Unit 1: Principles of Programming for AI

Aims

- To introduce students to the development of computer software, including problem analysis, establishing requirements, designing, implementing and evaluating.
- To provide students with the terminology and concepts of programming, irrespective of the language being used. To provide practical skills at reading and writing programs and producing programs to solve real world problems.
- To help students gain confidence in programming in the taught languages and in being able to learn different programming languages and programming paradigms.
- To extend the notion of software development to AI as an application area.

Learning Outcomes

After taking this unit the student should be able to:

- Describe the design of a computer program separately from its implementation.
- Explain debugging and testing methods and how they contribute to robust code.
- Design, construct, evaluate and analyse the efficiency of data structures and algorithms.
- Implement more advanced concepts of AI programming using appropriate libraries and frameworks.

Content

- Introduction to common programming language for AI.
- Explore domain-specific applications, such as, simulation and models, algorithms for common domain specific tasks and complex data structures and algorithms.
- Limits of computation.

Assessment

- 10% - Exercise Sheet 1
- 10% - Exercise Sheet 2
- 10% - Exercise Sheet 3
- 60% - Enigma Machine (Python)
- 10% - Exercise Sheet 4

Unit 2: Mathematics for AI

Aims

Students should gain an understanding of the basic theory of probability and statistics. Students will recognise when this theory can be applied in practice.

Learning Outcomes

After taking this unit the student should be able to:

- Perform elementary mathematical operations in probability and statistics.
- Translate real-world problems into a probabilistic or statistical framework.
- Solve statistical problems in abstract form.
- Critically interpret outcomes in a real-world context.
- Relate underlying theory to requirements in practical data science.

Content

Example topics covered include: The laws of probability. Discrete and continuous random variables. Bayes' Theorem. Expectation, variance and correlation. Conditional and marginal distributions. Common distributions including the normal, binomial and Poisson. Statistical estimation including maximum likelihood. Hypothesis testing and confidence intervals.

Assessment

- Week 3: 30% - Problem Sheet 1
- Week 5: 30% - Problem Sheet 2
- Week 8: 40% - Problem Sheet 3

Unit 3: Foundations of AI

Aims

To introduce students to the fundamental concepts of artificial intelligence (AI).

Learning Outcomes

After taking this unit the student should be able to:

- Demonstrate understanding of a range of AI techniques, their strengths, and their limitations.
- Demonstrate understanding of the fundamentals of probability theory and its role in AI.
- Apply various AI techniques to simple problems.

Content

Goals, foundations, and history of AI; problem solving through state-space search; logical reasoning; probabilistic reasoning; machine learning; examples of state-of-the-art AI applications; social, legal, and ethical implications of AI.

Assessment

- Week 2: 30% - Sudoku, Search Algorithm (Python)
- Week 4: 30% - Dice Game, Markov Decision Process (Python)
- Week 8: 40% - Spam Filtering, Supervised Learning (Python)

Unit 4: Applications of AI

Aims

- To build confidence in numeric programming in a relevant language (for example, Python)
- How to undertake lower-level AI using that language (and its associated libraries) using the example of data science, and how to scale up and apply higher-level software to AI problems, using data science as an example e.g. to "Big Data".

Learning Outcomes

After taking this unit the student should be able to:

- Critically evaluate the features of various programming languages and software packages for AI focusing on data science as the application domain.
- Explain, relate and accommodate factors affecting complexity, performance, numerics, scalability and deliverability of solutions.
- Implement low-level data science functionality using a relevant programming language (e.g. Python).
- Apply a range of complex analytic methodologies, notably machine learning techniques, using relevant software libraries.
- Assess the applicability and relevance of key "Big Data" software technologies in varied scenarios.

Content

- Introduce a relevant programming language for data science (e.g. Python): general computing, use of essential libraries for data science as an applicatication domain of AI (e.g. Numpy, Scipy, Matplotlib, Scikit-learn in the context of Python) and numerical and performance factors underlying.
- The use of data structures, database systems, and software technologies for scalability, from the viewpoint of both storage and computation.
- Social, legal, and ethical implications of AI.

Assessment

TBA

Unit 5: Humans and Intelligent Machines

Aims

- To give students an understanding of current theoretical, methodological and practical research issues around human interaction with robots and other computational intelligence.
- To teach students relevant knowledge and skills related to the design, implementation, evaluation and management of systems involving humans and intelligent machines.
- To raise students' awareness of ethical and related challenges and constraints around the coexistence and collaboration of humans and intelligent machines.
- To give students experience of researching advanced topics in computer science, summarising the current state of the art, undertaking a relevant study and presenting the results.

