Artificial intelligence

About Artificial intelligence
Artificial intelligence (AI) is a technique by which computers perform multiple tasks, including cognitive tasks, which in the past have only been performed by humans. AI is increasingly becoming more interwoven in our society. AI algorithms perform an increasingly large number of daily tasks in modern society, though not usually labelled as AI. AI thus influences several aspects of our daily routine. This influence may be unnoticeable but has profound societal consequences. On the one hand, AI systems offer a range of advantages and opportunities. AI may help to ensure that operations run more efficiently, improve services for people, and reduce operational costs. For example, AI has been an important tool in several efforts to address the COVID-19 pandemic. Among other activities, AI has been used in outbreak prediction and tracking, contact tracing, early diagnosis, as well as curbing the spread of misinformation. On the other hand, many aspects of AI systems raise a host of ethical and governance issues. There are serious concerns that AI systems can violate human rights and exacerbate existing inequalities and structural discrimination.

This proposal considers AI as an inseparable element of the society. For AI to support humanity, human values should be central in the development of AI systems. As such, from the “comprehensive engineering” perspective, TPM intends to incorporate AI as an inseparable element of the society in research and in education. This implies “studying AI in society” as well as “using AI to understand society”. At present, TPM students still lack this understanding of AI as an element of socio-technical systems. They are thus not prepared to address the challenges and questions that AI will pose to them in their future careers. To fill this gap, the present MSc proposal has been developed especially for TPM students and students with closely adjacent backgrounds. This specialization has two AI pillars:

1. Studying the role of AI in society
    - Ethical consideration of AI
    - Societal and governance consideration of AI
2. Using AI to understand society
    - Data science and Machine learning for socio-technical systems
    - Modelling and Simulation as AI tools to study socio-technical systems”

Target group
TPM students and students with closely adjacent backgrounds. The students need to have some basic background knowledge in computer programming.

Job Specialisation
This specialization capacitates professionals to use and develop AI systems and deal with societal and ethical dilemmas associated with AI systems. It provides students with state of the art knowledge on data science, machine learning, simulation and modelling, and ethics and governance.

Overview
The AI specialization has three courses which are selected by students based on their preferences as well as the M.Sc. program they are following. The courses on Data Science and Machine learning as well as Modelling and Simulation are mandatory. For the third course, the students have the option to choose between "AI and Ethics" or "AI and Governance". Each course is briefly described below (more details can be found in the Appendix).

Detailed description

1. **Studying the role of AI in society**: Two courses are proposed here, and the students have the option to choose between them. The students from any of the TPM MSc programme can choose either of these courses depending on their interests.

Ethics of AI [option a] (TPM014B): The course first provides an introduction to theories of normative ethics: utilitarianism, deontology, virtue ethics. The distinction between descriptive and normative claim, epistemology and ethics, values, norms, and virtues.

- *Ethical and epistemological issues in AI*: identification of six different sources of ethical and epistemological concerns in AI.
- *Bias in AI*: Automated-decision making systems are polluted with different forms of bias that can be found at a different level. Here we address the different forms of bias and what can be done about it.
- *Explanatory AI and the right to explanation*: The GDPR grants the so-called "right to an explanation." But what does this means, and how far have we got into explanatory AI? In this unit, we explore the scope and limits of current approaches to explainable AI and how this affects users' rights
- *Privacy*: there are different forms in which privacy is studied and understood. In addition, this unit discusses the value of privacy in AI in comparison with other values, such as explainability, accuracy, bias, and fairness)
- *Trustworthy AI*: What does it mean to trust an AI system? is there more than one way to trustworthy AI? can we design trust? In this unit, we will address questions such as these. We will also present and discuss the two major approaches to trustworthy AI, namely, transparency and computational reliabilism. Lights and shadows of both.

Artificial Intelligence and Cybernetic Justice [option b] (TPM038A): The course will cover various concepts of AI governance. It will lean towards combining concepts that center marginalized communities and address issues of oppression and liberation, drawing from cybernetics, (eco)systems theory, critical algorithm studies, intersectionality studies, reflection and speculative and critical design for community empowerment. It will likely look at different kinds of ecosystems in which algorithms/data/AI play a role, including online ecosystems, work and labor, energy systems and ecological systems. The idea is to have teams of students study a particular kind of ecosystem and bring to bear a mix of the above contexts to better assess the implications and potential roles of data and algorithms and to identify ways of designing for social movement and change.

