COGNITIVE ARTIFICIAL INTELLIGENCE

MASTER PROGRAMME

Universiteit Utrecht

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Are you fascinated by the possibilities of the computer and the workings of the human mind? Would you like to employ knowledge of the human mind in the construction of intelligent artificial systems? Or put knowledge of machines to work in the process of achieving a better understanding of the human mind? Would you try to attain these goals by combining insights from philosophy, computer science, linguistics and cognitive science? Then Cognitive Artificial Intelligence is the master programme you are looking for!

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INTRODUCTION

The central theme of the master programme Cognitive Artificial Intelligence - CAI - is the integration of two kinds of knowledge: knowledge of human intelligence and knowledge of machine intelligence.

The man/machine theme can be given two different directions of fit: alternately, our primary focus may be understanding human intelligence or constructing intelligent machines. If the primary focus is understanding human intelligence, then knowledge of machines becomes a modeling tool. We use machines to simulate human abilities, thereby learning things about those abilities. If, on the other hand, the primary focus is the construction of intelligent machines, then our knowledge of human capacities can be used as

a heuristics in developing the desired capabilities for such machines. In the CAI master programme there is a balance between the two perspectives: both directions of fit are omnipresent.

It will be clear that the idea of modeling plays a crucial role in CAI. The methodology of modeling functions as a bridge between theory and experiment. For this reason our students have to master the use of modeling tools from logic and computer science. An additional essential component of our curriculum, which makes the CAI master programme unique among the Dutch Artificial Intelligence master programmes, is the importance it attaches to philosophical reflection. Various philosophical courses in the curriculum study the man/machine theme from a foundational perspective.

Every CAI student chooses an individual track. Though it is expected to cover the whole area of Artificial Intelligence, each invididual track is required to have its own methodological emphasis: experimental, philosophical or mathematico-logical. In order to help the student in choosing, we have developed three ready-made sample tracks:

- Cognitive Dynamics (experimental)
- Artificial Intelligence and its foundations (philosophical)
- Agents, Language and Speech Technology (mathematico-logical)

These sample tracks will be discussed below.

GLOBAL STRUCTURE OF THE PROGRAMME

Cognitive Artificial Intelligence consists of a full-time two-year master programme of 120 ECTS. The 60 ECTS of the first year are spent on 3 mandatory courses (22,5 ECTS) and 5 optional courses (37,5 ECTS). The Seminar Artificial Intelligence is a mandatory course which has to be taken by all CAI master students; the other two mandatory courses are determined by the individual track one is following.

In addition to this, all CAI master students devote half (30 ECTS) of their second year to research work which results in writing a master's thesis. The destination of the remaining half year (30 ECTS) depends on the particular profile of the master programme. In the research-oriented P-profile it is devoted to research, possibly carried out in the context of a research internship; in the societal M-profile it is spent on an internship in a company, optionally in combination with one or more management courses; and in the C&E-profile the internship in the field of communication and education may be combined with one or more didactic courses.

TRACK 1: COGNITIVE DYNAMICS

Artificial intelligence can be approached in different ways. Some see artificial intelligence as a matter of engineering, where anything goes as long as it works. However, as argued above, Cognitive Artificial Intelligence takes a more restricted route. It aims at obtaining knowledge of how our brain and body are engineered by nature and tries to put this knowledge to use.

More specifically, the CAI master track Cognitive Dynamics is primarily focused on understanding human intelligence. Questions such as: how do we perceive, how do we solve problems, how do we understand and produce language, how do we store information, etc., have been addressed since decades by cognitive scientists, and answers to AI questions should be based on that massive source of information.

Accordingly, the track Cognitive Dynamics does not produce engineers but provides students with a thorough knowledge of how the brain works and how the brain and body interact with the environment. Moreover, and that makes Cognitive Dynamics different from an ordinary cognitive science approach, the track also focuses on how this fundamental knowledge can be used for building working applications.

As persons, we are constantly in interaction with our environment. As such, we are dynamic entities. This also holds for artificial humanoids. We act and react to language, and problem solving is another example of an active process in which many different brain areas are involved. These areas are recruited at the time the brain thinks they are needed. There is no such thing as static brain and body activity. Therefore, Cognitive Dynamics focuses on the study of cognitive processes. The name of the track signals the conviction that, in last analysis, cognition can only be understood as a process.

a master's thesis

COGNITIVE DYNAMICS

EVA VAN DEN BROEK: Birdsong often assumes a rhythmic form. What evolutionary forces could have shaped the form of animal signals in this direction? Darwin already suggested a possible mechanism: female choice. By now, there is mathematical and empirical evidence that the rhythm of birdsong is indeed a reliable basis for female assessment of mate quality. In my master's thesis I explore the idea of rhythm as a quality indicator for partner choice by constructing an evolutionary model. The choice for an evolutionary approach is based on the nature of the problem: in communication and, more generally, signaling, the design of the signal and sender/receiver influence each other over evolutionary time. My model represents both male 'songs' and female 'judging devices' as bit strings. Males produce songs by copying their inborn template with a number of mistakes, inversely proportional to their quality. The females assess mate quality by comparing their own template to the male song. As the number of a female's offspring (inheriting the used templates) is relative to the quality of the male, choosing a high quality male will yield an evolutionary advantage. **EXCERPT FROM ' "**PiepPiepPiep - Ich Hab' Dich Lieb**":** Rhythm as Indicator of Mate Quality **'**

TRACK 2: AI AND ITS FOUNDATIONS

The very idea of Artificial Intelligence has emerged from philosophical debates about the nature of thinking, reasoning and logic. These debates have surfaced throughout the history of philosophy, but have become permanently prominent since it was shown at the end of the nineteenth century that logic could be formalized in an abstract calculus. This result immediately raised the question whether human thinking itself could be compared to a kind of computation or, to put it more boldly, was nothing but a computational manipulation of symbols.

When Alan Turing was developing his blueprints of possible mechanical procedures for proving the truth of certain mathematical theorems, his ideas were mere thought experiments. However, the development of sophisticated hardware computers has given the nature of these thought experiments a realistic twist. As a result, the question whether computers can think has become a real-life issue. And from this straightforward question more refined ones have ensued, such as: what test, if any, could possibly determine whether computers can think? Are symbols required for thinking? Is thinking inextricably involved with emotions? Does thinking require consciousness? Does not the existence of mathematical creativity establish that the mechanical procedures followed by computers will always fall short of the criterion for genuine thinking?

To address these questions properly it is necessary to study the philosophical questions in some detail, in order to appreciate the challenges they raise, and to do research in the foundational field of information science, in order to find out to what extent these challenges can be met. For this reason, the CAI master track Artificial Intelligence and Its Foundations supplements philosophical reflection with theoretical computation.

a master's thesis

WOUTER HUIJNINK: In my master's thesis I have tried to find out whether supervenience is a useful concept for nonreductive theories of mind. One of the main topics in the philosophy of mind is the relation between mind and matter: how can it possibly be that physical stuff gives rise to mental phenomena? Many philosophers agree that we need a concept for reconciling a materialistic ontology with a nonreductive view of the mental domain, and Davidson introduced the by now quite popular idea of supervenience for this very purpose. Supervenience comes down to: `no difference of one sort without differences of another sort'. If, for example, the tuning of a guitar supervenes on the tension on its strings, then two guitars cannot be differently tuned without differing in the tension on their strings. The philosopher Kim, who started out as an inspired proponent of supervenience, eventually arrived at the conclusion that supervenience is useless and that, in fact, it is even impossible to formulate a tenable nonreductive theory of mind. My master's thesis is devoted to a critical analysis of Kim's argumentation.

EXCERPT FROM 'Supervenience in Nonreductive Theories of Mind'

AI AND ITS FOUNDATIONS

TRACK 3: AGENTS, LANGUAGE AND SPEECH TECHNOLOGY

The CAI master track Agents, Language and Speech Technology brings together two fields of study that all too often are moving in separate orbits. On the one hand, research on Agents focuses on intelligent computer systems with the ability to act and communicate autonomously in a dynamically changing environment. On the other hand, Computational Linguistics studies the most versatile instrument for communication, reasoning, coordination and negotiation—human language—and seeks to embed linguistic knowledge in language and speech technology. The combination of the two disciplines allows the student to fully appreciate the foundational basis and the computational techniques that are shared by them.

In this respect the following key topics should be mentioned: the use of modal logic, both in (multi-)agent technology and for modeling the composition of form and meaning in language; a focus on resource-sensitive, rather than general-purpose, models of computation which allow for tailored technology exploiting built-in economy principles of specific subsystems that may not be shared at a global system level; and, related to the above, the careful balance between statistical approaches and 'deep' logic-based methods where reasoning and inference are concerned.

The course offerings in this track reflect cutting-edge research themes of the faculty involved. This means that students can actively participate in, and contribute to, high-profile research projects, both of a more foundational nature and with an application-oriented perspective. Examples of such research projects are Cooperative and Adaptive Multi-Agent Organizations, or the Spoken Dutch Corpus, the new fundamental resource for the development of Dutch language and speech technology.

a master's thesis

JURRIAAN VAN DIGGELEN: Agent research comprises three areas: agent theories aim at providing a mathematical formalization of agents; agent architectures attempt to design software systems that display the desired behavior of agents; and agent programming languages seek to implement agents in a clear and intuitive way. In existing research, one can distinguish at least two different views on the relationship between theory and practice. Many people agree that achitectures or programming languages should be grounded in solid formal theories: 'no implementation without specification'. Since such one-way traffic tends to result in implementations that cannot handle noisy and unpredictable circumstances or theories that refrain from possible implementation, some people have reversely insisted: 'no specification without implementation'. Attempting to establish harmony between theory and implementation, my master's thesis proposes a model which develops theory, architecture and programming language simultaneously. The resulting agent theory combines dynamic and epistemic logic with probabilities and serves as a foundation for an agent programming language.

EXCERPT FROM 'Using Modal Logic in Mobile Robots'

AGENTS, LANGUAGE AND SPEECH TECHNOLOGY

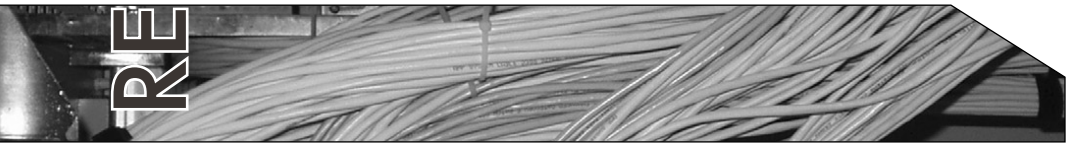
RELATED MASTERS

Artificial Intelligence can also be mastered at the University of Amsterdam, at the Free University in Amsterdam, and at the Universities of Groningen, Nijmegen and Maastricht. Moreover, Utrecht University offers two masters which are closely related to Cognitive Artificial Intelligence. We will briefly describe them and explain the main differences.

First, there is Agent and Computational intelligence (ACI), which is part of the master programme Computer Science. In ACI, the focus is on the construction of intelligent artifacts, where insight in the human capacities is used as a possible heuristics. ACI operates entirely from the engineering perspective and the methods taught are mainly derived from computer science and logic.

On the human/cognitive side, there is the master Cognitive Neuroscience (CNS), which is part of the master programme Neuroscience and Cognition. In CNS, there is a strong focus on experimental data concerning human functioning and on experimental techniques. CNS operates from the perspective of experimental science.

In Cognitive Artificial Intelligence, the technical and the experimental perspective are present as well, but the question of man/machine intelligence occupies a central position. In consequence, the CAI curriculum pays substantial attention to insights concerning man and machine, to modeling methods and methodology, and to philosophical foundations.



CAI AND ITS ENVIRONS

UTRECHT UNIVERSITY Utrecht has a reputation for the quality and innovative nature of its teaching and research in many fields, several of which are recognised for their excellence, both nationally and internationally. Another distinguishing trait is the strong multidisciplinary collaboration among departments and faculties. Accordingly, Utrecht University is a highly suitable location for interdisciplinary studies.

INCOGNITO Cognitive Artificial Intelligence boasts an extremely active community of students. The center of this activity is the students' association Incognito, whose membership comprises more than 95% of all CAI-students! Incognito, which has a room of its own at the department, organizes scientific activities such as lectures, workshops and field trips to congresses and companies; Incognito also takes care of social activities such as parties, get-togethers, poetry nights, pool tournaments, and what have you; Incognito's magazine AiAiAi publishes satirico-scientific articles about everything the editing board considers fit to print; Incognito organises an annual scientific symposium and a yearly study trip, the latter of which combines scientific activities with socio-cultural exploration (previous destinations include Paris, Rome, Vienna, Prague and Budapest); and, last but not least, text books can be ordered via Incognito at a discount prize. . .

AFTER THE MASTER

Many graduated master students find employment in business or government, for example as employee—or entrepreneur—in an information and communication technology company. For graduates who have followed the research-oriented P-profile, the master degree provides an opportunity to start a Ph.D. research project leading to a doctoral degree in any CAI-related topic at a university in the Netherlands or abroad. Graduates who have opted for the society-oriented M-profile have somewhat different prospectives: they may become organization expert, management consultant, policymaker, etc. The ones who have chosen the communication-and-education-oriented C&E-profile may expect to find employment as a public relations employee or public information officer, or become a scientific journalist.

'In any domain, changing the way a person works requires not only a comprehension of the technical issues involved, but also a clear view of organisational, and even cultural, aspects. At the university I have learned to look at problems from multiple directions and to listen to people with different views. This multidisciplinary perspective is something I learned from studying CAI.'

After his graduation, ***Roland Staring*** *started working for Unilever Research. As a knowledge manager in the department of biotechnology, he was responsible for the development of tools for supporting bioengineers in their daily tasks of improving food quality and production optimisation. He did this for two years and then moved on to his second job at SURFnet. He is currently responsible for innovative use of information and communication technology in the educational domain.*

MORE INFORMATION:

- Visit information days; consult the online schedule at *http://www.studiekiezers.uu.nl*
- Consult *http://www.phil.uu.nl/onderwijs/cki* to get the most recent information about the Master programme's subjects.
- To get an idea about the people studying CAI, visit the website of Incognito, the student association *(http://www.uscki.nl)*.
- If you have specific questions, contact the student counsellor *(studieadviseur.cki@phil.uu.nl or 030 - 253 1259)*.

REQUIREMENTS

WO BACHELOR: BSc in Artificial Intelligence or a Bachelor's degree in one of the following subjects, with a corresponding minor in AI: Cognitive Science, Linguistics, Philosophy, or Computer Science.

HBO BACHELOR: HBO graduates can be accepted depending on the candidate's actual programme.

Application forms can be ordered via http://www.uu.nl/masters.

An interview could be part of the application procedure.

'The combination of psychology, computer science, philosophy and logic is one of the most promising and expanding research fields. More and more mechanisms of brain processes are being formulated in biologically plausible systems.

Combining multiple research fields is, according to me, the advantage of the CAI master programme: it incorporates sufficient education in all these areas – which gives you a step ahead.'

Two months before his graduation, ***Stefan van der Stigchel*** *successfully applied for a Ph.D.-position at the Free University in Amsterdam. He is now working at the Cognitive Psychology lab, where he is doing experimental research on eye movements and developing a computational model for programming them.*