Learning Outcomes

After taking this unit the student should be able to:

- Demonstrate an understanding of current practice and developments in systems involving humans and intelligent machines.
- Show awareness of intelligent systems design issues.
- Critically evaluate examples of the design and deployment of intelligent systems.
- Recognize and challenge advances in the state of the art of intelligent systems.
- Design, conduct and critique original research to address questions and challenges in the design and use of systems involving humans and machine intelligence.

Content

Course content will draw on a range of foundational and current issues in relevant areas. Examples of the topics from which these will be drawn include:

- What is machine intelligence?
- A systems approach to human-machine interaction.
- What aspects of humans and non-human agents should be considered in designing intelligent systems?
- Robots and diverse human needs, e.g. the young, the old, disabled people.
- Active learning.
- Social, legal, and ethical implications of AI, focusing on the ethics and safety of machine intelligence.
- Centaur AI and cyborgs.

Assessment

TBA

Unit 6: Introduction to NLP

Aims

To provide an introduction to the theory and practice of natural language processing.

Learning Outcomes

After taking this unit the student should be able to:

- Demonstrate knowledge of the fundamental principles of natural language processing.
- Demonstrate understanding of key algorithms for natural language processing.
- Write programs that process language.
- Evaluate the performance of programs that process language.

Content

Topics covered by this unit will typically include language models, word vector, topic models, part-of-speech tagging, named entity recognition, parsing, information extraction, information retrieval, text classification, speech recognition, sentiment analysis, machine translation, social, legal, and ethical implications of AI.

Assessment

TBA

Unit 7: AI Systems Engineering

Aims

- To develop skills in critically analysing problems for appropriate software solutions.
- To develop the ability to contrast the various software development paradigms.

Learning Outcomes

After taking this unit the student should be able to:

- Critically evaluate and contrast contemporary software engineering paradigms for defined software engineering problems, focusing on the development of AI software, given a set of relevant development constraints.
- Compare and contrast the roles, responsibilities, benefits and drawbacks of different team organization structures for software development, given a set of relevant development constraints.
- Identify social, legal, and ethical issues in applications of AI.

Content

- The building blocks of software focusing on AI software engineering.
- Software engineering concepts: abstraction, modularisation, encapsulation, data hiding, reuse, white-box and black-box inheritance, refactoring, smells, mocks, stubs, design patterns, formal verification, automated testing and property-based testing.
- Principles for engineering complex software systems. The effect of the programming language on design and implementation issues. Team structures. Tie vs. feature boxing. Pair working.
- Social, legal, and ethical implications of AI.

Assessment

TBA

Unit 8: Further AI

Aims

- To present a detailed introduction to formal artificial intelligence.
- To establish a practical understanding of intelligence and computation as strategies for problem solving, and the nature of the problems amenable to various established strategies and approaches.

Learning Outcomes

After taking this unit the student should be able to:

- Understand a wide range of AI techniques, their advantages and disadvantages.
- Appreciate AI as a mechanism to deal with computationally hard problems in a practical manner.
- Understand the concepts of formal AI and put them into practice. Write small to medium sized programs for aspects of Artificial Intelligence.
- Critically evaluate state-of-the-art AI applications.

Content

- Goals and foundations of AI.
- Problem solving (uninformed, heuristic, and adversarial search; constraint satisfaction).
- Logical reasoning (propositional logic, first-order logic, logic programming).
- Probabilistic reasoning (probability models, Bayesian networks).
- Machine learning (possible topics include decision trees, nearest-neighbor methods, reinforcement learning, neural networks, support vector machines, boosting).
- State-of-the-art AI applications will be discussed throughout the unit.
- Social, legal, and ethical implications of AI.

Assessment

TBA

Unit 9a: Machine Learning

Aims

To provide an overview of the theory and practice of machine learning.

Learning Outcomes

After taking this unit the student should be able to:

- Distinguish between different formulations of the machine learning challenge such as supervised and reinforcement learning,
- Demonstrate understanding of a wide range of machine learning techniques, their strengths, and their limitations,
- Write code in a relevant programming language (e.g. Python) and employ software libraries to solve problems in machine learning.

Content

Topics covered by this unit will typically include central concepts and algorithms of supervised, unsupervised, and reinforcement learning such as support vector machines, deep neural networks, regularisation, ensemble methods, random forest, Markov Decision Processes, Q-learning, clustering, dimensionality reduction and social, legal, and ethical implications of AI.

Assessment

TBA

Unit 9b: Foundations and Frontiers of Machine Learning

Aims

To develop a solid foundation for the theory and practice of machine learning, including mathematical, statistical and computational skills to understand and implement modern machine learning methods.

