NVAO THE NETHERLANDS

INITIAL ACCREDITATION

MASTER ROBOTICS

University Twente

FULL REPORT
4 April 2022

Content

1 Peer review

The Accreditation Organisation of the Netherlands and Flanders (NVAO) determines the quality of a new programme on the basis of a peer review. This initial accreditation procedure is required when an institution wishes to award a recognised degree after the successful completion of a study programme.

The procedure for new programmes differs slightly from the approach to existing programmes that have already been accredited. Initial accreditation is in fact an ex ante assessment of a programme. Once accredited the new programme becomes subject to the regular review process.

The quality of a new programme is assessed by means of peer review. A panel of independent peers including a student reviews the plans during a site visit to the institution. A discussion amongst peer experts forms the basis for the panel's final judgement and the advisory report. The agenda for the panel visit and the documents reviewed are available from the NVAO office upon request.

The outcome of this peer review is based on the standards described and published in the limited NVAO Assessment framework for the higher education accreditation system of the Netherlands (Stcrt. 2019, nr. 3198). Each standard is judged on a three-point scale: meets, does not meet or partially meets the standard. The panel will reach a conclusion about the quality of the programme, also on a three-point scale: positive, conditionally positive or negative.

This report contains the findings, analysis and judgements of the panel resulting from the peer review. It also details the commendations as well as recommendations for follow-up actions. A summary report with the main outcomes of the peer review is also available.

NVAO takes an accreditation decision on the basis of the full report. The NVAO decision can be positive, conditionally positive or negative. Following a positive NVAO decision with or without conditions the institution can proceed to offer the new programme.

Both the full and summary reports of each peer review are published on NVAO's website www.nvao.net. There you can also find more information on NVAO and peer reviews of new programmes.

Because of COVID-19 temporary measures apply for this peer review.

2 New programme

2.1 General data

Institution	:	University of Twente
Programme	:	Robotics
Mode of study	:	Full-time
Degree	:	MSc
Tracks	:	Mechatronics and Physical AI; Algorithms and Software AI; Human-Robot Interaction and Social AI
Location	:	Enschede
Study load	:	120 EC[1]
Field of study	:	Technics

2.2 Profile

Graduates of the master Robotics become robotics experts who can design and realize intelligent robotic systems that operate in structured and unstructured environments, and interact with the environment, including humans. The professional field represented in the Advisory Board strongly supports the master Robotics and assumes that graduated students will easily find jobs in the field of robotics.

At the start of the programme students choose one of the three specializations (1) Mechatronics and Physical Artificial Intelligence, (2) Algorithms and Software Artificial Intelligence or (3) Human-Robot Interaction and Social Artificial Intelligence. Within this specialization students will choose their profile: Research, Design, or Innovation and Entrepreneurship. The common core that unifies the master programme consists in the fist year of six compulsory courses and six electives. The first year course Systems Engineering is shared by all specializations. In Challenge Based Learning the students of the three specializations will collaborate in mixed teams to guarantee the development of broader knowledge of Robotics.

The professional field of Robotics will be involved in the programme by providing problems for Challenge Based Learning. Ethical, Legal, Social and Economic (ELSE) aspects also are a shared mandatory part of the programme.

2.3 Panel

Peer experts

1. Prof.dr. Ming Cao (*chair*), full professor with tenure of Networks and Robotics, Faculty of Science and Engineering, University of Groningen;
2. Dr. Felipe Nascimento Martins, lecturer and researcher at the Institute of Engineering, member of the research group Sensors and Smart Systems, Hanzehogeschool Groningen;
3. Prof.dr.ir Hans Butler, technical expert (mechatronics) dynamics & control architect at ASML and full professor in control systems at the High precision Mechatronics lab, TU Eindhoven;
4. Willem Gommans (*student*), student wo-ma Construction Management and Engineering, TU Eindhoven. Graduated from bachelor Werktuigbouwkunde.

[1] European Credits

Assisting staff
- Drs. Riekje de Jong, secretary;
- Drs. Jona Rovers, NVAO policy advisor and process coordinator.

Site visit (online)
1 March 2022

3 Outcome

The NVAO approved panel reaches a positive conclusion regarding the quality of the Master Robotics offered by the University of Twente. The programme complies with all standards of the limited NVAO framework.

The panel values the choice of the programme to work with a limited number of broadly formulated Intended Learning Outcomes (ILO's) on programme level that have been specified by the ILO's of the specializations, profiles and courses. The attainment levels are nicely aligned with (inter)national frames of references and meet the expectations of the professional field. Graduated students will very easily find jobs in the field of robotics.

The panel concludes that the curriculum is well thought-through and reflects the level and content as reflected in the end level of the programme. The structure of the curriculum is rather complex with three specializations and three graduation profiles. It is therefor important to provide students with clear information and guidance in making their choices.

