



## 2021 Cambridge AI+ Academic Programme (online)

### Course Outline

#### Course Dates

26th July to 27th August 2021

#### Course Duration

5 Weeks

#### Course Hours

48 hours in total

It includes: 6 hours of pre-learning, 19 hours of professor live teaching, 6 hours of professor supervisions/office hour, 2 hours of professor evaluation, and 15 hours of group work and self-study.

#### Prerequisites

A background in basic statistics is required for the course. Programming experience is helpful but not necessary.

#### Assessment

Assessed individually and in groups through group projects.

#### Skills Trained

Problem Solving, Teamwork, Presentation, Communication.

#### Materials Required

Internet connection and laptop for writing, researching and preparing presentations.



## Course Description

Driven by the combination of increased access to data, computational power, and improved sensors and algorithms, artificial intelligence (AI) technologies are entering the mainstream of technological innovation. These technologies are already impacting multiple areas, including fintech, new materials, healthcare, deep learning, international policy making, and blockchain.

The course is an introduction to AI from an applied perspective. It begins by introducing basic concepts in machine learning. After an introduction of basic concepts and techniques, the course illustrates both the potential and current limitations of these techniques with examples from a variety of applications. Students will explore these ideas in a final project.

This course is part of the blended course Cambridge Summer Academic Programme. (CSAP). It can be taken separately or combined with CSAP.

## Goals & Objectives

By the end of this course, participants will be able to:

1. Understand what artificial intelligence is and consider how it will affect society in the years to come.
2. Become familiar with a variety of learning algorithms.
3. Discuss applications of AI where AI techniques are applicable.

## Course Structure

Modules	Date	Contents	Hours
Pre-learning	One Week before	Pre-learning Materials	6
Basic/Advanced AI	26 <sup>th</sup> July-1 <sup>st</sup> August	Professors Live Lectures	6
		Professors Supervision	3
Academic Skills	2 <sup>nd</sup> -22 <sup>nd</sup> August	Academic writing & Research	4
		Academic presentation	
AI application Track (Choose one out of eleven)	2 <sup>nd</sup> -22 <sup>nd</sup> August	Professors Live Lectures	9
		Professors Office Hour	3
Evaluation	23 <sup>rd</sup> -27 <sup>th</sup> August	Presentations	2



## Course Syllabus

For the first part of the course, all students will take the same AI module. In the second part, students will choose one of the application areas for in-depth exploration.

### Basic/Advanced AI

- 1.) INTRODUCTION. What is Machine Learning and AI? Applications. Types of Machine Learning: Supervised, Unsupervised, Reinforcement. Two Simple Examples of Learning Problems.
- 2.) NEAREST NEIGHBOUR. Intro to Supervised Learning. Training and Test Set. Nearest Neighbour Algorithm. How to pick Parameters and Distance Functions. Implementation in Python. Importance of Data Cleaning and Normalisation. Application to Flower Classification.
- 3.) DECISION TREES. How to build Decision Trees? How to classify Decision Trees? ID3 Algorithm. Different Gain Measures including Training Error and Entropy. Application to Cancer Diagnosis.
- 4.) RECOMMENDER SYSTEM. Motivation: Long-Tail Phenomena. Content-Based versus Collaborative Filtering. Connection to Nearest Neighbour. User-to-User versus Item-Item Filtering.
- 5.) BASICS OF CLUSTERING. Intro to Unsupervised Learning. The k-Means Algorithm. Implementation Details, Efficiency and Choice of Parameters. Clustering of Graphs vs. Clustering of Points.
- 6.) ESTIMATION AND INFERENCE. Brief Recap of Relevant Probability Theory. Unbiased Estimators. Accuracy of Estimators: Mean-Squared Error. Maximum Likelihood. Application: Estimating Population Sizes through Sampling.
- 7.) REGRESSION. Intro: Regression vs. Classification. Linear Regression. Simple Example in One Dimension. Least-Squares, Polynomial Regression. Logistic Regression. Statistical Interpretation.
- 8.) REINFORCEMENT LEARNING. What is Reinforcement Learning? Markov Processes and Markov Decision Processes. Bellman Equation. Finding Optimal Policies.
- 9.) PERCEPTRON. Motivation and Connection to Neurons. Linear Classification Problem. The Perceptron Algorithm. Illustration of the Algorithm. Application to SPAM Classification.
- 10.) A GLIMPSE AT NEURAL NETWORKS AND DEEP LEARNING. Biological Inspiration of Neural Networks. How to Build Neural Networks. Deep versus Width. Classification using Feed-Forward. How to Use Neural Networks in Character Recognition.



## **AI Application Track - Students choose one of the following:**

### ***Financial Innovation & Blockchain Technology***

Business these days revolves around data. AI and big data-like technologies are evolving to be the key player in transforming modern business operations. Businesses are making use of AI technology in business decision-making, pattern analysis, and predictions.

Blockchain originated from Satoshi Nakamoto's Bitcoin, and as the underlying technology for Bitcoin, is essentially a decentralized database. It is a technical solution that collectively maintains a reliable database by decentralizing and de-trusting it. Blockchain technology is a technology solution that does not rely on a third party and uses its own distributed nodes for the storage, verification, delivery and exchange of network data. Blockchain technology will be used far beyond the imagination of Bitcoin's founders, and it will also play an important role in the future business world.

### ***Business Analysis & Innovation***

The rapidly emerging of Machine Learning and automation is stimulating strategists to reshape their business models. The Business Analyst role has been partially or fully automated in banking, finance, investment banking, or portfolio management. As Artificial Intelligence makes it easy to simulate human thinking and actions using “learning algorithms,” the future possibilities are endless. We can expect to see a major turnaround in economic achievements in the next 10 to 20 years. If humans and machines learn to work together now, then very soon the “physical-digital teamwork” can transform workplaces around the world.

