Delft University of Technology. From that time he started a second study psychology at the University of Leiden and finished this study in 1990. From that time he worked as an Assistant Professor and later as an Associate Professor Artificial Intelligence at Delft University of Technology (DUT) in the group Knowledge Based Systems headed by Prof Koppelaar. Since 1998 he worked as a Professor Sensor Systems at The Netherlands Defence Academy (NLDA). In 2011 he retired from DUT and in 2013 also from the NLDA.
Leon Rothkrantz supervised more than 150 MSc students and 15 PhD students. He published more than 200 scientific papers in Journals and Conference Proceedings. He was involved in many National and European Research and Educational Projects. He is honored with golden medals from the Technical University of Prague and the Military Academy from Brno.

Prof. dr. Patrick De Causmaecker is a Full Professor in Computer Science and the head of the CODeS group at KU Leuven. He holds a master in mathematics and a PhD in theoretical physics from the University of Leuven (1983). The subject of his PhD was a calculus for particle collisions at high energies, which is still in use today. After thirty years, his papers on this subject are still regularly cited. After he switched to the field of information processing in 1984, he has successfully conducted research in heuristic combinatorial optimization and constraint solving, specifically for planning, scheduling and rostering problems. He is particularly interested in combinatorial optimisation at the interface with data interpretation and knowledge discovery. This research was in close cooperation with a multitude of small and medium sized companies specialized in planning and scheduling for production, transport, education and medical care. Special attention goes to developments in meta heuristics and hyper heuristics. Apart from this research program, he spends about half of his time in teaching at the undergraduate level. Subjects include programming, data structures and algorithms and operating systems. He coordinates project development training in the second year of bachelors in engineering studies and he is responsible for research training in the third year of the bachelor in computer science. He supervised 10+ PhD students.

Rik Claessens BSc is a Master student Artificial Intelligence at Maastricht University. Before the Master programme, he graduated Cum Laude from the Bachelor of Knowledge Engineering at the same university. During his Bachelor, Rik obtained the Top 3% Student Scholarship award twice, before it being abolished in the final year. For his Bachelor Thesis he received the third prize for the best thesis. Currently, he is performing an internship at Thales Research & Technology in Delft on Dynamic Bayesian Networks.
Rik is also a member of the Swarmlab@Work team from Maastricht University who is the Robocup 2013 World Champion in the Robocup@Work division. While studying in Maastricht, Rik had a number of side jobs as a freelance programmer. From January 2011 until August 2013 he was employed as a Software Engineer at Flycatcher Internet Research, performing various IT-related tasks, ranging from database management to application and web development.
Rik is also active as a promo-teamer of the university and has been a member of the Education Committee of the Department of Knowledge Engineering for three years. Since the age of seven, Rik has been a percussionist, graduating Cum Laude from the Music

Academy in Kerkrade in 2006. He is also a percussion instructor of Harmonie St. Jozef Kaalheide, Kerkrade.

Prof. dr. ir. Dirk Heylen is Professor Socially Intelligent Computing at the University of Twente. After his studies of Linguistics, Computer Science and Computational Linguistics at the University of Antwerp he moved to the Institute of Dutch Lexicology in Leyden, to develop tools for enriching natural language databases. After a couple of years he went on to the Utrecht University and got involved in the big European project Eurotra on Machine Translation. After coordinating a follow-up EU project, he started his PhD project on a logical approach to natural language analysis and parsing (Type Logical Grammar). At the University of Twente he started working on embodied dialogue systems (aka virtual agents or embodied conversational agents). This made his interests shift from pure linguistic analysis to body language, from text analysis to real-time human-machine interaction, and from the logical analysis to a much broader concern with emotion and social relations in interaction. His research interests cover both the machine analysis of human (conversational) behaviour and the generation of human-like (conversational) behaviour by virtual agents and robots. He is especially interested in the nonverbal and paraverbal aspects of dialogue and what these signals reveal about the mental state (cognitive, affective, social). These topics are explored both from a computational perspective and as basic research in the humanities, reflecting my training as a computational linguist.

Dr. Jimmy Troost is Director Research & Technology at the Thales in Delft. After completing his studies at Radboud University Nijmegen and obtaining his PhD in cognitive science at the same university, he worked as a researcher for the Dutch Royal Army. Between 1993 and 1994 he had a postdoc position at the University of York, working in the field of visual perception. Since then, he has worked at various companies in the Research and Science industries, and has occupied various positions at Thales. His specialities include Innovation Management, Research & Development, Change Management and Behaviour Change.

Appendix 2: Domain-specific framework of reference

Frame of reference Bachelor and Master programmes in Artificial Intelligence
The Dutch perspective
January 16, 2013

This document is an update of the 2006 Frame of Reference as developed by the KION[1] task force on Curricula for Artificial Intelligence, which was based on:

- Computing Curricula 2013 Strawman Draft for Computer Science developed by the Joint Task Force on Computing Curricula, IEEE Computer Society and the Association for Computing Machinery[2].
- The Onderwijs- en Examenregelingen (OER) of the bachelor and master programmes in Artificial Intelligence administered by the Dutch Universities.
- Tuning Educational Structures in Europe[3].

1 Introduction

This document is an update of the 2006 frame of reference for the Dutch University programmes included in the category Artificial Intelligence of the Dutch register of higher education programmes (CROHO)[4]. 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.

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 Technology (Kennistechnologie), Cognitive Artificial Intelligence (Cognitieve Kunstmatige Intelligentie) as well as Artificial Intelligence (Kunstmatige Intelligentie).