Learning Outcomes

After taking this unit the student should be able to:

- Understand the important theoretical concepts and algorithms in modern machine learning.
- Understand state-of-the-art applications of machine learning and open research questions.
- Appraise the suitability of various machine learning methods for a given application.

Content

Topics covered by this unit will typically include optimization, stochastic gradient descent, backpropagation, various architectures for neural networks, and state-of-the art applications of machine learning and social, legal, and ethical implications of AI. Also included are research seminars based on current research in the department.

Assessment

TBA

Unit 10a: AI as a Social and Political Practice

Aims

This unit will:

- Explore and evaluate key theoretical and political debates around the development, emergence and adoption of (digital) technologies in social and political practice.
- Explain the position of AI, machine-learning and robotics in relation to these debates, and assess their distinctiveness as specific technological developments.
- Explore the ways in which contemporary developments in the use of automation, AI and robotics (may) challenge political, social and economic relationships, including those of power and inequality.
- Apply these social scientific understandings to specific case examples of the application of such technologies in politics, the economy, and public policy/governance.

Learning Outcomes

After taking this unit the student should be able to:

- Demonstrate in-depth understanding of the parameters of debates around the development, emergence and adoption of (digital) technologies.
- Demonstrate advanced critical understanding of the distinctiveness of AI as specific technological development and its implications for political economy, politics and social practices.
- Demonstrate advanced critical understanding of how these implications are reflected in, or challenged by, the adoption of AI, machine-learning and robotics in specific empirical cases.

Skills

After taking this unit the student should be able to:

- Explain and evaluate the main historical and contemporary debates explaining the development, adoption and application of AI/machine-learning/robot technologies (T/A)
- Explain and evaluate the social, political and economic distinctiveness of AI & related technologies as specific set of technological developments, and their wider implications (T/A)
- Critically evaluate how AI (automation, machine-learning & robotics) are applied in specific empirical cases, and assess the social, political and economic implications of these applications (T/F/A)
- Develop a coherent line of argument that evaluates alternative positions (T/F/A)
- Use appropriate evidence, standards of logic and argumentation to support such arguments (F/A)
- Apply critical theoretical understanding to specific empirical cases (F/A)
- Use appropriate standards of referencing, citations and presentation (F/A)

Content

CONTEXTS & THEORETICAL PERSPECTIVES

- Machines, monsters and the social world.

- Learning machines and digital personhood.
- Political economy & power in digital environment.

IMPLICATIONS

- Political economy and automation.
- Politics in the online information environment.
- Digital statehood and algorithmic rule.
- Citizenship, new technologies, and the idea of ‘the public(s)’.

Assessment

TBA

Unit 10b: Reinforcement Learning

Aims

This unit introduces the reinforcement learning problem and describes basic solution methods.

Learning Outcomes

After taking this unit the student should be able to:

- Describe how reinforcement learning problems differ from supervised learning problems such as regression and classification.
- Formulate suitable real-world problems as reinforcement learning problems by defining a state space, an action space, and a reward function appropriate for the context.
- Critically evaluate a range of basic solution methods to reinforcement learning problems.
- Analyse the difficulties encountered in solving large, complex reinforcement learning problems in practice.

Skills

- Intellectual skills: Develop algorithmic thinking for sequential decision making under uncertainty (T/F/A)
- Transferable skills: Enhance perspective of decision making (T/F)
- Oral presentation of ones work (F/A)

Content

Topics covered normally include: dynamic programming, Monte Carlo methods, temporal-difference algorithms, integration of planning and learning, value function approximation, policy gradient methods and social, legal, and ethical implications of AI.

Assessment

TBA

Unit 11a: Robotics

Aims

To provide knowledge and awareness of key concepts in intelligent mobile robotics.

Learning Outcomes

After taking this unit the student should be able to:

- Explain typical design of mobile robots.
- Describe multi-sensory based perception in real-world scenarios.
- Describe typical locomotion for mobile robot and their uncertainty in motion.
- Evaluate and apply machine learning methods for mobile robots.

Content

Control theory and PID controllers, software architectures for robotics, locomotion, mobile robot kinematics, robot perception, vision-based simultaneous localisation and mapping, as well as planning and navigation and social, legal, and ethical implications of AI.

Assessment

TBA

Unit 11b: Robotics and Machine Vision

Aims

- To provide knowledge of key concepts in intelligent mobile robotics.
- To provide the students with an in-depth knowledge of practical artificial intelligence to control real-time autonomous systems, including autonomous robots, scientific simulations, and virtual-reality characters.
- To provide students with sufficient knowledge of intelligence in nature for them to critically evaluate and compare natural and artificial intelligent systems.

