

Programmes and their Project Requirements

This comprehensive document outlines each of our master's programmes and what their thesis requires/entails. This document will provide a description of the thesis, areas of research, examples of past project titles and the requirements of the thesis for each of the programmes. We hope that this document will answer any questions you may have, as well as allow you to submit project proposals more easily and correctly.

If you have any questions please do not hesitate to contact us at thesisfair-IvI@uva.nl.

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Time/duration

• Duration of project: depends on the programme and ranges from 3 months to 8 months Language

- Project submission language: the project proposal submission needs to be **in English**, but you can indicate that the language of the project will be Dutch. Please make sure to clearly indicate this with the project proposal submission
- The final project submission must be in English

Supervision

• Every student will require a dedicated daily supervisor/mentor at your organisation. Workspace

- Throughout the project, you will need to give the student will time and space to be able to conduct their research
- Students will be required to attend meetings with their UvA supervisor and other MSc thesis meetings. Please give the student the flexibility to attend these meetings.

Compensation

- Compensation is not required.
- Students are not expecting compensation but would be a nice benefit and this can be discussed individually with the student.

MSc Artificial Intelligence

Project requirements

The submitted project must be written in English. If the project requires a Dutch speaker please state that in the project description.



Thesis projects for the AI Master should focus on research. Hence the main project requirement is an interesting and novel research question the student can dive into.

The goal of the thesis

The final grade of the thesis project is determined by one thing: the thesis manuscript. The entire thesis project should be geared towards this manuscript.

Examples of successful past thesis projects

Successful examples:

- 1. Greedy InfoMax for Self-Supervised Representation Learning
- 2. Deep Learning Methods for Deconvolution in Radio Astronomy
- 3. Deep Reinforcement Learning for Coordination in Traffic Light Control

What does a good project proposal look like?

A good proposal includes a solid and new research question, an interesting research problem, and relevant context (which includes motivation for the research question and optional references).

What does an MSc student from your programme look like?

An AI MSc student undertaking their thesis will be a 2nd year master's student. The student has a solid foundation in machine learning theory and application, with specialties ranging from computer vision and natural language processing to reinforcement learning and traditional AI.

Main areas of research

- Machine learning
- Computer vision
- Natural language processing
- Reinforcement learning
- AI
- Information retrieval

Internships and NDAs

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For any questions please contact <u>internshipagreement-science@uva.nl</u> **Timeline of the thesis**

The thesis project is either 6 or 8 months long. Please be mindful of this and submit projects for both lengths if possible. A rough expected timeline is as follows:

- 1 month: developing and understanding
- 2-4 months for developing method for developing
- 2 months: finalising
- 1 month: writing

Scope of the project

A thesis manuscript should contain relevant analyses, methods, and experiments to support the research question.

MSc Computational Science

Project requirements



The submitted project must be written in English. If the project requires a Dutch speaker please state that in the project description.

The graduate in Computational Science has a thorough knowledge of modelling and simulation of complex systems, computational methods and techniques, and the application of computational methodologies in application fields (ranging from e.g. physics or biology to medical sciences or engineered systems to complex social systems).

The computational science thesis should include one or more of the following broad aspects: (i) developing computational models, that implement causal mechanisms to understand and predict the behaviour of any system. This could be any system such as social, technical, engineered, biological, physical etc. or

(ii) computational or mathematical techniques to analyze the behaviour of such models. These include strategies for sensitivity analysis, calibration and validation of models. or (iii) developing computing techniques (e.g. distributed algorithms) to enable large scale, computational models.

The goal of the thesis

The thesis aims to enable the student to develop more in-depth knowledge, understanding, capabilities, and attitudes in the study programme. A Master of Computational Science thesis should emphasize the scientific and modelling (computational) aspects of the specific system under investigation. The thesis's overall goal is to display the knowledge and capability required for independent work as a computational scientist.

