# 2021 Cambridge AI+ Academic Programme (online)

## *Application Track: Biotechnology Engineering & Healthcare Technology*

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 | 26th July-1st August | Professors Live Lectures | 6 |
| | | Professors Supervision | 3 |
| Academic Skills | 2nd -22nd August | Academic writing & Research | 4 |
| | | Academic presentation | |
| AI application Track (Choose one out of eleven) | 2nd -22nd August | Professors Live Lectures | 9 |
| | | Professors Office Hour | 3 |
| Evaluation | 23rd-27th 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 - Biotechnology Engineering $ Healthcare Technology

### Introduction

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.

### Aims

- Understand the context of healthcare technology development
- Understand the opportunities and challenges for application of AI in healthcare
- Research potential applications of AI within a healthcare system

### Syllabus

1. Introduction to healthcare
    - Healthcare research and practice
    - Technology developments
    - Working within a healthcare system

2. Opportunities and challenges in healthcare
    - Healthy living
    - Diagnosis and treatment
    - Data issues
    - Dealing with people

3. Examples and topic suggestions

### Topics for discussion

**Diagnosis:** dermatology; cancer detection; early stage heart disease; Parkinson's disease; image analysis

**Therapies:** drug discovery; predicting drug behaviour; predicting brain injury patient outcome

**Surgery:** assisted and robotic surgery

**Training:** eye tracking; virtual reality

**Healthcare in developing countries:** remote monitoring and treatment; outsourcing expertise; low-cost solutions

**Data:** data availability and reliability; population variability; privacy and consent; regulation

**People:** healthy living; healthcare systems; healthcare relationships; personal and population behaviour; policy; ethics; liability

## 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.

## Course Professors:

Basic/Advanced AI

**Prof. Thomas Sauerwald**

Reader at the Department of Computer Science, University of Cambridge
Director of Studies at Emmanuel College

**Research Interests**

- Markov chains and Random walks (slides on Coalescing Walks and Dynamic Graphs)
- Randomised algorithms (poster on load balancing)
- Machine Learning
- Data Science
- Distributed computing
- Graph Theory

AI+ Application Track:

**Prof. Michael Sutcliffe**

Head of the Biomechanics Group, Department of Engineering, University of Cambridge
Head of Division C: Mechanics, Materials and Design

**Research Interests**

- Biomedical engineering
- Mechanical behaviour of materials
- Biological tissue behaviour (e.g. arteries, brain, Eustachian tube)
- Joint biomechanics (e.g. human and canine knees)
- Composite materials (e.g. textiles, manufacturing, truck lightweighting)

## Reading List

Readings will be provided to students prior to the course.