The panel has met a committed management and very well qualified development and teaching team in the field of research, design and innovation of robotics. The setting up of a Robotics Research Centre offers added value in the field of robotics. In the centre researchers in the field of robotics from different faculties can collaborate, offer internships and supervision of students and can meet the industry. The ambition of the Robotics Research Centre is to function as a linking pin between robotics education and the needs of lifelong learning of the industry.

The overall quality of the examinations and the evaluation of the quality of assessments are safeguarded in the assessment policy of the master and well embedded in the faculty's assessment policy. The panel advices the examination board to support the development team in safeguarding the PILO's of the Master Robotics and in supporting a well-integrated assessment of Ethical, Legal, Social and Economic aspects and Challenge Based Learning.

Standard	**Judgement**
1 Intended learning outcomes	meets the standard
2 Teaching-learning environment	meets the standard
3 Student assessment	meets the standard
Conclusion	**Positive**

4 Commendations

The programme is commended for the following features of good practice.

1. **Unique personal profile** - the Master Robotics offers students unique options to start in a specialization, work in mixed teams and choose a profile directed to research, design or innovation and entrepreneurship.

2. **Strong relationship with field of Robotics** - the committed Advisory Board gives feedback on course development, will offer students research problems to work on in mixed teams and will provide supervision to students in internships.

3. **Challenge Based Learning (CBL)** - in CBL small teams of students from the different specializations re-define a problem in the field of robotics that is challenging for everyone, supplemented with a personal challenge that has to be resolved. The multidisciplinary CBL approach adds professional capacity to the robotics industry.

4. **Research Centre Robotics** - the overarching Research Centre Robotics is a (virtual and physical) centre in which researchers in the field of robotics cooperate in developing new knowledge. The centre will be a bridge between robotics education and lifelong learning in the industry.

5 Recommendations

For further improvement to the programme, the panel recommends a number of follow-up actions.

1. **Clear information and guidance to students** - develop clarifying information about goals, content and learning tracks and offer students good guidance in making choices to enable them to take full advantage of all options the Master Robotics offers. Otherwise, students may get lost in the rather complex programme set-up.

2. **Role of student-assistants in CBL** - student-assistants will be coaching CBL groups. By giving students feedback the student-assistants will indirectly play a role in assessment. Offer student-assistants a mandatory, tailor-made professional development programme.

3. **Realize constructive alignment of electives** - the alignment of electives is still unclear. Because electives could inspire and help students in choosing a profile, better alignment of the electives in the specializations and profiles is needed.

6 Assessment

6.1 Standard 1: Intended learning outcomes

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

Judgement
Meets the standard.

Findings, analysis and considerations
The master Robotics is a joint initiative of the Faculty of Electrical Engineering, Mathematics and Computer Sciences (EEMCS) and the Faculty of Engineering Technology (ET). The programme is co-developed and will be taught by lecturers of both departments (and more) faculties and relevant University of Twente (UT) research groups. The Advisory Board of ET is positioned on faculty level while the Advisory Board of EEMCS is positioned on department/programme level. Both models have advantages. Before starting the programme a decision about the positioning of the Advisory Board Robotics will be made.

Graduates of the master Robotics become robotics experts, specialists who can design and realize intelligent robotic systems that operate in structured and unstructured environments, and interact with the environment, including humans.

At the start of this programme students have to choose one of the three specializations: (1) Mechatronics and Physical Artificial Intelligence (AI), (2) Algorithms and Software AI or (3) Human-Robot Interaction and Social AI. Within this specialization students will choose their graduation profile: Research, Design, or Innovation and Entrepreneurship. To include all specializations and profiles the Programme Intended Learning Outcomes (PILO's) are formulated rather broadly. The programme consists of six PILO's. Three PILO's ensure the desired Robotics basis, advanced knowledge of students' chosen specialization and graduation profile, and knowledge of the other specializations. The other three PILO's guarantee graduates' level of academic skills that reflect the desired multi-disciplinary and system-engineering approach and their broad scope with respect to Ethical, Legal, Social and Economic (ELSE) aspects.

This choice puzzled the panel in the beginning and has been discussed with all stakeholders. The management and the development and teaching team have explained that the involved departments already have robotics research groups and robotics courses in several programmes. In developing the new programme the attainment levels were often formulated according to the perspectives of these groups. This also was the case with the responses of consulted industrial stakeholders. That is why the choice is made to represent the shared perspectives on the attainment levels in the PILO's of this Robotics programme. The broad PILO's are elaborated by the intended learning outcomes of the three specializations and other parts of the curriculum, for example in Challenge Based Learning (CBL) and ELSE aspects.

In analyses presented in the documentation the PILO's have been matched with (inter)national frames of reference and trends and challenges expected in the field of

Robotics. The master Robotics broadens the offer of Robotics programmes in the Netherlands and will most likely also be attractive for international students.