Computational models are intended to implement causal processes in a single mechanism, which sets them apart from traditional data analysis techniques (such as machine learning) which are applied directly to available data. Without incorporating the same causal mechanisms either explicitly or implicitly (on which research indeed is taking place), in general, data analysis should be restricted to make inferences or predictions 'within the data (e.g., clustering, regression, interpolation) or perhaps 'near extrapolation' (hypothetical scenarios which are still close to that of the data). The outcome of 'far extrapolation', however, requires incorporating the relevant causal processes (since their validity extends beyond any data set), which is by definition the goal of computational modelling.

This distinction can also be seen by comparing the 'inductive capability' of the learning algorithms (from past data, one can identify patterns) with the deductive capability of computational (mechanistic) models.

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Examples of successful past thesis projects

- 1. Understanding biomass dynamics in semi-arid ecosystems A computational means to an organic end.
- 2. Causal Discovery from Spontaneous Targeted Interventions
- 3. Effects of internal viscosity contrasts in a blood flow model based on immersed boundary lattice Boltzmann methods
- 4. Optimizing Resource Allocation in Socio-economic Systems with the Minority Game: A Case Study on Electric Cars

What does a good project proposal look like?

A good project proposal should:

- 1. Clearly highlight the novelty of the proposed research and how it builds on the current stateof-art?
- 2. Clearly highlights the significance of the research. Why now?



- 3. Clearly highlight the data availability (if applicable) and how data will be accessed.
- 4. Computational techniques that will be applied in the research.
- 5. Planned research outcome.

What does an MSc student from your programme look like?

The programme is oriented to prepare students for entry into a PhD programme in Computational Science or related disciplines, or into research positions outside academia. This is mainly triggered by the strong need in science and society for computationally trained researchers, in academia, industry and business.

A number of core and constrained courses (in the first year) help develop students with an independent and scientific mindset.

1) A CLS student is an expert in modelling and simulation as the third pillar of science and is capable of applying abstract models to understand societal questions. Courses such as Agent-Based Modelling and Complex System Simulation (in addition to teaching knowledge and skills) ask students to develop their own research questions and models by themselves on a diverse set of topics.

2) Students can apply models to Implement and study interventions and what-if scenarios to improve/optimize with respect to a practical application.

3) The student has basic knowledge about different techniques for modelling biochemical reactions, metabolic pathways, regulatory networks and cells (Boolean networks, coupled with ordinary differential equations, examples of partial differential equations, optimization techniques, and cell-based models)

4) Students obtain insight into distributed algorithms - concurrency concepts and are offered a bird'seye view of a wide range of algorithms for basic and important challenges in distributed systems

Main areas of research

- Theory of complex systems
- Urban complexity
- Computational Biology
- Computational Finance

A rough timeline of the thesis

The research should be independent, but conducted under the daily supervision of (one or more) staff member(s) and embedded in a scientific project of the host institute, and should aim at a scientific publication in a conference or peer-reviewed journal. The Master thesis (42EC) should include an extensive literature survey (accounting for 6EC) that will normally commence during Block 2 of Year 2. From Block 3 Year 2 a student on the normal schedule will then spend full time on the



graduation research (a remaining 36EC). The final scheduling should be discussed with the supervisor of the graduation thesis and typically lasts 7 months.

Scope of the project

The projects are not limited to any systems and context as long as they adhere to the requirements.

MSc Computer Science

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By completing the project, a student will be able to:

- Identify a scientific problem in a computer science-related field
- Formulate one or more research questions to guide the project
- Design a solution to answer the research question(s) in a limited period of time, implement the solution and critically analyze the results
- Collaborate with supervisors and other students and communicate (both orally and in writing) about their progress, the results, and the lessons learned.

Main areas of research

- Artificial Intelligence
- Bioinformatics
- Computer Systems
- High Performance Distributed Computing
- Systems and Network Security
- Massivizing Computer Systems
- Foundational and Experimental Security
- Sustainable Digital Society
- Software and Sustainability
- User Centric Data Science
- Decentralized Information Society Engineering
- Theoretical Computer Science

Duration

The thesis should be concluded within 5 months with the majority of the students starting in February.

Course Content

The Master Project is the programme component where scientific and professional skills are trained most extensively. The Master Project always involves an element of originality or creativity. A student will use all the knowledge acquired during the studies to perform a design task or to contribute to solving a scientific problem in the computer science field.