[1] Kunstmatige Intelligentie Opleidingen Nederland
[2] http://www.acm.org/education/ (last visited on November 1st, 2012)
[3] http://www.unideusto.org/tuning/ (last visited on November 1st, 2012)
[4] Centraal Register Opleidingen Hoger Onderwijs

In 1999, the number of recognized labels in the CROHO was reduced, and the aforementioned study programmes were united under the name *Artificial Intelligence*[5]. 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 abovementioned 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 and a master 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 programme, with the aim of advancing an adequate fit of all Dutch bachelor programmes to all Dutch master requirements.

Aim of this document

Now that the Dutch Artificial Intelligence programmes are coming up for accreditation in 2013, KION feels that the essence of the 2006 Frame of Reference is still valid, but an update is called for. 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 setting international standards for Artificial Intelligence programmes that, to our knowledge, do as yet still not exist.

2. Programme characteristics

This section describes definitions regarding the build-up of bachelor and master programs.

Areas, courses, modules, and topics

A bachelor programme in Artificial intelligence is organized 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'.

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

[5] In Dutch: Kunstmatige Intelligentie

complete undergraduate curriculum. Every undergraduate programme must include additional elective courses from the body of knowledge. This report does not define what those courses should be, but does enumerate options in terms of modules.

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 recognized throughout the world, but within the European Community agreement has been reached upon a uniform European Credit Transfer System[6] (EC) in which study load is measured in European Credits (ECs). One EC stands for 28 hours of study time and a full year of study is standardized at 60 EC. In this document, we shall use the EC metric as the standard of measurement for study load.

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

- Adopt a teaching methodology that emphasizes 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.

3. Shared identity

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

[6] http://ec.europa.eu/comm/education/programmes/socrates/ects/index_en.html (last visited on September 1st, 2012)

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.

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 program should include each of the following aspects:

- 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 a thorough grounding in that foundation.
- 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 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 example.
  - 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.
- 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.
- 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.
- 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.
- 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.
- Demonstration that each student has integrated the various elements of the undergraduate experience by undertaking, completing, and presenting a capstone project.

Shared background for bachelor 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, specialized 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 programme in AI. At the same time, it allows for a wide range of individual and/or institute specific specialisation. The list is an update (extension) of the shared programme agreed upon by the KION platform in 2006.

Common core between AI bachelor degree programmes

The following topics and skills are part of each of the bachelor programmes, either as a dedicated course or as a substantial topic within one or more courses.

Artificial Intelligence modules

- Autonomous systems
- Cognitive psychology
- Computational linguistics
- History of Artificial Intelligence
- Human-computer interaction
- Knowledge representation and reasoning
- Machine learning
- Multi-agent systems
- Philosophy for Artificial Intelligence

Support modules

- Computer science
  - Programming
  - Data structures and algorithms
- Logic
- Mathematics
  - Calculus
  - Probability theory
  - Linear algebra
  - Statistics

Academic skills

Apart from curriculum specific skills, the bachelor program supports 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

Artificial Intelligence elective courses
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 or Master, each Bachelor should offer a substantial subset of the following list as part of their Bachelor programme, either as specific course, or as a substantial part of a broader course.

- Cognitive modelling anArchitectures of cognition
- Data mining
- Information retrieval
- Language and speech technology
- Neural nets
- Genetic algorithms
- Probabilistic models
- Cognitive and computational neuroscience
- Perception (Computational and Natural)
- Robotics
- Reasoning under uncertainty
- Virtual reality and Gaming
- Web Intelligence
- Bio-informa

Bachelor 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.Objectives
The objective of the bachelor 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.

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

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.

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

Place in society
The bachelor 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.

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[7]. Together these final qualifications must lead to alumni that exemplify the shared identity defined in section 3.

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.

Qualifications:
- Basic understanding of key areas in Artificial Intelligence in accordance with the shared identity.
- 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.
- Knowledge of the symbolic approach to Artificial Intelligence.
- Knowledge of the numerical, non-symbolic, approach to Artificial Intelligence.
- Knowledge of the most important philosophical theories regarding the fundamental questions of AI as well as its ethical, legal and societal implications.
- Knowledge of the most important theories developed in the area of empirical sciences, particularly psychology.
- Expertise in constructing and evaluating computational models of cognitive processes and intelligent systems.

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.

[7] http://www.jointquality.org/ (last visited on September 1st, 2012)

Qualifications:

- The ability to understand, apply, formulate, and validate models from the domains of Artificial Intelligence.
- The ability to apply the symbolic approach to Artificial Intelligence.
- The ability to apply non-symbolic approaches to Artificial Intelligence.
- The ability to design, implement, and evaluate knowledge-intensive.
- The ability to apply tools from mathematics and logic.
- The ability to apply important programming languages used in Artificial Intelligence.
- 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.
- The ability to submit an argument in the exact sciences (or humanities) to critical appraisal.
- Analytical and critical way of thought and ability to apply logical reasoning.
- Openness to interdisciplinary cooperation and ability to effectively participate therein as an academic professional.
- The ability to create an effective project plan for solving a prototypical Artificial Intelligent problem in a supervised context.
- Manage one's own learning and development, including time management and organizational skills.
- The ability to transpose academic knowledge and expertise into (inter)national social, professional and economic contexts.
- Readiness to address new problems in new areas, emerging from scientific and professional fields.

Making judgements

The bachelor has the ability to gather and interpret relevant data (typically within the field of study) and to formulate judgements that include reflection on relevant social, academic or ethical issues.

