CM500329	Applications of Artificial Intelligence

Learning Outcomes
On completion of this unit, the student should be able to: 1. Critically evaluate the features of various programming languages and software packages for AI focusing on data science as the application domain, 2. Explain, relate and accommodate factors affecting complexity, performance, numerics, scalability and deliverability of solutions, 3. Implement low-level data science functionality using a relevant programming language (e.g. Python), 4. Apply a range of complex analytic methodologies, notably machine learning techniques, using relevant software libraries, 5. Assess the applicability and relevance of key "Big Data" software technologies in varied scenarios.
Overview
Artificial intelligence is a field concerned with any intellectual task – we used a phrase like this in the previous unit on this degree. It is important to understand AI in the abstract and learn about algorithms which can solve a broad spectrum of problems, but it is equally important to see these techniques in action as well. There is more to the application of AI than simply writing code to solve a well-defined problem, although this is certainly part of the complete picture as well. In this unit we will look at data science as an application of artificial intelligence. This will require understanding how low-level tools are used to manipulate data: from the manipulation of bits on your hard drive, to the maths behind observations and analysis, to the storing of data in databases and beyond. This will also require a high-level understanding of processes: how do we deal with imperfect data, how does the representation of data alter the story we are telling, and how can we ensure we follow our ethical and legal responsibilities.
Content
Topics covered in this unit may include (but are not limited to) the following: 1. Introduce a relevant programming language for data science (e.g. Python): general computing, use of essential libraries for data science as an application domain of AI (e.g. Numpy, Scipy, Matplotlib, Scikit-learn in the context of Python) and numerical and performance factors underlying. 2. The use of data structures, database systems, and software technologies for scalability, from the viewpoint of both storage and computation. 3. Social, legal, and ethical implications of AI.
Assessment
Coursework 100%

CM500325	Mathematics for Artificial Intelligence

Learning Outcomes

On completion of this unit, the student should be able to:

1. Demonstrate knowledge of higher mathematics and its use within artificial intelligence and computer science more widely.
2. Perform elementary mathematical operations in calculus, linear algebra, probability and statistics.
3. Formulate mathematical problems from real-world AI situations, in particular using logical, probabilistic and statistical frameworks.
4. Solve mathematical, probabilistic and statistical problems in abstract form
5. Compare approaches to a variety of mathematical problems, evaluating which are more or less appropriate in each instance.
6. Relate underlying theory to requirements in artificial intelligence theory and practice.

Overview

In this unit, a concise but rigorous introduction to some of the key mathematical topics for artificial intelligence research and practice is given, with a focus on mathematical abstraction and formalisation, introducing students to the way that mathematics in research-level articles is written and thought about. Students will engage with cutting-edge AI research, seeing how the mathematical concepts and ideas they are introduced to are used in practice.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. Mathematical notation.
2. Propositional logic.
3. Predicate logic.
4. Set Theory.
5. Calculus.
6. Linear Algebra (e.g. Vector Spaces, matrix multiplication, matrix inversion (2x2), change of basis, eigenvectors, eigenvalues).
7. Representation of Numbers (e.g. Number bases and binary arithmetic + fixed/floating point. Mathematics in research-level AI).
8. Probability Spaces.
9. Bayes Theorem.
10. Random Variables.
11. Mass and Density Functions.
12. Distributions.
13. Multiple Random Variables.
14. Hypothesis Testing.