The project can take place either inside the Department of Computer Science of the VU or the Informatics Institute of the University of Amsterdam or as an internship in a company. In the case of an internship, supervision will be in cooperation with a daily supervisor at the company. In both cases, a detailed project proposal must be written and approved in advance by a staff member, who in this way agrees to act as project's main supervisor. The proposal must include: the problem statement, the research question(s), a short description of the proposed method, and a planning that also states the frequency the student will meet with the daily supervisor/main supervisor. The main supervisor needs to find a second reader for the thesis, who must also be a staff member.

Additional Information Teaching Methods

In most cases, the Master project is performed as an individual project, under close and regular supervision by the main supervisor and the daily supervisor. In exceptional and well-argued cases, students may execute projects in small groups, when the project lends itself for. The project starts when the project proposal has been signed by both students and supervisors. The student plans regular meetings with the daily supervisor and the main supervisor to discuss the progress. Towards the end of the project, the student gives a presentation in the research group of the supervisor or at the company where the internship took place. The student submits their thesis which will be evaluated by the main supervisor and the second reader.

Duration The thesis should be concluded within 5 months.

MSc Information Studies (Data Science (DS) and Information Systems (IS))

The MSc Information Studies has two tracks, namely Data Science (DS) and Information Systems (IS). Both investigate the use of particular technology with respect to the origination, collection, classification, analysis, sensemaking, manipulation, storage, retrieval and dissemination of information.

In this context, students in the DS track focus on data, related structures and their algorithmic processing, for the generation of information, and the maintenance of data and information, mainly using machine learning approaches.

Students in the IS track focus on cognitive and social implications for the structures within and the use of information systems. Here the relation between data, information and knowledge is investigated on a systems level, including the design of datasets, interaction environments and underlying system architectures.

Project requirements

The submitted project must be written in English. If the project requires a Dutch speaker please state that in the project description. The student has to have finished all courses from the 4 blocks of the programme. The research project's objective is to give the student an opportunity to acquire practical experience in quantitative and qualitative scientific research methods and to learn to work independently. The project requires an implementation that can be validated.



A typical Data Science thesis requires hand-labelled data, sufficient complexity going beyond simple approaches such as linear regression and a proper evaluation setup (cross-validation, using more than 1 dataset, train/test, et cetera). For an Information Systems thesis, it is required to have a proper validation for a quantitative or qualitative study. When interviews are used to get a requirement set, the set must be validated and this will normally be done by means of a design (interface, small algorithmic test, outline of a test framework, et cetera).

A master thesis is defined as "an individually written record of the student's performed original research or design of a scientific nature". It is an original, independent piece of work especially composed for this occasion containing the creative ideas of the student. Claims, hypotheses, policy recommendations and design choices need to be supported with arguments based on existing theory or empirical evidence.

The master thesis cannot consist of copied resources (internet, books, and journals), unless properly quoted, and the material has not already been submitted elsewhere (other courses, study programmes, universities) with the aim to receive study credits for this. The master thesis can, however, elaborate on previously submitted work, as long as it is clear which contribution of the student has been submitted for which study programme component.

The goal of the thesis

The focus of the thesis research will be the scientific study of a problem-oriented toward actual research themes in academia and society. The thesis project provides students with first-hand experience in working with established scientists or industry experts for a prolonged period of time.

The learning objectives of the research project comprise, that after completion of the thesis project, the student:

- is able to formulate a clear research question in the field of information studies and design a plan to answer that question
- can show state-of-the-art knowledge in the area of the research project based on the relevant literature by applying in a practical situation
- is able to process the research data and to critically judge the obtained results in relation to the goals and the line of research of which the research project is part
- is able to describe and critically discuss the above activities in a written report, in which the methodology is accounted for and the original phrasing is substantiated
- is able to present and discuss the results to a scientific and non-scientific audience
- is able to function in a professional environment.