Qualifications:

- Ability to critically review results, arguments and problem statements from accepted perspectives in the field of Artificial Intelligence and neighbouring disciplines.
- Initial competence in search and critical processing of professional literature in Artificial Intelligence.
- Acquaintance with the standards of academic criticism.
- Awareness of, and responsible concerning, the ethical, normative and social consequences of developments in science and technology, particularly resulting from Artificial Intelligence.

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.

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

5. Master 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.

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.

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.

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

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.

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.

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[8]. Together these final qualifications must lead to alumni that exemplify the shared identity defined in section 3.

Knowledge and understanding

The master demonstrates knowledge and understanding in a field of study that builds upon and supersedes their bachelor 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.

Qualifications:

- Advanced understanding of key areas in Artificial Intelligence.
- 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.
- The master is able to judge the quality of his of her work or the work of others from scientific literature.

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:

- 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.
- The ability to determine the feasibility of a proposal to lead to a solution or design as specified.
- 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.
- The ability to choose, apply, formulate, and validate models, theories, hypotheses, and ideas from the domains of Artificial Intelligence.
- 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.
- The ability to translate academic knowledge and expertise into social, professional, economic, and ethical contexts;
- Awareness of, and responsibility concerning, the ethical, normative and social consequences of developments in science and technology, particularly resulting from original contributions.

Making judgements

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

[8] http://www.jointquality.org/ (last visited on September 1st, 2012)

Qualifications:

- Competence in the search and critical processing of all sources of information that help to solve an open and ill-defined problem.
- The ability to demonstrate a professional attitude conform the (international) scientific conduct in Artificial Intelligence.
- The ability to provide and receive academic criticism conform the standards in one specialism of Artificial Intelligence-research.
- The ability to formulate an opinion and to make judgements that include social and ethical responsibilities related to the application of one's own contributions.

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.

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:

- Being able to reflect upon one's competences and knowledge and, if necessary, being able to take the appropriate corrective action.
- The ability to follow current (scientific) developments related to the professional environment.
- 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 recognize that the Dutch national context appears to be rather special in that we only know of specialized 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 programmes of study programmes in a related field, notably Cognitive Science. Furthermore, we will compare the Dutch bachelor 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 programmes, there are several well-known specialized Artificial Intelligence master programmes outside the Netherlands, study programmes at the master level are much more divergent than at the bachelor level. A comparison can therefore only be provided in global, subject-independent, terms.

We have drawn up both the bachelor and master 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.

Comparison of bachelor programmes

The Artificial Intelligence bachelors in Edinburgh
Edinburgh University (United Kingdom) offers a range of bachelor degrees related to Artificial Intelligence, one of them in Artificial Intelligence as such, the others in combination with other disciplines (AI & Computer Science, AI & Mathematics, Cognitive Science). An ordinary bachelor degree consists of 3 years, however admittance to the (1-year) master programme can only be obtained by an honours degree, which takes a fourth year of study. In order to compare this system with the European standard of a 3-year bachelor and a 1-2-year master, we will take the honours year of the Edinburgh bachelor programme to be equivalent to the first year of a 2-year master degree in other European countries, and base our comparison of bachelor programmes on the first three years.

Comparison with the Dutch frame of reference
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 communality between the Edinburgh Artificial Intelligence bachelors is smaller than communality within the Dutch framework. It seems that the wide variation in Edinburgh Artificial Intelligence related bachelor degrees actually means that the degrees themselves are much more specialized than the Dutch framework proposes, some of them having little or no (cognitive) psychology, others having no mathematics, etcetera. Areas such as philosophy appear not to be obligatory at all.

The Cognitive Science bachelors in Osnabrück and Linköping
Both the University of Osnabrück (Germany) and the University of Linköping (Sweden) offer 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.

Comparison with the Dutch frame of reference
Based on studying both programmes, we conclude that the Dutch frame of reference recognizes 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.

Comparison of master programmes

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
- Knowledge management, representation and reasoning
- Learning from data
- Natural language processing

Comparison with the Dutch frame of reference
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 degree.
- The Edinburgh system knows a 'Diploma' whereas the Dutch system does not. As described above, this Diploma can be awarded after completing only the taught part of the course.
- 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.

Stanford
Stanford has four majors in computer science: Computer Science, Computer System Engineering, Mathematical and Computational Sciences and Symbolic Systems. Symbolic Systems most closely relates to the Artificial Intelligence programmes in the Netherlands. Symbolic Systems is an interdisciplinary program 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 program explores the ways computers and people reason, perceive, and act. Within

the Symbolic Systems major, there is a core set of required classes; beyond this core, students choose an area of concentration in order to gain depth.[9]

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

- It is surprisingly difficult to find programme objectives, final qualifications etcetera in the available information. This information is mainly of subject-independent, administrative nature. For example "This programme prepares for entering a PhD programme".
- It was already 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. But still, this variety is on the Computer Science level rather than the Artificial Intelligence level.
- The Stanford programmes seem to have a large freedom in elective courses. In other words, the core of compulsory courses is limited and students have select many elective courses.
- The Dutch framework has more formal subjects (logic etcetera) than the Symbolic Systems programme.

7. Concluding remarks

Artificial Intelligence is a developing field. Due to its relatively recent start as a coherent field of research, the term Artificial Intelligence does not have the stature of Physics, Psychology, or even Computer Science. Internationally, the study of natural and artificial intelligence with computational means is firmly, but usually not very visibly, 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. Future challenges will force products, services, and even societies to react faster but remain reliable, to be both flexible and effective, be both efficient and versatile, and to utilize natural resources with maximal benefit. Making the most of this combination of conflicting demands, which is very much at the core of in the concept of *intelligence*.