Assessment

Coursework 100%

CM500324	Principles of Programming for Artificial Intelligence

Learning Outcomes
On completion of this unit, the student should be able to: 1. Describe the design of a computer program separately from its implementation. 2. Explain debugging and testing methods and how they contribute to robust code. 3. Design, construct, evaluate and analyse the efficiency of data structures and algorithms. 4. Implement more advanced concepts of AI programming using appropriate libraries and frameworks. 5. Design a computer program separately from its implementation. 6. Debug and test your applications to ensure they are robust.
Overview
This unit introduces the principles of development of computer software, including problem analysis, designing, implementation and evaluation. It explains the terminology and concepts of programming, irrespective of the language being used, and teaches practical skills in reading and writing programs with the aim of producing programs to solve real-world problems. After this unit, students should feel confident programming in the taught languages, as well as confident in their ability to learn different programming languages and paradigms. With the skills gained in this unit, students will have been introduced to the notion of software development for artificial intelligence (AI).
Content
Topics covered in this unit may include (but are not limited to) the following: 1. Introduction to common programming language for AI. 2. Explore -specific applications, such as, simulation and models, algorithms for common domain specific tasks and complex data structures and algorithms. 3. Limits of computation.
Assessment
Coursework 100%

CM500328	Introduction to NLP

Learning Outcomes
On completion of this unit the student should be able to: 1. Demonstrate knowledge of the fundamental principles of natural language processing, 2. Demonstrate understanding of key algorithms for natural language processing, 3. Write programs that process language, 4. Evaluate the performance of programs that process language, 5. Assess the feasibility and appropriateness novel NLP approaches presented in literature.
Overview
In this unit, a wide range of NLP techniques and applications, from the most basic to the advanced are introduced and discussed. By the end of the unit, students will be taught both theoretical knowledge and practical skills in NLP, learn about the fundamental concepts as well as the most popular tasks and implementation strategies and will be able to structure their own NLP projects in an end-to-end manner.
Content
Topics covered in this unit may include (but are not limited to) the following: 1. An introduction to NLP systems. 2. Information retrieval. 3. Information extraction. 4. Text classification approaches. 5. Unsupervised approaches in NLP. 6. Sequence-based prediction and modelling in NLP. 7. Semantic tasks. 8. Current challenges and future directions.
Assessment
Coursework 100%

CM500327	Artificial Intelligence Systems Engineering

Learning Outcomes

On completion of this unit, the student should be able to:

1. Develop and critically evaluate how AI-enabled systems can deliver on organisational objectives
2. Analyse the design, architecture and development of production systems with AI components.
3. Understand how software engineering principles are applied to build AI-enabled systems.
4. Understand Machine Learning Life Cycle and application of AutoML and MLOps in ML model engineering and in production systems.
5. Design and develop data infrastructure for learning and serving models.
6. Critically evaluate and contrast cloud-based services to develop AI-enabled systems.
7. Critically evaluate risks, deployment, and telemetry in AI-enabled systems

Overview

AI Systems Engineering is an emerging field. This unit draws upon a range of perspectives published by multidisciplinary experts. This is a growing field and standards are still being defined. The intention behind this unit is to expose students to different viewpoints of AI System Engineering from real world settings, to give context to what is traditionally a narrow academic focus of the subject. The unit content therefore comes from a carefully curated set of sources that is intended to give a well-rounded view of the subject, as well as to guide students on how to synthesize literature to develop their understanding of the domain. You are encouraged to continue reading further into the perspectives offered by the experts referred to throughout this unit.

In this unit, concepts for building applications and products with machine learning (ML) will be presented. Assuming that an ML-model to make predictions can be learnt, what does it take to turn the ML-model into a product and actually deploy it, build a business, and successfully operate and maintain it?

The unit tends to establish a working relationship between software engineers and data scientists as both contribute to developing AI-enabled systems using different approaches. This unit is aimed at software engineers who want to understand the underlying concepts that must be considered when building robust and responsible systems which meet the specific challenges of working with AI-components, and at data scientists who wish to understand the requirements of the ML-model for production use and want to simplify getting a prototype model into production. The unit considers all the steps required to turn an ML-model into a production system in a reliable and accountable manner.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. AI-enabled systems and adoption of AI in our society.
2. How AI-enabled systems are developed and operated.
3. Applying agile software development to building AI-enabled systems.
4. Modern trends in AI-enabled systems such as DevOps, AutoML and MLOps.
5. Introduction to Cloud computing and cloud-based AI-enabled systems.

