AI And Neuroscience

October - December 2022 Syllabus

In this course, we'll be looking at the way Neuroscience can help us create better and more advanced Artificial Intelligence and how we can apply this knowledge to the creation of problem-solving systems. The study of how humans and other animals learn gives us a large insight into the way we can make computers learn to solve complex tasks, and we will be looking at how we can implement this ourselves. We will cover a selection of different AI systems, and learn to implement a selection of versatile systems.
In the same vein, we will take a brief look into how research into AI can help us understand the human brain, and how computers can give us an insight into how we as humans learn.
This course is targeted towards people with little-to-no AI experience, but a moderate understanding of programming concepts. We will be using Python (Jupyter Notebooks) to create our systems and will be using the pytorch, tensorflow, and nltk libraries, but knowledge of these languages or systems in the first place are not necessarily required, as we will be covering them in the course.

Course Structure

This course will have 12 sessions, each containing roughly 90 minutes of lecture/teaching time and demonstrations, followed by 90 minutes of practical time where students will be able to remain on in the call (or in breakout rooms) to do any practical work set in the teaching. Students are expected to complete any unfinished set work during the week before the next session. Certain sessions will be structured differently where stated. Estimated course duration is 36-40 hours over 12 sessions, plus time for independant study where required.

Learning Outcomes

By the end of this course, students will understand different approaches to AI from the neuroscience perspective, including evolutionary psychology, predictive modelling, and neural networks. Students will be able to implement and use different simple artificial system (both with and without machine learning approaches) to solve various problems. Students will be able to interpret performance data from AI systems and suggest improvements to increase the accuracy of these systems.

Class Structure

What is AI

An introductory session to the course, where we'll discuss the concepts we're touching on in more depth. An introduction to the theory behind AI and how AI relates to psychology and neuroscience. This session will consist of roughly 2 hours of lectures and live demonstrations (with questions welcome) and an additional 30 minutes of questions to conclude.

Intro to programming

Our introduction session is essential for students who have limited experience with Python. In this session we will be focusing on making sure everyone has the coding skills required to create AI. Due to the libraries we will be using and the relative simplicity of the systems we will be producing, most students will be able to pick up all the concepts we're covering in this session. The session will consist of around 1 hour of lectures and talks, followed by a 2 hour practical where students will put into breakout rooms to work on a simple project. Help will be provided for any students that may struggled to pick up all the required concepts.

Intro to data

Data collection, interpretation, analysis, and processing are very important when creating AI, so we will be running a session dedicated to it. We will be learning how data is used, what types of data are needed for different types of learning, and creating some basic data importing, searching, and sorting tools. As with the last session, breakout rooms will be made and help will be provided for any students that require it.

Abstraction – Thinking things apart

Abstraction is a basic principle that is required for making functional AI. Data and problems need to be broken down into their constituent parts so they can be processed correctly. We will be using a text corpus and using principles of abstraction to make an category classification system. This will include a 1 hour lecture, 30 minutes of live demonstration and around 90 minutes of time for students to implement their own simple systems. This will need to be finished in independent study if not finished in the class.

and Building them back up

We will be continuing on with out abstraction project and reconstructing our data into new and novel ideas. We will be using a simple N-Gram to generate novel and human-like text based on a selection of input phrases. We will have a lecture here, followed by a live demonstration and time for students to implement their new systems. We will end with some more talks and a shorter lecture about Creative Computing.

Evolutionary Psychology

In this session we will discuss evolutionary psychology and how we can use our knowledge of the real world to make more advanced systems. We will have a short lecture about evolutionary psychology before a live demonstration where we will use knowledge of evolutionary psychology to make a computer solve tasks for us. We will then have time for a practical where students will implement their own genetic algorithm to solve combinatorial optimisation problems.

Simulated Annealing – Where evolution fails

Evolution isn't always foolproof and chances are always made. This make evolution very versatile, but not great as a problem solving system. We will be covering a system called

”simulated annealing” which will allow us to make our evolutionary systems function better. Simulated annealing is a powerful concept which we can link into every AI system we create. We will have an hour long lecture about this, followed by a 30 minute live demonstration and a 90 minute practical. We will also look at data representation and how we can use performance graphs to learn how to make our systems function better.

Thinking like a human

Abstraction is great, but doesn't represent how humans think very well, meaning that it is severely limited. We will be looking at human-like processing algorithms in this session. Looking at the way humans solve problems will allow us to create more advanced algorithmic systems. We will have a lecture, followed by a live demonstration which will link into the practical.

Faster Computation

With the system we have made in the past session, we still have a way to go. We will be implementing more human-like logic to make our system run faster and create a system which will function better than the average human. This is where we truly start seeing the power of Artificial Intelligence.

Neural Networks

Neural networks act as a computer-based representation of the human brain. By mimicking the processes of neurones and synapses in the animal brain, we can create system which are fast, efficient, and accurate. Neural networks are a major building block in AI research and are constantly being improved. This session will be longer than the others as there is more content to cover. We will have a lecture, live demonstration, and a practical which will be split up by a small talk mid-way through.

Multi-Layer Perceptrons

The brain has more than just 1 neurone, so we need to add more. A multi-layer perceptron allows us to stack up neurones into a mesh of connections and solve more complex issues. We'll have a lecture in this session, followed by live demonstration and a longer practical.

Food for Thought: Hopfield Networks and Hebbian learning

In these food for thought sessions, we won't have practicals. They are explanatory lectures where we'll talk about some more complex topics and allow questions during a live demonstration. These lectures are optional, but students are recommended to pick a couple that they are interested in and try to attend. They will be happening one per day for the 12th week. In Hopfield Networks and Hebbian Learning, we'll talk about some more advanced neural networks which sacrifice their performance for better representations of the human brain, and better ways of learning with less data.

Food for Thought: Predictive Coding, and What Computers Can Tell us About Schizophrenia

Predictive Coding is a new and novel system that is being developed to allow computers to learn from minimal data by mimicking the predictive processing found in the human brain. Systems like this can give us insight into introspection and beliefs behind schizophrenia.

Food for Thought: Creative Machines

In Creative Machines, we'll talk about whether or not machines can truly be "creative" and talk about new systems like Dalle-2 and GPT-3 in a field which is highly debated.
*Food for Thought: Therapy robots? Therapy robots have been questioned for a while. Here we'll discuss what we could to to make them a reality, where we're at with development, and why they're still a way away.

Food for Thought: Computer Vision

Computer vision is a major field in computer science and AI. We're always working on making computers better at object recognition and perception to make self-driving cars better and make video-based GPS. We'll talk about uses for computer vision, approaches to object recognition, and how Captcha is helping make AI better.