The Dutch situation is special because of the existence of Artificial Intelligence bachelor and master programs 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 and master programmes in Artificial Intelligence of Dutch universities contribute to educate alumni that will take a leading role in meeting these future challenges.

[9] http://symsys.stanford.edu/courses (last visited on September 5th, 2012)

Appendix 3: Intended learning outcomes

Bachelor's programme Artificial Intelligence

The profile for a graduated bachelor student ("the bachelor") in AI can be specified according to these qualifications as listed below:

1. *Relevant disciplines:* The bachelor has basic knowledge and understanding about key aspects of psychology, computer science, mathematics, logic, linguistics, philosophy and neuroscience. The acquired knowledge and understanding provide a basis or opportunity for originality in developing (under supervision) or applying ideas.
2. *Cognition:* The bachelor has basic knowledge and understanding about human cognition, such as problem solving, perception, language and motor behaviour.
3. *Methods and techniques:* The bachelor has basic knowledge and understanding about methods and techniques in AI, such as search, inference, learning and logic.
4. *Analytical skills:* The bachelor is, under guidance, capable of analysing an abstract problem, pursuing its solution by means of an operational computer program and (if relevant) formalising a theoretical generalization of the problem. In addition, the bachelor is capable of translating a theory to an algorithm or model, and formalizing and validating theoretical predictions of the model.
5. *Paradigms:* The bachelor can describe and comment upon particular aspects of current research, such as similarities and differences in the architecture and functionality of different models, such as the classical symbolic, the connectionistic and modern dynamical and probabilistic models. The bachelor also has an understanding of the theoretical implications thereof, and of the relevance of different model types for different application domains.
6. *Philosophy:* The bachelor has an eye for the philosophical foundations and implications of the influential paradigms and model types in AI, as well as for the social and ethical implications of developments in the field, e.g. concerning topics like autonomy, agency, and societal implications of robotics.
7. *Communication:* The bachelor is able to express himself/herself in writing according to the accepted norms for scientific AI publications (both formally, e.g., IEEE (Institute of Electrical and Electronics Engineers), Computer Society, APA (American Psychology Association), and in terms of content), and to effectively digest articles in relevant journals. S/he also has oral skills that enable him/her to report on executed research, and to communicate on an equal basis with specialists in AI, as well as with non-specialists.
8. *Research:* The bachelor is, under guidance, able to design, execute and analyse empirical research by applying the methods and techniques that s/he has learned, to review, consolidate, extend and apply his/her knowledge and understanding. The output has the potential of a publication at peer-reviewed fora, like BNAIC.
9. *Practical application:* The bachelor is able to think and act in a practical way. S/he can translate demands from the practice (e.g., from a user group) to the design and implementation, or the improvement or extension, of an existing computer program. The bachelor is able to put the learned competences to practice in different work forms, such as large programming tasks that require a working product to be tested in demonstration sessions or designing an empirical or theoretical research project, such as in the context of the design, implementation and testing of software products.
10. *Critical attitude:* The bachelor has a critical scientific attitude towards research in general and AI in particular. The bachelor has the capacity to critically evaluate arguments, assumptions, abstract concepts and data (that may be incomplete), to make judgments about their soundness and validity. The bachelor has obtained the ability to integrate

multi-disciplinary knowledge, develop (partly under guidance), scientific research questions and pursue these questions in a way that may be largely self-directed or autonomous.

Master's programme Artificial Intelligence

The eleven final qualifications implement five AI learning objectives (see Appendix 4b), which operationalize the five Dublin objectives with respect to the AI profile in Nijmegen:

1. Relevant level: The master has demonstrated knowledge and understanding in the field of AI, founded upon the knowledge and understandi.ng associated with a bachelor's level qualification, that extends and/or enhances the latter, and paves the way for an original contribution in developing and/or applying ideas, often within a research context. The level of the MSc-programme exceeds that of the BSc-programme in that it uses more advanced course material (such as scientific papers), work forms (such as the design of innovative interaction platforms) and amount of independence and responsibilities for, e.g., designing/performing experiments and for scientific communication, both orally and in writing;
2. Relevant disciplines: The master has obtained relevant knowledge and understanding in the fields of psychology, computer science, mathematics, logic, linguistics, philosophy and neuroscience, at a level at which s/he can actively relate AI to those fields, and is able to incorporate the contributions of scientists in different fields into AI projects;
3. Cognition: The master has obtained relevant knowledge and understanding of several human cognitive functions and skills, such as problem solving, perception, language processing and motor behaviour, at a level that enables an original contribution to the computational modelling of such a functionality;
4. Paradigms: The master has obtained knowledge and understanding of the similarities and differences in architecture and working between different model types, such as the classical-symbolic, the connectionist and the more recent dynamic and probabilistic model types. The master also has an understanding of the theoretical implications thereof, and of the relevance of different model types for different application domains;
5. Analytical skills: The master is able to make an independent analysis of an abstract problem that is complex and underspecified, in such a way that a solution can be sought by means of a working computer programme, and, if relevant, a theoretical generalisation can be made. In addition, (s)he has the ability to translate a theory into an algorithm or a computational model, deduce model predictions, and test those predictions;
6. Research: The master is able to independently design, execute and analyse empirical research in a methodologically correct way;
7. Practical application: The master is able to think and act in a rational way, and to translate complex and/or extensive practical requirements (for instance those of a user group) into a work plan for developing, improving or extending a computer programme;
8. Philosophy: The master has an eye for the philosophical foundations and implications of the influential paradigms and model types in AI, as well as for the social and ethical implications of developments in the field;
9. Critical attitude: The master has a critical, scientific attitude towards research in general and AI in particular, and is able to form a well-founded opinion about the latest developments in several areas of AI;
10. Communication: The master is able to express him/herself in writing according to the accepted norms for scientific AI publications (both formally, e.g., IEEE (Institute of Electrical and Electronics Engineers) Computer Society, APA (American Psychology Association), and in terms of content), and to effectively digest articles in relevant

