Artificial Intelligence and Machine Learning: Theory and Practice

LMH Summer Programmes are provided by Lady Margaret Hall, a college in the University of Oxford

Course:	Artificial Intelligence and Machine Learning: Theory and Practice
Available:	Programme Session 1: 26th June to 14th July 2023 Programme Session 3: 7th August to 25th August 2023
Lectures:	18 Hours
Seminars:	12 Hours
Tutorials:	3 Hours
Independent Study:	Approximately 120 Hours
Recommended Credit:	15 CATS / 7.5 ECTS / 4 US Credits

About this Course:	This course provides a hands-on introduction to artificial intelligence and machine learning. The course functions in a self-contained manner with only basic knowledge of calculus and linear algebra required. Prior knowledge of artificial intelligence or machine learning is not essential. The course will begin with a quick introduction to Python and the theoretical foundations of basic concepts in artificial intelligence and machine learning. Students will start with a simple linear regression example where they will derive and implement the gradient descent for a curve fitting problem and develop their understanding of the concepts of loss function, regularization techniques, and bias-variance trade-off. Students will then be introduced to stochastic gradients descent and will implement stochastic gradient descent for regression using TensorFlow and PyTorch. Students will design simple neural networks for MNIST classification and implement the full forward and backward pass for the training of the neural network. Following this, students will be introduced to Convolutional Neural Networks and will implement MNIST classification with CNNs. Students will understand how PyTorch and TensorFlow handles the forward and backward pass during training. In the final part of the course, large scale problems of semantic segmentation, edge detection and metric learning will be implemented on AWS/ Google cloud. As exercises for the course, the students will solve small scale practical problems of machine learning and artificial intelligence from diverse domains.

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Course Overview:	Week 1:
	• Introduction to Artificial Intelligence and Machine Learning
	  ○ Artificial Intelligence
	  ○ Machine Learning
	  ○ Deep Learning
	  ○ The history of the field
	• Introduction to Python Programming
	  ○ Simple Python programs
	  ○ Variable and Simple Data Types
	  ○ Basic Containers
	  ○ Loops
	  ○ Python Function
	• Object-Oriented Programming
	  ○ Objects and Classes
	  ○ Inheritance
	• Simple Linear Regression
	  ○ Functions and Basis
	  ○ Regression from Data
	  ○ Under-fitting, Over-fitting, and Regularisation
	Week 2:
	• Logistic Linear Regression
	  ○ Logistic Regression
	  ○ Kullback-Leibler Divergence and Cross-Entropy Loss
	• Optimisation Review
	  ○ Finding the Stationary Points of a Non-linear Function
	  ○ Gradient Descent
	  ○ Gradient Descent with Backtracking
	  ○ Stochastic Gradient Descent
	  ○ Second Order Methods: Newton Method
	• Neural Networks
	  ○ Basic Blocks of Neural Networks
	  ○ Activation Function
	  ○ Back-propagation and Weights Update in Neural Networks
	Week 3:
	• Convolutional Neural Networks
	  ○ Drawbacks of Neural Networks for Images
	• Advanced Topics
	  ○ Numpy
	  ○ Plotting in Python
	  ○ PyTorch Basics
	  ○ Data Loading and Transformation
	  ○ TensorFlow Basics
	  ○ MNIST Classification

Key Texts:	Bishop, C.M., *Pattern Recognition and Machine Learning*, 2006, New York. Goodfellow, I., Bengio, Y., and Courville, A., *Deep Learning*, 2016, Cambridge MA.
Learning Outcomes:	By the end of the course, the students will: • Understand the theory of machine learning and artificial intelligence • Know about ML and AI tools used in practice

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	• Know how to implement basic algorithms of AI and ML and train small networks for practical problems • Be able to identify and use relevant AI and ML tools in their research • Know how to implement and deploy ML and AI algorithms on AWS/Google cloud.
Admissions Requirements:	LMH Summer Programmes are designed for students who want to gain and develop knowledge in their chosen subject area. LMH Summer Programmes are intensive courses of study aimed at undergraduates who have completed one, two, or three years of their degree, or entry level postgraduate students. We will consider each applicant's academic ability and expect successful applicants to have a minimum grade point average equivalent to 2:1 level on the British grading scale. For example, this would mean at least a 3.2 GPA on the 4.0 grading scale in the United States, and 80% in China. **This course would suit STEM students in undergraduate or entry-level postgraduate study. Basic knowledge of calculus and linear algebra is required, and some experience of coding is recommended. Prior knowledge of Artificial Intelligence, Machine Learning, or the Python programming language is not required.** To participate fully in the programme all students will need to have proficiency in English. English language requirements for students who are not native English speakers: • Overall TOEFL score of 85; • or IELTS score of 6.5 (no less than 6.0 in each component); • or CET-4 at 550 or CET-6 at 520. If the language of instruction in your home institution is English you do not need to provide evidence of your English proficiency.
Teaching Methods:	Core syllabus material will be covered in lectures. Students attend four lectures each week and each lecture lasts 90 minutes. Seminars in smaller groups offer students space to discuss and debate, to dig deeper into difficult concepts, and to explore their own ideas. Student contribution to seminars is vital, and tutors will ensure everyone takes part in discussions. Seminars last 2 hours and students will take part in two seminars each week. Independent study is a crucial part of an LMH Summer Programme and of the Oxford teaching model. Tutors will recommend important reading to do between lectures and seminars that will enable students to come to class equipped to understand the information presented and prepared to take part in discussion and debate. Each week students will have an assignment of independent work to complete and submit in advance of the tutorial. There is an appropriate amount of space in the timetable to complete the necessary reading, preparation, and assignments. Students should expect to do around 40 hours of independent study each week. The final class each week is a tutorial, a very small class typically including only 2-4 students and central to the teaching methods used by the University of Oxford and on LMH Summer Programmes. Guided by their tutor, students will receive feedback on their assignments and be challenged to defend, justify, or even rethink their work and ideas. These rigorous academic discussions help develop and facilitate learning in a way that cannot be done with lectures and seminars alone.

Assessment:	On a three-week LMH Summer Programme students produce one piece of assessed work every week, which is submitted to the tutor and then discussed in a tutorial. At the end of each week students will receive a percentage grade for their submitted work. Each week's work counts for a third of the final percentage grade, so the final grade is an average of the mark received for each piece of work. Students who stay for six or nine weeks will receive a separate grade for each 3-week course.
Academic Credit:	Lady Margaret Hall will provide a transcript of students' assessed work, and can send this directly to your home institution if required. LMH Summer Programmes are designed to be eligible for academic credit, and we will communicate with home institution to facilitate this as needed. As a guide, we recommend the award of 15 CATS / 7.5 ECTS / 4 US Credits for each 3-week course.

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