### ***Organizational Leadership & Business Management***

The effects of artificial intelligence will only be magnified in the coming decade, as industries transform their core processes and business models to take advantage of its capabilities. Business leaders need to understand and act on the tremendous opportunities AI offers their industry. The potential applications of artificial intelligence excite forward-thinking leaders, who see the opportunities AI will provide to advance careers and business results faster. Artificial intelligence in business is a breakthrough that can enable good managers to be great.

The applications of artificial intelligence in business are many, from improving relationships with employees and customers to finding patterns in extreme data volume to performing repetitive tasks. These should be a great benefit to most managers, and the key is to embrace the opportunity artificial intelligence in business presents for individual and organization success, including scaling their skills and using AI to scale their impact.

### ***Deep Reinforcement Learning & Networks***

Artificial neural networks (ANNs) mimic the human brain through a set of algorithms. A neural network is comprised of four main components: inputs, weights, a bias or threshold, and an output. Neural networks help us cluster and classify. They help to group unlabeled data according to similarities among the example inputs, and they classify data when they have a labelled dataset to train on. Deep learning is the name we use for “stacked neural networks”; that is, networks composed of several layers. As with other machine learning methods, neural networks have been



used to solve a wide variety of problems, such as machine vision and speech recognition. These are problems that are difficult to solve by traditional rule-based programming.

### ***Machine Learning & Neural Networks***

Data mining is an interdisciplinary subfield of artificial intelligence, machine learning and statistics with an overall goal to extract information from a data set and transform the information into a comprehensible structure for further use. The more complex the data sets collected, the more potential there is to uncover relevant insights. Retailers, banks, manufacturers, telecommunications providers and insurers, among others, are using data mining to discover relationships among everything from price optimization, promotions and demographics to how the economy, risk, competition and social media are affecting their business models, revenues, operations and customer relationships.

### ***Nanomaterials & Quantum Computing***

For hundreds of years, new materials were discovered through trial and error, or luck and serendipity. Now, scientists are using artificial intelligence to speed up the process. We can use databases and computations to quickly map out exactly what makes a material so much stronger or lighter -- and that has the potential to revolutionize industry after industry.

### ***Biotechnology Engineering & Healthcare Technology***

Healthcare applications that leverage artificial intelligence could be used to make more accurate diagnoses, identify at-risk populations, manage and assign administrative resources, forecast the potential value of research projects, and better understand how patients will respond to medicines and treatment protocols. AI will empower doctors to treat patients more efficiently, even remotely. It suggests exciting food for thought: the developing world may be able to leapfrog the developed world in healthcare delivery.

### ***Electronic & Information Engineering***

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. As these professionals strive for innovation, their pursuits may overlap with the rapidly expanding applications for artificial intelligence. Machine learning and electrical engineering professionals leverage AI to build and optimize systems and also provide AI technology with new data inputs for interpretation. Discovering and implementing the latest engineering applications of artificial intelligence may prove to be a path for career advancement on the cutting edge of the field.

### ***International Relations & Policies***

Artificial intelligence poses a new challenge for international policy and national policy making. How can data security be addressed? How can transnational data coordination and management be established? This is a new area of interdisciplinary research, and the module will unfold with a clear practical goal: to work together to ensure that we, as humans, make the most of the opportunities of AI from an international relations and policy-making perspective in the coming decades.



## ***Humanistic & Artistic Creation***

Creativity may be the ultimate moonshot for artificial intelligence. Already AI has helped write pop ballads, mimicked the styles of great painters and informed creative decisions in filmmaking. Experts wonder, however, how far AI can or should go in the creative process. Artificial intelligence is drastically changing the nature of creative processes. Computers are playing very significant roles in creative activities such as music, architecture, fine arts, and science. We believe that we must aim at more ambitious relations between computers and creativity. Rather than just seeing the computer as a tool to help human creators, we could see it as a creative entity in its own right. This view has triggered a new subfield of Artificial Intelligence called Computational Creativity.

### **Assessment:**

Participation: 10%

Application track project: 90%

### **Final Project:**

Students will complete a final project at the end of the course. The professor chooses the project assignment, and the project will focus on applications of AI.

### **Format:**

Zoom will be the primary tool to conduct the lectures and supervisions. A few other online learning platforms will be used for material delivery, communication, and research paper submission. For the students from Asia, other methods might be added on depending on the internet environment at that time.

## **Cambridge Professors:**

### **Basic/Advanced AI**

#### **Prof. Thomas Sauerwald**

Reader at the Department of Computer Science, University of Cambridge

### **AI+ Application Track**

#### **Prof. Raghavendra Rau**

Sir Evelyn de Rothschild Professor of Finance, Cambridge Judge Business School

#### **Prof. Jochen Runde**

Director of Faculty & Professor of Economics & Organisation, Cambridge Judge Business School

#### **Prof. Pietro Lió**

Reader in Computational Biology in the Computer Laboratory, University of Cambridge

#### **Prof. Thomas Sauerwald**

Reader at the Department of Computer Science, University of Cambridge

#### **Prof. Colm Durkan**

Deputy Head of Department of Engineering, University of Cambridge



**Prof. Michael Sutcliffe**

Head of the Biomechanics Group, Department of Engineering, University of Cambridge

**Prof. Jossy Sayir**

Director of Studies at Newnham College, University of Cambridge

**Prof. Ian Shields**

Teaching Associate at Department of Politics and International Studies, University of Cambridge

**Reading List**

Readings will be provided to students prior to the course.