journals. In addition, the master has obtained oral skills that enable reporting on performed research, and communicating on an equal basis with specialists in AI and the fields mentioned in the second point, as well as with non-specialists;

11. Independent learning skills: The master has obtained the necessary learning skills to enable further learning in an independent self-directed manner.

Appendix 4: Overview of the curricula

Bachelor's programme Artificial Intelligence

Overview of the curriculum of the BSc-programme

Themes	B1	B2	B3	Thesis
Core and Elective AI themes (42 EC)	BKI120 Introduction AI (6)	BKI212 AI: Search, Planning and ML (6)	BKI312 Knowledge Representation and Reasoning (6)	(12 EC)
	BKI115a Introduction Robotics (6)	BKI242 Robotics 2 (6)		
	BKI114 Introduction HCI (6)	IBII08 Datamining (6)		
Brain (18 EC)	BPSBR10 Introduction Brain (6)	BKI230 Neural Networks (6)	BKI323 Introduction BCI (6)	
Cognition (20 EC)	BKI110a Introduction Cognitive Psychology (4)	BPSBR41 Language in Action (4)	BKI211 Computational and Formal Modeling (6)	
			BPSGE30 Advanced Behaviour (6)	
Computer (24 EC)	IPI002 Programming (6) / IPI005 Object Orientation (6)	IBI008 Functional Programming (3)	IBI001 Software Engineering (6)	
Support Courses (36 EC)	BPSST10 Statistics 1 (6)	BPSST20 Statistics 2 (6)		
	IPK001 Formal Thinking (6)	IPK001 Asserting and Proving (6)		
	IPI007 Math-1 (3) / BKI104 Math-1A (3)	BKI316 Mathematics 2 (6)		
Academic Skills (12 EC)	BKI101 Caleidoscope (2EC)	BKI301 Prof. Field Orientation (2) BKI304 Colloquium (1) BKI201 Presentation Skills (2)	BKI243 Philosophy of Cognitive Science (6)	

Numbers between parentheses indicate the number of EC. BKI-codes are organized by the AI staff, I-codes by Computer Science and BPS-codes by Psychology.

Master's programme Artifical Intelligence

Overview of curriculum of the MSc-programme

Specialisation	Core courses (24 EC)	Restricted choice (36 EC)	Optional (12 EC)	Thesis (18 EC) / Internship (30 EC)
Cognitive Artificial Intelligence (CAI)	Trends in AI Bayesian and Decision models in AI Cognition & Complexity Adv. in Human-Computer Interaction or Research Methods	See table below.	See below.	

Specialisation	Core courses (24 EC)	Restricted choice (36 EC)	Optional (12 EC)	Thesis (18 EC) / Internship (30 EC)
Brain-Computer Interfacing (BCI)	Trends in AI BCI Practical Course Brain Reading Machine Learning in Practice or Research Methods	See table below.	See below.	

Overview of the Restricted choice courses

Course	Thematic relation to AI	Specialisation	Source programme
Evolutionary algorithms	Computing science	CAI	**Master Artificial Intelligence**
Thinking in Design Patterns	Computing science	CAI/BCI	
Capita selecta	To be determined by BoE	CAI/BCI	
[1,2]Bayesian and Decision models in AI	Computing science	CAI	
[1]Cognition & Complexity	Cognitive science	CAI	
[1]Adv. in Human-Computer Interaction	Human-computer interaction	CAI/BCI	
[1]BCI Practical Course	Cognitive neuroscience	BCI	
[1]Brain Reading	Cognitive neuroscience	BCI	
[1,2]Machine Learning in Practice	Computing science	BCI/CAI	
[1]Research Methods	Experimental methods	BCI/CAI	
Cognition and Representation	Cognitive science / computing science	CAI	**Master Computing Science / FNWI**
Statistical Machine Learning	Computing science	BCI/CAI	
Informational Retrieval	Computing science	CAI	
Bioinformatics	Computing science	BCI	
Bio-inspired algorithms	Computing science	CAI	
Business Rules Specification and Application	Business design	CAI/BCI	
Computational Neuroscience	Computational modeling	BCI	
Trends in Cognitive Science	Cognitive science	CAI/BCI	**Research Master Cognitive Neuroscience**
Motor Control	Cognitive psychology	CAI/BCI	
Perception	Cognitive psychology	CAI/BCI	
Social Neurocognition	Cognitive neuroscience	CAI	
Multilingualism	Psycholinguistics	CAI	
Neurophilosophy	Philosophy/Neuroscience	BCI	
Neuroimaging	Cognitive neuroscience	BCI	
Behavior regulation	Behavioral science	CAI/BCI	**Research Master Behavioral Science**
Emotion	Behavioral science	CAI/BCI	
Behavioral decision making	Behavioral science	CAI	
Philosophy of Mind	Philosophy	CAI	**Research Master Philosophy**

Course	Thematic relation to AI	Specialisation	Source programme
Computer-assisted language learning	Human-computer interaction / linguistics	CAI/BCI	**Master Linguistics**

[1] Can be chosen in the restricted choice space only if they are not already chosen as part of the student's specialisation.
[2] Taught by staff at the Faculty of Science (FNWI), but are also core courses for the specialisations in the MSc-programme.