The management team emphasized the increasing importance of AI and related opportunities of European funding. Embodied AI is realized in tangible structures, in machines that move and show very clever behaviour. By implementing AI in this master programme students will be well prepared for the future. The Advisory Board (AB) with stakeholders of the industry convincingly explained the panel that all specializations of the intended master are needed in the rapidly developing field of robotics applications. The industry needs highly qualified Robotics graduates.

The panel discussed the academic nature of the programme. The involved teaching team explained convincingly that, although robotics includes a lot of practice, the specializations always are research informed and methodology based. Students learn to be designing researchers, taking the 'why' question into consideration from the beginning. In the profile Innovation and Entrepreneurship students have to think about making robotics commercially available. In developing a business case they have to rely on both robotics expertise and management and business instruments.

In conclusion, after discussions during the online site visit, the panel values the choice of the programme to work with a limited number of broadly formulated PILO's that have been specified by the ILO's of the specializations and courses. The attainment levels are nicely aligned with (inter)national frames of references and meet the expectations of the professional field. The panel concludes that the Advisory Board strongly supports the master Robotics and will be involved in the development of the programme by providing problems for Challenge Based Learning. Graduated students will probably very easily find jobs in the field of robotics. The panel decides to evaluate Standard 1 as positive.

6.2 Standard 2: Teaching-learning environment

The new Master Robotics consists of 120 EC. Bachelor students with a bachelor Mechanical or Electrical Engineering can enrol in the programme. Students with an Engineering-related bachelor degree of universities of applied studies can enrol after following a premaster programme of 30 ECs.

At the start of the programme students have to choose their specialization. Mentors from the three specializations will guide and support students in making this choice. During the programme students can change their specialization, but the later this happens, the more study delay is probable.

In the interviews, management and development and teaching team clarified the common core that is unifying the programme. In the first year all specializations offer six compulsory courses. In addition, students have to choose six electives. The first year course Systems Engineering is shared by all specializations. The ELSE aspects are also a shared mandatory part of the programme. The students of the three specializations will collaborate in mixed teams in CBL to guarantee the development of broader knowledge of Robotics. The development and teaching team explained the content and level of the required courses of the curriculum and explained the modification of existing courses to fit well in the programme

of the Master Robotics. The panel concluded that the curriculum reflects the level and contents as reflected in the PILO's.

Students can use the electives to select one of the graduation profiles: Research, Design, or Innovation and Entrepreneurship. In the second year, students can choose between three variants: (1) an internship in one of the research groups or outside in the robotics industry, (2) an academic-skills project and two more electives or (3) four electives. In their thesis (research project) research will always be focused on the key of the profile: research, design, or innovation and entrepreneurship. Especially in the research profile students are pushed to go deeper into research and do electives inside the university or an internship at another university.

Reading the documentation, the panel concluded that the structure of the programme is rather complex and offers students a lot of choices. In discussions with the different representatives of the programme these options were clarified. In summarizing all information, the panel concludes that providing clearer information about goals, content and learning tracks to students and guidance in making choices is needed to enable students to take full advantage of the options the programme presented.

Working in multidisciplinary teams is very important in the field of robotics. The panel thoroughly discussed the CBL model with all stakeholders/representatives of the programme. Teachers explained the importance of CBL not only for working in a multidisciplinary context, but also to develop autonomy as learner. The CBL project is provided separately from the courses but the presented problems must be solved by using course knowledge. In small groups of (max.) six students from at least two different specializations students select their problem and define their challenge. In their challenge students have to use a component of their course. The group product, group work and the individual challenge of students will be assessed.

In the introduction to CBL students learn about the CBL process and content. They think about and reflect on the different steps of CBL with a focus on defining the challenge and how to define a challenge that applies to everyone. The student groups are coached by a mentor to steer their work in the right direction. The Advisory Board informed the panel that the robotics industry will easily provide (a lot of) problems student can work with in CBL. With an enrolment of 60-200 students a year the management clarified that in addition to teachers, student-assistants will be assigned. Because team leading skills will be assessed in CBL the panel advises to offer mandatory training to these student-assistants to guarantee precision and goal directedness in observation and giving feedback to students. The teaching staff is looking forward to introducing CBL. Although it is new, they have a lot of experience in project-based education.

The panel is very positive about the quality of the development and teaching team. They are all involved in research and having good relationships with the industry. The teaching team meets weekly to discuss topics in developing the programme and to realize alignment. The panel has met an enthusiastic, dedicated and well-prepared teaching staff.

The management and programme committee have initiated a Robotics Research Centre in which researchers in the field of robotics from different faculties can collaborate, offer internships and supervision of students and can meet the industry. Until now this research

centre is virtual because housing is still a problem. The management expects that the housing of the centre will be realised within three years. The ambition of the robotics research centre is to function as a linking pin between robotics education and the needs of lifelong learning of the industry. The panel concludes that the quality of the lab facilities is in line with what is needed and will be further strengthened by the expansion of the Robotics Research Centre.