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Examples of successful past thesis projects

- 1. Efficient Image Similarity Clustering within Apple Orchards on Edge Devices
- 2. Echocardiographic Clustering by Machine Learning in Children with Early Surgically Corrected Congenital Heart Disease
- 3. End-to-End Learning on Multi-Edge Graphs with Graph Convolutional Networks
- 4. Improving the Precision of the HyperLogLog Algorithm by Introducing a Bias
- 5. A Business Value Perspective on Metadata Management
- 6. A Requirements-Driven Redesign of a Terminology Maintenance Process in the Netherlands
- 7. Carsharing: panacea or everlasting promise: Simulating the effect of car sharing policies on the modal split in Amsterdam

What does an MSc student from your programme look like?

The students have good analytical skills regarding problem identification. They can identify potential solutions to the problem and then find in this solution space the answer that best addresses the problem.



Main areas of research

- Machine Learning
- NLP
- Media analysis
- data analytics
- HCI

As the program is interdisciplinary the students have a broad variety of domains they are knowledgeable in.

A rough timeline of the thesis

The project runs in two parts - a 3-month thesis design (part-time) and a 3-month project (full-time). The usual start date of the actual thesis project is the 1st of April to the 30th of June).

Scope of the project

The student has addressed a feasible problem through a research question that can be answered through quantitative or qualitative methods. As the project time is fixed to 3 months the problem cannot be complex and might address a smaller problem (i.e. the comparison of two machine learning approaches to identify the applicability of one as superior).

MSc Logic

Project requirements

The submitted project must be written in English. If the project requires a Dutch speaker please state that in the project description.

30EC of work, including the writing of the thesis.

The goal of the thesis

The thesis is a report on a substantial piece of scientific work, usually including a significant amount of original research that clearly demonstrates the student's capacity to independently conduct research in an interdisciplinary environment.

Examples of successful past thesis projects



- 1. Communicate and Vote: Collective Truth-tracking in Networks
- 2. The Classicality of Epistemic Multilateral Logic
- 3. A Compositional Analysis of Dependence Statements
- 4. Hyperintensional Logics for Evidence, Knowledge and Belief
- 5. Algebraic models of type theory

What does a good project proposal look like? What do you want to see included?

To be decided case by case.

What does an MSc student from your programme look like?

Mainly formal-theoretical research skills, background in the theoretical sciences like, e.g., Theoretical Computer Science, Theoretical Linguistics, Mathematics and Philosophy.

Main areas of research

Theoretical sciences such as:

- Theoretical Computer Science
- Theoretical Linguistics
- Mathematics
- Philosophy

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The whole thesis amounts to roughly 5 months of work.

Scope of the project

Depends on the project.



MSc Software Engineering

Project requirements

The submitted project must be written in English. If the project requires a Dutch speaker please state that in the project description.

The project requires scientific research contributions. The project should be a mix of theory and practice.

The goal of the thesis

The student should aim to master the scientific research process.

Examples of successful past thesis projects

 Measuring the degree of library dependency (available at: <u>https://zenodo.org/record/4280883#.YqiXvexBzPY</u>)

What does a good project proposal look like? What do you want to see included?

A clear description of the dataset/infrastructure/lab-like environment/real-life case/application that the company can provide the student access to.

What does an MSc student from your programme look like?

The students from MSc SE are quite heterogenous: different countries, and different previous education; one thing they have in common: software is their second nature.

Main areas of research

- Software engineering
- Software testing
- Software evolution
- Model-based design
- DevOps
- Requirements engineering
- Software process



- Microservices
- Programming languages
- Cybe-physical systems
- MLOps
- DataOps
- DApps
- Data engineering

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1 month thesis proposal, 3-5 months thesis implementation

Scope of the project



Ideally, publishable research, at least at a workshop level

Important information

We work a lot of time on co-designing the research proposals. We do not expect companies to be able to formulate scientific research questions, but we always find very interesting scientific research problems that could be solved by our students and the solutions validated in the context of these companies. So, for SE, the companies are lab-like environments where our students conduct real-life experiments. This is extremely valuable and makes our program attractive and high standard. This means however a lot of work in the weeks after the Thesis Fair when the thesis coordinator sits down with students and helps them identify the research gap in these industry projects.

Of course, this is mostly not the case with projects proposed by our former students that are now working in various companies. They already know what we look for in a project and how to formulate scientific research questions.