Overview of the optional courses

- Students can use this space in their curriculum to explore unexpected or unusual cross-links between their own field of study in AI and other (apparently) more distant fields of study. This is entirely in the spirit of the interdisciplinary nature of Artificial Intelligence. For instance, even though a course in Psychopathology or Medieval Literature may not prima facie seem relevant for a Master programme in AI, for an individual student who happens to be interested in application of Brain-computer interfacing in Psychiatry, or in application of information retrieval for the analysis of classical texts, such courses can form an enriching addition to the student's curriculum.
- Students can use the 12 EC on optional courses to enrich their education by gaining international experience and taking courses abroad as part of an international visit to a different university.
- Students who did not complete their Bachelor degree programme in Nijmegen, can use this space to compensate for possibly missing knowledge or skills. For instance, students who did their Bachelor studies in AI at a different Dutch university may not have taken a course (equivalent to) Introduction to Brain-Computer Interfacing, while this course is a prerequisite for the BCI specialisation. Similarly, most of our foreign students have a BSc degree in Computing Science, and may lack the background in cognitive psychology or neuroscience to specialise in CAI or BCI. These students can complete their missing competences and establish a proper MSc-programme by selecting, for instance, a course like Language in Action as part of their free choice space.

Appendix 5: Quantitative data regarding the programmes

Data on intake, transfers and graduates

Bachelor's programme Artifical intelligence

Intake distinguished by pre-education

Year						Total	NL Average	DWH
	VWO	HBO-prop	HBO*	Foreign	Other			
2006-07	28	0	1	3	2	34	32	36
2007-08	25	2	0	4	1	32	26	34
2008-09	18	2	0	2	2	24	36	22
2009-10	44	2	1	3	0	50	44	52
2010-11	43	2	1	2	1	49	37	56
2011-12	45	0	0	10	0			55
2012-13	46	0	0	4	2			52

Drop out from the programme, VWO intake (source VSNU, Table B2.1, October 2012).

Year	Cohort size		Drop out (accumulative percentage)					
			Year 1		Year 2		Year 3	
	NL	RU	NL	RU	NL	RU	NL	RU
2006-07	157	28	24	25	33	32	39	50
2007-08	128	25	30	28	36	32	41	44
2008-09	130	18	29	22	45	50	*49	*50
2009-10	186	44	40	32	*47	*41		
2010-11	157	43	*32	*23				
Average			31	26	40	39	43	48

Presented are numbers averaged over all five bachelor programmes in AI in the Netherlands (marked NL, in blue) and the numbers from the BSc-programme at Radboud University Nijmegen (marked RU). Numbers marked with a '*' are based on 1-October information.

Efficiency of the total intake

Year	Re-registrations		% of total cohort		Bachelor efficiency of re-registred students				
					After 3 years		After 4 years		
	NL	RU	NL	RU	NL	RU	NL	RU	DWH
2006-07	147	26	76%	76%	26%	23%	42%	50%	56%
2007-08	111	23	71%	72%	20%	9%	40%	26%	27%
2008-09	112	18	70%	75%	13%	0%			36%

Master's programme Artificial Intelligence

Intake distinguished on pre-education

Year	Own BSc	Other University	HBO	Other	Total	(m/v)	%v
2006-07	8				8	(5 / 3)	60%
2007-08	9				9	(7 / 2)	29%
2008-09	16				16	(12 / 4)	25%
2009-10	15	1			16	(8 / 8)	50%
2010-11	6			1	7	(6 / 1)	17%
2011-12	5	2			7	(5 / 2)	28%
2012-13	13	1			14		

Cohort size

Year	Population size of MSc-programme			Total in NL			
	Total (KI)	Male	Female	Total	Male		Female	
2006-07	2 (+9)	2 100%	0 0%	146	122	84%	24	16%
2007-08	7 (+4)	6 86%	1 14%	195	152	78%	43	22%
2008-09	13 (+3)	10 77%	3 23%	207	162	78%	45	22%
2009-10	18	14 78%	4 22%	242	209	86%	33	14%
2010-11	26	17 65%	9 35%	256	221	86%	35	14%
2011-12	22	16 73%	6 37%	233	198	85%	35	15%

Duration of the programme and total stay at RU

Year	Duration of MSc-programme			Total stay at University	
	Number of MSc-diplomas	Nijmegen (months)	Avg. in NL (months)	Nijmegen (months)	Avg. in NL (months)
2006-07			22		64
2007-08	3	19	27	72	81
2008-09	5	26	28	77	75
2009-10	10	21	29	73	79
2010-11	7	23	34	69	84
2011-12	9	23			
Average	6.8	22.4	28	72.8	76.6

Efficiency of the programme

Cohort	Cohort size	≤ 2 years	≤ 3 years	Still busy	Stopped	Switched to other master
2006-07	6	3 (50%)	5 (83%)		1 (17%)	
2007-08	9	5 (55%)	7 (77%)		2 (22%)	
2008-09	12	7 (58%)	10 (83%)		1 (8%)	1 (8%)
2009-10	14	5 (35%)	9 (64%)	3 (20%)		2 (14%)
2010-11	7	1 (14%)	5 (71%)	2 (28%)		
2011-12	7	1 (14%)		6 (86%)		