6. Cloud service models. 7. Specialised hardware for machine learning. 8. Scaling production AI-enabled systems and designing a system to process huge amounts of training data, telemetry data, and user requests. 9. Analysing wrong predictions which the ML-model can make. 10. Safety and security assurance despite possible mistakes. 11. End-to-end design of AI-enabled systems. 12. Applying AI frameworks to develop strategies for organisations. 13. Detecting data quality issues, concept drift, and feedback loops in production. 14. Evaluating the quality of an ML-model's predictions in production and the entire AI-enabled system. 15. Identifying what is important in an AI-enabled product in a production setting for a business.
Assessment
Coursework 100%

CM500330	Humans and Intelligent Machines

Learning Outcomes

On completion of this unit the student should be able to:

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

Overview

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

Content

Topics covered in this unit may include (but are not limited to) the following:

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

Assessment

Coursework 100%

CM500337	Robotics and machine vision

Learning Outcomes

On completion of this unit the student should be able to:

1. List the key tasks of a robotics application and the building blocks of a robotic perception system.
2. Explain key algorithmic paradigms involved in robot perception system e.g., SLAM.
3. Explain the operating principles of various robot sensors, in particular of the intensity camera, as well the associated challenges in raw data acquisition.
4. Explain the core theory behind visual data interpretation algorithms and apply the knowledge in practice.
5. Explain the core theory behind scene representation and manipulation in 2D and 3D and apply the knowledge in practice.
6. Describe and classify hardware options in data acquisition and locomotion tasks. Discuss the interaction of hardware with interpretation and control algorithms.
7. Discuss the historical development of robotics, providing examples, and the current technical and non-technical challenges the field faces.

Overview

The Robotics and Machine Vision unit is a technical introduction to this application domain, with a particular focus on perception systems. The key aspects of the pipeline such as raw data acquisition, processing & representation and interpretation will be covered in the course. The main emphasis will be on the algorithms, yet the unit will also touch on some hardware aspects of robotics, such as those involved in sensing and locomotion. With perception systems being the focus, and intensity camera the designated main sensor, the unit inevitably ventures into the domain of machine vision and graphics, covering important topics of scene reconstruction, modelling and manipulation in 2D and 3D using projective geometry. In the unit, robotics as an area of research will be given context, in terms of history of its development against the backdrop of generic AI evolution, as well as in terms of ethical practices, safety and accountability. The unit includes state-of-the-art robotics application examples where the theory can be seen applied in the real world.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. History of development, state-of-the-art and current technical and non-technical challenges (including ethics) in robotics.
2. Robot perception systems from data acquisition through processing/representation to data interpretation, vision-based data interpretation such as visual odometry or simultaneous localisation and mapping), associated mathematical frameworks, software architectures, image processing and projective geometry techniques.
3. Sensors for data acquisition, image as a data structure, basics of photometric and geometric image formation, basics of camera calibration models.
4. Robot Locomotion

Assessment

Coursework 100%

CM500331	Further Artificial Intelligence

Learning Outcomes

On completion of this unit, the student should be able to:

1. Understand a wide range of AI techniques, and their advantages and disadvantages.
2. Appreciate AI as a mechanism to deal with computationally hard problems in a practical manner.
3. Explore the linkages between AI and brain-, nature-inspired computing, and evaluate the opportunities and challenges.
4. Apply search algorithms to find the optimal solution to a problem.
5. Use logical programming to solve practical problems.
6. Understand the basics of AI planning and use Planning Domain Definition Language (PDDL) to formulate planning problems and compare various planning approaches.
7. Use probabilistic reasoning to estimate inference in Bayesian network, and to predict conditions using hidden Markov models.
8. Understand specific machine learning techniques, apply them to a given dataset, and interpret the results.
9. Understand the basics of neural networks and produce a code to classify a given pattern.

