Course Introduction

Session 2 | 21st July - 11th August

2019 Cambridge Summer Academic Programme

Course Option | Computer Science and Artificial Intelligence

Course Description

Computing is one of the most significant advances of the twentieth and twenty-first centuries. Within the discipline of computing, artificial intelligence is one area with growing impact on everyday life. Artificial Intelligence holds potential to solve problems previously impossible to overcome. This course introduces artificial intelligence and principles which can be employed to generate solutions to real-world problems. The course begins with an overview introducing the history of artificial intelligence and industry applications in use today. Building upon this overview, the course continues with a practical in the second module by exploring machine learning in the second module. Practical strategies will include simple algorithms and sophisticated applications.

Module 1: Applications of Artificial Intelligence

Module Description

This module is an introduction to the nowadays popular and widely used areas of Artificial Intelligence, including pattern recognition, machine learning, data science and more. The module will provide an interactive guide through the dawn and present of these techniques and an open discussion of the future we are facing.

Module Aims

- Overview of the development and history of Artificial Intelligence
- Introduce data science
- Expand on applications of AI in business, healthcare, and more areas

Module Objectives

- Understand the history of Artificial Intelligence
- Think critically about current challenges within rapidly developing areas of AI
- Evaluate ways artificial intelligence can be used as a driving force to improve our society

Module 2: Machine Learning and Big Data

Module Description

This module teaches selected topics within the broader areas of Machine Learning and Algorithms. It begins with an introduction to spectral graph theory, revealing fascinating connections. This theory will then be applied to central problems in Machine Learning and Computer Vision. We then conclude with the topic of randomised algorithms.

Module aims

- Spectral Graph Theory and Clustering
- Random Walks and Randomized Algorithms
- Online Algorithms for Machine Learning

Module objectives

- Become familiar with different paradigms within machine learning
- Understand the basic ideas and intuitions behind spectral graph theory
- Appreciate the power of algebraic and randomized techniques to solve a variety of problems

Course Option | Electronic and Information Engineering

Course Description

Electrical and electronic engineers are at the forefront of the challenge to use technology to improve the performance of electronic equipment and power distribution, and to improve communication in different aspects of life. First, the course looks at how the most common semiconductor devices operate and what their performance metrics depend on, allowing us to think about how they are engineered into the future. As we constantly try to improve the performance of semiconductor devices, we need to understand quantitatively how they operate and therefore how their performance depends on their geometry and the material that we use for their manufacture. The module then provides an introduction to how microfabrication techniques are used to manufacture semiconductors and MEMS devices. Microfabrication has enabled the development of the consumer electronic devices that we rely on today. The second module of the course features an introduction to information theory, a field which has had a great impact in computer engineering, communications, and signal processing.

Module 1: Semiconductors and Microfabrication

Module Description

This module begins with an introduction to the ubiquity of semiconductor devices, crystalline silicon and alloys, metallization and materials characterization. The second half of the module introduces microfabrication. It looks at why microfabrication is important and presents two key classes of materials that are used: silicon-based materials and metals, including how to characterize these materials.

Module Aims

- Pn Junction Diode, metal semiconductor junctions and current flow in the pn junction
- Bipolar junction transistors and MOSFETs
- How to characterize silicon-based materials and metals

Module Objectives

- Appreciate the key engineering considerations in the design of pn junction diodes, metal-semiconductor diodes, bipolar junction transistors and MOSFETs

- Appreciate the importance of microfabrication for the development of modern electronic components

- Understand how to produce silicon-based materials and metals

Module 2: Information Theory

Module Description

This module introduces the concepts of information theory that are essential building blocks in the design of communication and storage systems. It reviews the probability theory of discrete random variables, introduces fundamental measures of uncertainty and information, and derives the fundamental limits of communication and storage. Furthermore, it presents a number of practical compression and error control algorithms.

Module Aims

- Entropy and uncertainty

- Huffman coding and arithmetic coding

- Limits of reliable transmission / storage

Module Objectives

- Understand principles and applications of information theory

- Define channel capacities and properties

- Understand encoding and communication schemes

Course Option | Materials Science and Environment Engineering

Course Description

This course provides an introduction to nanotechnology and quantum mechanics, two areas which have become essential to materials science and engineering. From Quantum mechanics to relativity, science was shaken at its roots over a century ago, and this led to the interest in all things small. The first module of this course takes a look at the origins of nanotechnology, deep in the mists of time when science thought it had all the answers, and then became clear from one discovery after another that this was not the case. It looks at nanotechnology in everyday use, providing an understanding of the basic underpinning principles to view where this exciting field is heading. The second module explores the foundations of quantum mechanics and how they led to a deepening understanding of the world, and how many of the properties of matter can be explained. The module will examine what quantum technologies are, where they have come from and where they can and are being used.

Module 1: Nanotechnology

This module looks at what nanotechnology really is, how and why the properties of nanometer-sized objects are fundamentally different to larger things, and how we can take advantage of this. It then examines specific examples of nanotechnology applications in healthcare, electronics, textiles, defence, automotive industry, fuels, food, etc. Finally, it looks at how to explore the properties of nanometer sized things.

Module Aims

- Overview the Classic Science of Nanotechnology
- Introduce the Modern Science of Nanotechnology
- Explore applications of Nanotechnology

Module Objectives

- Understand how, why and where Nanotechnology is employed

- Have an appreciation of the fundamental scientific principles underpinning Nanotechnology
- Analyse the key industrial sectors where Nanotechnology is used and assess the impact

Module 2: Quantum Mechanics

Module Description

This module explores quantum mechanics and how this field has led to novel devices in computing, data storage, information processing and other fields. It encourages an appreciation for this often-misunderstood branch of science. The module introduces the Schrodinger equation and solves it for a number of everyday problems which will reveal the breadth of this field.

Module Aims

- Provide an introduction to Quantum Mechanics
- Present specific examples of the application of Quantum principles
- Overview Quantum technologies & Quantum computing

Module Objectives

- Understand the basic principles of Quantum Mechanics
- Be able to perform calculations predicting the behavior of quantum systems
- Appreciate the principle of operation of quantum computers

Successful investing is anticipating the anticipations of others.

———John Maynard Keynes