Learning Outcomes

After taking this unit the student should be able to:

- Explain typical design of mobile robots.
- Describe multi-sensory based perception in real-world scenarios.
- Describe typical locomotion for mobile robot and their uncertainty in motion.
- Evaluate and apply machine learning methods for mobile robots.

Content

- Software architectures for robotics, locomotion, mobile robot kinematics, robot perception, vision-based simultaneous localisation and mapping, as well as planning and navigation.
- Why intelligent control is (computationally) hard, outline / review of historic strategies (proof / search based, reactive / dynamic planning, machine learning, hybrids of these).
- Perception and Learning: sensor fusion, memory, and learning. The beginnings of cognition.
- Natural intelligence: Evolution and cognitive control, variation in cognitive strategies found in nature, individual variation in nature; perception and action selection in nature.
- Ethics and philosophy of AI, can we build consciousness? What should our users believe about our agents?

Assessment

TBA

Unit 12: Research Seminar and Project Preparation

Aims

The aim of this unit is to introduce students to research in AI and the department more specifically to allow them to place their studies in a wider context and to prepare them for choosing their dissertation project.

Learning Outcomes

After taking this unit the student should be able to:

- Summarise and critique computer science research papers focusing on AI research.
- Distinguish various research themes in AI and highlight broad research aims within.
- Determine which research area they would like to work in for their dissertation.
- Critically analyse and review previous work in a chosen subject area.
- Undertake and document a detailed literature review in a chosen area of computer science research.
- Have a feasible project proposal for the dissertation.
- Understand the principles of structuring a dissertation.

Skills

- Presentation skills (T/F/A), Peer marking (T/F/A), Research skills (F), Communication (T/F/A), Critical thinking (T/F/A)
- Undertaking a primary research literature search (T/F/A); assessing the relevance of research publications (T/A); judging the quality of secondary research resources, such as web resources (T/A); critical analysis of research papers (T/F/A)
- Writing a review of a research area (T/A); preparing a research proposal (T/A)

Content

- At the start of the unit students will be divided into small groups. Each group will be assigned a research paper to read and study. The available papers will be from a wide range of computer science areas and present state-of-the-art research.
- The content of their assigned research paper is the starting point for students to explore a particular research stream. For their presentation students will need to demonstrate an understanding of the context of the work, the research methods used in this area of computer science, critique the validity, rigour and the ethical integrity of the paper within the context of its research domain.
- Towards the mid/end of the unit this paper and its wider context will be presented to the class. For each presentation, two other groups (who have been assigned different research areas) will be asked to prepare questions for the presenting pair.
- In the weeks preceding the presentations, members of the department will be invited to give a talk about their research topic and the types of MSc projects they supervised in the past.

- Skills needed for writing for scientific reports, papers and dissertation. Having identified the area of work and been assigned a project advisor, the student will undertake a conceptual review, a literature search, and a critical analysis of previous work.
- In consultation with the project advisor the student will write a research review and proposal for a subsequent research project.

Assessment

TBA

Unit 13: Dissertation

Aims

To develop skills of individual research project effort in an Artificial Intelligence-based undertaking with original development content related to the Masters theme studied by the student.

Learning Outcomes

After taking this unit the student should be able to:

- Identify the tasks to be completed in a research project, plan a scheme of work, and complete the project to a professional standard.
- Assemble and create the necessary analysis, design and development tools, carry out the development of the solution of a technical problem in Artificial Intelligence, and evaluate the effectiveness of the solution against common standards of quality.
- Demonstrate the successful completion of these tasks in a well-structured and coherently written dissertation, which will include a discussion of the research outcomes of the work, and future directions.
- Evaluate and critique the project.

Skills

- Ability to review research literature (F/A)
- Critical analysis of research work and ideas (F/A)
- Effectively judge potential solutions and solution paths (F/A)
- Formulating and testing hypotheses (F/A)
- Communication skills (F/A)

Content

- The student will follow an appropriate problem-solving route, building on the detailed literature review and dissertation project proposal written in the Research Seminar and Project Preparation unit.
- The student will analyse possible problem solutions based on an extensive review of related research work and choose appropriate methods and approaches. This will lead to the implementation of the chosen solution, its testing and evaluation. In most cases the project will be a synthesis of both an analytical and a computational approach to solving or investigating a substantial Artificial Intelligence problem. However, projects will vary in style, and some may be more experimentally-based, and some may be purely theoretical.
- A comprehensive dissertation will be submitted at the completion of the project.

Assessment

TBA