Teacher-student ratio achieved

Considering the total student population of the BSc/MSc-programmes at December 1 2012, the student/staff ratio is 186/6.55=28.4

Average amount of face-to-face instruction per stage of the study programme

Bachelor's programme Artificial Intelligence

Year	B1		B2		B3	
	Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6
2010-11	21.7	19.1	16.0	18.0	16.3	18.0
2011-12	19.6	18.6	17.6	18.0	17.0	9.5
2012-13	21.0	20.0	18.8	17.0	15.0	9.5
Average	20.8	19.2	17.5	17. 7	16.1	12.3

Masters's programme Artificial Intelligence

Year	M1		M2		
	Semester 1	Semester 2	Semester 3		Semester 4
			Q1	Q2	
Average*	10	10	10	1-4**	1-4**

* The average amount of face-to-face instruction in the master's programme is a rough estimate, as it depends on the choices students make. Based on five 6 EC courses per semester (20 weeks) and about 40 hours of face-to face instruction per course, students receive some 200 hours of instruction per 20 weeks or 10 hours per week in the first five quarters of their study.

** In the last three quarters of their study, students take an internship and work on their thesis. The amount of face-to-face instruction depends on the choices each student makes and his/her progress.

Appendix 6: Programme of the site visit

Dinsdag 21 mei

9.00	**11.30**	**Visitatiecommissie**	**A.03.06**
		Startbijeenkomst **9.15 uur** introductie opleidingen dr. P. Haselager; **9.30 uur** inloopspreekuur	
11.30	**12.30**	**Management: inhoudelijk verantwoordelijken**	**A.03.06**
		Prof. dr. H. Schriefers, vicedecaan Prof. dr. D. Wigboldus, directeur onderwijsinstituut Ps&KI Dr. P. Haselager, hoofd opleidingen KI en AI Prof. dr. P. Desain, hgl. KI (Donders Inst. Brain, Cogniton, Behaviour)	
12.30	**13.00**	**Lunch**	**A.03.06**
13.00	**13.45**	**Studenten bachelor KI**	**A.03.06**
		B1: Caspar Safarlou en Marein Könings B2: Jules Kruiswijk en Mike Overkamp B3: Jasper van Dalen en Sil van de Leemput	
13.45	**14.30**	**Docenten bachelor KI**	**A.03.06**
		Dr. P. Haselager Dr. F. Grootjen Dr. L. Louis Vuurpijl Dr. I. Sprinkhuizen-Kuyper Dr. P. Kamsteeg Prof. dr. F. Vaandrager (onderwijsdirecteur Informatica)	
14.30	**14.45**	**Pauze**	**A.03.06**
14.45	**15.30**	**Studenten master AI**	**A.03.06**
		M1: Wouter Bulten* M1:Roland Meerten* M1:Jan van Acken (Duitse nationaliteit, BCI-specialisatie), M2: Maaike Veltmaat* M2: Francesco Sgaramella (Engelstalig, Bachelor in Italië)* M2: Rick Janssen (Bachelor in Utrecht behaald)* *CAI-specialisatie	
15.30	**16.15**	**Docenten master AI**	**A.03.06**
		Dr. M. van Gerven Dr. I. van Rooij Dr. M. Sadakata Dr. Ir. M. van Otterlo Dr. J. Farquhar (Engelstalig) Prof. dr. T. Heskes (oz.directeur ICIS/Informatica)	
16.15	**16.30**	**Pauze**	**A.03.06**
16.30	**17.00**	**Opleidingscommissie bachelor KI**	**A.03.06**
		dr. F. Grootjen, vz. dr. M. van Gerven dr. S. Smetsers (opleidingscoördinator Informatica) I. Roete T. Wabeke S. Reitsma K. Stoffelen (student Informatica) dr. M. Sadakata, secr.	
17.00	**17.30**	**Opleidingscommissie master AI**	**A.03.06**
		mw. dr. I. van Rooij, vz. dr. ir. M. van Otterlo dr. J. Sarbo (staflid Informatica) L. Sloff K. Dijkstra A. Junk (Duitse nationaliteit, BSc Osnabrück, Engelstalig) K. Stoffelen (student Informatica) dr. M. Sadakata, secr.	

17.30	**18.15**	**Alumni**	**A.03.06**
		Ruud Barth MSc (Universiteit Wageningen) Rik vd Brule MSc (PhD student in AI (Social Robotics) at RU) Steven Rekke MSc (Rodo Intelligent Computing) Maya Sappelli MSc (PhD student in CS RU (Information Foraging) Jaap v.d. Sant MSc (Everest, BCI-specialisatie) Jered Vroon MSc (Nedap)	
19.00	**21.00**	**Diner visitatiecommissie**	**extern**