Because of the strong international character of the robotics field, the panel affirms English as language used within the master Robotics. This also offers opportunities to attract international students. There are a lot of vacancies in the field of robotics and graduates of the programme will probably easily find jobs in strongly international oriented companies, world-wide and in the Netherlands. According to the panel, the staff is proficient in English.

Summarizing from the documents and the interviews the panel has met a committed management and very well qualified development and teaching team in the field of research, design and innovation of robotics. The panel concludes that the curriculum is well thought-through and reflects the level and content as reflected in the PILO's.
The panel considers that the structure of the curriculum is rather complex with three specializations and three profiles. To find their way students will need clear information and guidance. The role of CBL offers students a unique option to learn in small teams of students of at least two specializations in close connection to the robotics field. The Robotics Research Centre offers added value in the field of robotics. The panel decides to evaluate Standard 2 as positive.

6.3 Standard 3: Student assessment

The programme has an adequate system of student assessment in place.

Judgement
Meets the standard.

Findings, analysis and considerations
The assessment policy of the master Robotics is founded on the policies and guidelines of UT and the faculty of EEMCS. There is one examination sub-board specific for the master Robotics. The panel concludes that the assessment policy and the rules & regulations are clear and safeguarding the validity, reliability and transparency of the assessments.

Examiners use assessment matrices and apply the four-eyes principle in developing assessments. The panel especially discussed the assessment of CBL and ELSE aspects because they are directly related to the PILOs. The panel agrees that the CBL assessment reflects a balanced mix of portfolio and individual challenge assessment, with reports and presentations. Assessment rubrics are already in place. The status of student-assistants in the CBL assessments, however, is unclear. The panel advises the examination board to monitor the supervision of student-assistants and to support mandatory professional development/training of the student-assistants.

ELSE aspects are integrated in courses and assessed in written exams. In the view of the panel the given example by the examination board of “adding one ELSE question to the written exam” will be not always appropriate to evaluate the quality of the examination of ELSE aspects.

Although lecturers of other faculties/departments are involved in assessing students for example in ELSE aspects and skills needed in leading and working in multidisciplinary teams, the panel advises that alignment and integration of these assessments in courses and CBL could be a point of attention of the examination board.

The panel concludes that the assessment policy of the master is well embedded in the faculty's assessment policy. So, the overall quality of the examinations and the evaluation of the quality of assessments are safeguarded. The panel advices the examination board to support the development team in safeguarding the PILO's of the master Robotics and in supporting a well-integrated assessment of ELSE aspects and CBL. The panel decides to evaluate Standard 3 as positive.

6.4 Degree and field of study

The panel advises awarding the following degree to the new programme: Master of Science. The panel supports the programme's preference for the following field of study: Technics.

6.5 Programme extension

The University of Twente proposes that the master programme Robotics has a duration of 2 years. The management has given arguments concerning the breadth and complexity of the programme and the content of the curriculum, reflecting the requirements of the professional field. The panel has assessed the arguments, using the criteria put forward in the 'Protocol verlenging reguliere studielast', published in March 2022.

Findings, analysis and considerations
The panel judges that the programme has shown that the two-year curriculum is designed to allow for fulfilment of the intended learning outcomes. The professional field represented in the Advisory Board has convinced the panel that all specializations of the intended master are necessary in the rapidly developing field of robotics applications. The attainment levels are well aligned with (inter)national frames of references and meet the expectations of the professional field. The Advisory Board strongly supports the current set-up of the master Robotics with three specializations, three profiles within these specializations, a common core of six compulsory courses and six electives, and Ethical, Legal, Social and Economic aspects embedded throughout the programme.

In addition the panel notes that master programmes in engineering, science and technology generally have a duration of two years. Related master programmes at the University of Twente (e.g. Electrical Engineering, Embedded Systems, Mechanical Engineering) also have a two-year curriculum. The panel strongly feels that the qualifications graduates should have in order for them to be competitive in the (inter)national job market cannot be achieved in a programme in less than two years.

Conclusion
Given these arguments in favour of a two-year curriculum, the panel advises to grant University of Twente the right to offer a two-year master programme of 120 EC.

Abbreviations

AB	Advisory Board
AI	Artificial Intelligence
CBL	Challenge Based Learning
EEMCS	Electrical Engineering, Mathematics and Computer Sciences
ELSE	Ethical, Legal, Social and Economic aspects
ET	Engineering Technology
PILO	Programme Intended Learning Outome
UT	University of Twente

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The full report was written at the request of NVAO and is the outcome of the peer review of the new programme Master Robotics of the University of Twente

Application no: AV-1141

NVAO

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