Overview

In this unit, we will discuss some of the advanced topics in artificial intelligence (AI). This is a continuation of the Foundations of AI unit, and you will learn a broad range of topics including fundamental concepts and recent advancements in the area. This unit is designed in a way that will allow you to gain theoretical knowledge as well as develop their practical skills in the area.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. Classical definitions, applications and history of AI and its relationship with neuroscience.
2. Problem-solving: algorithms inspired by nature and science.
3. Planning: an important subfield of AI
4. Logical reasoning (propositional logic, first-order logic, logic programming).
5. Probabilistic approaches (Markov chain, causality).
6. Machine learning (decision trees and clustering approaches (e.g., hierarchical).
7. Introduction to Neural Networks.

Due to the multidisciplinary nature of the subject, we will cover a range of topics including:

1. Introduction to further AI
2. Beyond classical search methods
3. Artificial intelligence and planning

4. Introduction to logic programming 5. Probabilistic models 6. Machine learning techniques and applications 7. Neural networks.
Assessment
Coursework 100%

CM500336	Reinforcement learning

Learning Outcomes

On completion of this unit, the student should be able to:

1. Describe how reinforcement learning problems differ from supervised learning problems such as regression and classification
2. 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
3. Critically evaluate a range of basic solution methods to reinforcement learning problems
4. Analyse the difficulties encountered in solving large, complex reinforcement learning problems in practice

Overview

This unit provides a solid foundation in the exciting and fast-moving field of reinforcement learning. Reinforcement learning is concerned with training agents to select appropriate actions in their environments to achieve some goal. The types of problems tackled in reinforcement learning are very different from those tackled in other branches of machine learning. By the end of this unit, students should be able to identify sequential decision problems in the real world, formulate them as Markov decision processes, select appropriate solution methods, and implement them successfully. In the first half of the unit, students will cover the fundamentals of reinforcement learning. Starting from the very basics, students will build up fundamental concepts from first principles, before looking at key reinforcement learning algorithms and applying them to solve simple problems. In the second half of the unit, students will apply these key ideas to more complex problems using function approximation. At the very end of the unit, students will study some active areas of research on the cutting-edge of the field.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. The reinforcement learning problem.
2. Markov decision processes.
3. Dynamic programming methods.
4. Monte-Carlo methods.
5. Temporal-difference methods.
6. Planning and n-step methods.
7. Function approximation and generalisation in reinforcement learning.
8. Linear function approximated methods.
9. Deep reinforcement learning methods.
10. Policy-gradient methods.
11. Hierarchical reinforcement learning.
12. Intrinsically motivated reinforcement learning.
13. Social, legal, and ethical implications of AI.

Assessment

Coursework 100%

CM500326	Foundations of Artificial Intelligence

Learning Outcomes

On completion of this unit, the student should be able to:

1. Demonstrate understanding of a range of AI techniques, their strengths, and their limitations.
2. Demonstrate understanding of the fundamentals of probability theory and its role in AI.
3. Apply various AI techniques to simple problems.
4. Understand a wide range of artificial intelligence (AI) techniques, their advantages and disadvantages.
5. Appreciate AI as a mechanism to deal with computationally hard problems in a practical manner.
6. Understand the concepts of formal AI and put them into practice.
7. Write small- to medium-sized programs for aspects of AI.
8. Critically evaluate state-of-the-art AI applications.

Overview

This unit gives a broad overview of some foundational topics in artificial intelligence introducing some of the techniques that are used in this field. Students will be implementing theoretical knowledge in a practical way, with programming exercises to accompany many of the algorithms discussed, where students can apply these algorithms to solve new problems.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. Goals and foundations of AI.
2. Problem solving (uninformed, heuristic, and adversarial search; constraint satisfaction).
3. Logical reasoning (propositional logic, first-order logic, logic programming).
4. Probabilistic reasoning (probability models, Bayesian networks).
5. Machine learning (possible topics include nearest-neighbour methods, neural networks).
6. Social, political and ethical issues relating to AI.
7. State-of-the-art AI applications.

Assessment

Coursework 100%

CM500335	Foundations and frontiers of machine learning

Learning Outcomes

On completion of the unit, the student should be able to:

1. Understand the important theoretical concepts and algorithms in modern machine learning,
2. Understand state-of-the-art applications of machine learning and open research questions,
3. Appraise the suitability of various machine learning methods for a given application,
4. Demonstrate a basic understanding of the important theoretical concepts and algorithms in modern machine learning,
5. Demonstrate familiarity with state-of-the-art applications of machine learning and open research questions.
6. Appraise the suitability of various machine learning methods for a given application and write code in a relevant programming language to solve problems.
7. Demonstrate an understanding of a range of deep learning techniques, including MLP, CNN and RNN.
8. Demonstrate an understanding of how deep learning algorithms work, how to build them and how to train them.
9. Apply deep learning techniques to solve real-life problems using deep learning libraries.

Overview

Today, humans and machines generate an enormous amount of data that surpasses our capacity to absorb, interpret, and make complex decisions based on it. The future of complex decision-making lies in Artificial Intelligence (AI), which is the foundation of all computer learning. This course will provide foundational understanding of deep learning techniques (multilayer perceptron, convolutional neural networks, etc.) as well as demonstrate how these models can solve complex problems in a variety of industries, from medical diagnostics to image recognition.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. 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.
2. Research seminars based on current research in the department.

Assessment

Coursework 100%

CM500338	Research Project Preparation

Learning Outcomes

On completion of this unit, students will be able to:

1. Summarise and critique research papers in Computer Science and AI.
2. Distinguish various research themes in the selected field, with a broad understanding of suitable approaches and methodologies.
3. Determine which research topic they would like to work on for their dissertation.
4. Critically analyse and review previous work in the chosen subject area
5. Create a feasible project proposal for the dissertation.
6. Understand the principles of structuring a dissertation.
7. Reason for methodological and ethical considerations of their chosen topic.

Overview

The aims of this unit are to prepare students for their dissertation research project, giving them an advanced level of understanding of what a research project is, what the various research themes are in the Department of Computer Science at the University of Bath, and how to find and critically evaluate relevant literature. Throughout this unit, students will be developing a feasible project proposal that will lead to an effective dissertation. As part of their research proposal students will need to start thinking about project methodologies and the ethical considerations needed for their project.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. Selecting an appropriate topic for a dissertation research project
2. Researching relevant academic literature
3. Assessing the relevance of research publications
4. Assessing the quality of secondary research resources, such as web resources
5. Critical analysis of research papers
6. Preparation of a research proposal

Assessment

Coursework 100%

CM500339	Dissertation

Learning Outcomes

On completion of this unit, students will be able to:

1. Identify the tasks to be completed in a research project, plan a scheme of work, and complete the project to a professional standard.
2. Conduct independent research, following the ethical principles and processes.
3. Assemble and create the necessary analysis, design and development tools, carry out the development of the solution of a technical problem in Computer Science, and evaluate the effectiveness of the solution against common standards of quality.
4. 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.
5. Evaluate and critique the project.

Overview

Students will follow an appropriate problem-solving route, building on the detailed dissertation project proposal written in the Research Project Preparation unit. The student will analyse possible problem solutions based on an extensive literature and technological 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 computer science 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.

Content

Topics covered in this unit may include (but are not limited to) the following:

1. The requirements of a Computer Science dissertation project: refining the project proposal with project bounding and planning using appropriate Project Management techniques, estimating the computational time in experiments.
2. Effective and ineffective written communication. When to use graphs, diagrams and pictures. Citing and use of references. Styles of written English. Structure of a dissertation, depending on the nature of the project. Awareness of plagiarism and academic integrity.
3. The project dissertation. Conducting effective independent research. Review and relation to the project of: laws relating to intellectual property, copyright and patent, Data Protection and Freedom of Information laws, professional practice, ethical experimental practice. Understand and address the ethical aspects of data and code in view of the ethical scrutiny.

The course of study for each project will depend on the agreed project proposal. Individual project supervisors provide academic direction and appropriate guidance to students, to develop the project that they proposed. This will include direction to appropriate academic material and skills training that may be required by the student.

Assessment

Dissertation 100%