2. **Using AI to understand society** - Machine learning and data science: Two courses are proposed here to accommodate COSEM/EPA and MOT students. For IE students, given the diverse educational backgrounds, either of the courses are possible after consultation with the coordinators.

Machine learning for socio-technical systems (TPM034A) for EPA students and COSEM students: Machine Learning (ML) is rapidly changing the way we do science and engineer systems and services, both inside and outside academia. Due to its increasing and widespread use, ML will be more and more engrained in, and be an integral part of, future societies. Successful adoption of ML by societies in all its breadth does not only require skilled ML professionals that do the hard-core programming (i.e. professionals with full-fledged computer science backgrounds), but also of the sort that have profound domain knowledge where ML is applied, such as in socio-technical systems. ML will increasingly be a part of the puzzle to solve complex challenges of today's networked, urbanized knowledge societies. Therefore, TPM MSc students of all programmes must have a thorough understanding of ML.

Introduction to Data Science (EPA1316A - Q1) for MOT Students: The primary purpose of this course is to teach future data scientists to look beyond the technical power of artificial intelligence and recognize the possibilities and

limitations of data and the spatial inequalities that galvanize as a result of the data-driven policy. This course will engage students at the intersection of data science, urbanization, and effective communication. By interrogating the sociotechnical nature of urban problems, students should then be able to approach solutions to these problems in ways that priorities social equality and equity. This class will train students to gather, fuse and clean data from multiple sources, in order to gain useful insights into the reality of multiple problems in urban ecosystems, understand and estimate alternative implications of solutions and communicate results to a wide audience effectively. NOTE: for this course, you need to have basic programming knowledge, otherwise you will not be able to follow this course and therefore the specialization.

3. **Modelling and simulation**: Two courses are proposed here to accommodate COSEM/EPA and MOT students. For IE students, given the diverse educational backgrounds, either of the courses are possible after consultation with the coordinators.

Simulation Masterclass (SEN9110 - Q1) for EPA and COSEM students: System Theory, Object Orientation, Discrete Event System Specification, Multi-Formalism Simulation, Distributed Simulation, Real-Time Simulation, Multi-Paradigm Simulation, Multi-Resolution Simulation, and Simulation Language selection will be the core topics of the course. After an introduction to system theory, the inner working of simulation environments will be illustrated on the basis of the DEVS, DESS, and DTSS formalisms. Then, possible integrating of the different formalisms will be shown. Several special topics will be taught, based on the latest research in simulation. This material will be illustrated in intensive and interactive courses. In addition to the lecture topics, several other simulation topics will be studied by groups of students, who will write a scientific paper, and present their findings in class. These topics can be focused on the MSc program that the students participate in; special topics to study are available for TIL, CoSEM, EPA, Computer Science, and other students. Finally, groups of students will study a simulation package in-depth and discuss the commonalities and differences with other packages. Again, the package chosen can be targeted at the MSc program of the students. TIL students can, e.g. study a package that is more aimed at logistics and transport, CoSEM students can focus on a package that is used in systems design, whereas EPA students can focus on a package used in policy analysis. Most packages can be made available for use from home. The course contains very little overlap with other simulation courses such as EPA1321, EPA1351, TB233A. It requires experience with a simulation environment such as Arena, Simio, or Toma.

Introduction to TPM Modelling (EPA1324 - Q2) for MOT students: This module introduces two different methods for modelling and simulating complex grand challenges. The theory is discussed according to the modelling cycle: Problem articulation, Conceptualization, Formulation, Evaluation, and Policy analysis. The course focusses on the basics of continuous modelling (i.e., System Dynamics) and of discrete modelling (i.e., Agent Based modelling).

Prior knowledge
Basic programming knowledge is required to follow this specialization. Please also check the requirements for each course before starting this specialization

Additional information
For other courses related to AI from other faculties, please have a look at the TPM AI lab website. Other courses from other faculties can replace the courses within this specialisation upon consultation with the specialization coordinator.

Contact
In case of questions, please contact the coordinator A. Ghorbani (A.Ghorbani@tudelft.nl).