Woensdag 22 mei

09.00	**10.00**	**Examencommissie en studieadviseur**	**A.03.06**
		dr. P. Kamsteeg, vz. mw. dr. I. Sprinkhuizen-Kuyper (secr.) dr. L. Vuurpijl dr. J. Farquhar (Engelstalig) mw. drs. J. Verbruggen (studieadviseur)	
10.00	**11.00**	**Visitatiecommissie voorbereiden eindgesprek met formeel verantwoordelijken**	**A.03.06**
11.00	**12.00**	**Eindgesprek met formeel verantwoordelijken**	**A.03.06**
		Prof. dr. H. Schriefers, vicedecaan Prof. dr. Daniël Wigboldus, directeur onderwijsinstituut Ps&KI Dr. P. Haselager, hoofd opleidingen KI en AI Prof. dr. Peter Desain, hgl. KI (Donders Inst. Brain, Cogniton, Behaviour)	
12.00	**12.30**	**Lunch & mogelijkheid rondleiding** (dr. F. Grootjen)	**A.03.06**
12.30	**15.00**	**Visitatiecommissie vaststellen bevindingen**	**A.03.06**
15.00	**15.15**	**Mondelinge presentatie (voorl.opige) bevindingen**	**SP3**
		visitatiecommissie, gesprekspartners, belangstellenden dankwoord onderwijsdirecteur prof. dr. D.Wigboldus	
15.15	**---**	**Informele afsluiting**	**Tuin Reska 3**
		visitatiecommissie, management, belangstellenden	

Appendix 7: Theses and documents studied by the committee

Prior to the site visit, the committee studied the theses of the students with the following student numbers:

Bachelor's programme Artificial Intelligence

0609951	3041921	0750514
3040585	0600067	0722049
0436844	0630969	0439789
0733857	3030938	0615323
0454710	0815411	0725862

Master's programme Artificial Intelligence

0609943	0513474	0316717
0513393	0436933	0526088
0609978	0309060	0513504
0513423	0610038	0413593
0513431	0541796	0616443

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

- Information material;
- Books and syllabi, readers, study guides;
- Examples of projects, portfolios, research reports of students;
- Thesis regulations and guidelines for completing assignments;
- Regulations/manuals;
- Examination regulations;
- Key materials (exams, test instructions, key policies, etc.) with model answers;
- Recent reports of the Programme Committee, Examination Committee, annual education, bachelor-master transitional arrangements;
- Teaching and curriculum evaluations, student satisfaction monitor(s), etc.;
- Alumni surveys;
- Material of the study associations;
- Annual reports (education, research, last three years).

Appendix 8: Declarations of independence

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ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: León Rothkrantz

PRIVÉ ADRES: Ir. Werffstraat 19
2722 AR Zoetermeer

IS ALS DESKUNDIGE / ~~SECRETARIS~~ GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

Kunstmatige Intelligentie

AANGEVRAAGD DOOR DE INSTELLING:

RUG/UU/RU/UT/UvA/VU

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

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nederlands-vlaamse accreditatieorganisatie

VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Utrecht DATUM: 14 maart 2013

HANDTEKENING:

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ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: Dirk Herfen

PRIVÉ ADRES: Oude Hontensepad 32
3582 CX UTRECHT

IS ALS DESKUNDIGE / ~~SECRETARIS~~ GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

KUNSTMATIGE INTELLIGENTIE

AANGEVRAAGD DOOR DE INSTELLING:

RUG/RU/UU

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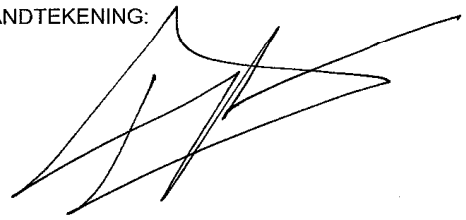
VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Utrecht

DATUM: 14/3/2013

HANDTEKENING:



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ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

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ONDERGETEKENDE

NAAM: J. M. Troost

PRIVÉ ADRES: Molenweg 7
6862 HM Oosterbeek

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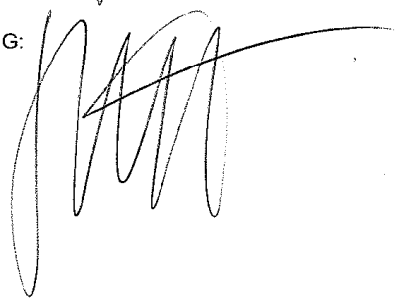
VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Delft DATUM: 14/3/2013

HANDTEKENING:



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INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: DE CAUSMAECKER PATRICK

PRIVÉ ADRES: REIBROEKSTRAAT 128

BE 9940 EVERGEM

BELGIE

IS ALS DESKUNDIGE / ~~SECRETARIS~~ GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

Kunstmatige Intelligentie

AANGEVRAAGD DOOR DE INSTELLING:

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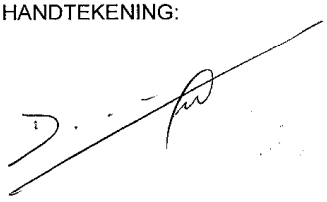
VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: UTRECHT DATUM: 14/3/2013

HANDTEKENING:



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INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: Rik Claessens

PRIVÉ ADRES: Laurastraat 72

6491 GM Eygelshoven

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AANGEVRAAGD DOOR DE INSTELLING:

RUG/UU/RU

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

nvao
nederlands-vlaamse accreditatieorganisatie

VERKLAART HIERBIJ ZODANIGE RELATIÉS OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Utrecht

DATUM: 14-03-2013

HANDTEKENING: R. Maessens.

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: H.A.T. Wilbrink

ADRES: Oude Vest 191
2312 XX Leiden

IS ALS DESKUNDIGE / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING: Kunstmatige Intelligentie

ZIE BIJLAGE

AANGEVRAAGD DOOR DE INSTELLING: RUG/UU/RU/UM/UvA/VU

ZIE BIJLAGE

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

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PLAATS: Utrecht DATUM: 14/03/2013

HANDTEKENING: