Applicable to 42470–1 Students (2019/20 Intake Cohort and onwards of normal Year 1 entry)

The Hong Kong Polytechnic University
Department of Electronic and Information Engineering

Minor Change to the BEng (Hons) in Electronic and Information Engineering (42470) (BEng in EIE) Programme Curriculum

Adding an elective subject "EIE4122 Deep Learning and Deep Neural Networks" to the curriculum

To align with the development trend of many electronic and information engineering as well as computer science academic programmes around the world where training on Artificial Intelligence (AI) is introduced into the curriculum, the Department has proposed a number of relevant minor changes to the BEng (Hons) in Electronic and Information Engineering (BEng in EIE) (42470) programme. One of which is the introduction of a new 3-credit elective subject, "EIE4122 Deep Learning and Deep Neural Networks".

This subject is for students who would like to equip themselves with cutting edge knowledge and knowhow in deep learning and deep neural networks. The goal of the subject is to enable students to join the machine learning and AI profession after graduation. Students will learn the foundations of deep learning and understand how to construct deep neural networks for real-world applications and AI systems. Students will also learn the major trends in deep learning and deep neural networks. The subject will cover topics such as (i) A High-Level Perspective of Deep Learning and Deep Neural Networks; (ii) Neural Networks and Deep Neural Networks; (iii) Deep Learning; (iv) Convolutional Neural Networks (CNNs); (v) Recurrent Neural Networks (RNNs); (vi) Applications of Deep Learning; and (vii) Software and Hardware Tools. More details about the subject can be found in the syllabus (Appendix I).

The adding of "EIE4122 Deep Learning and Deep Neural Networks" to the 4-year curriculum of the BEng in EIE programme as a technical elective will take effect from 2021/22 and be applicable to 2019/20 intake cohort and onwards of normal year 1 entry and 2021/22 intake cohort and onwards of senior year entry.

Subject Description Form

Subject Code	EIE4122
Subject Title	Deep Learning and Deep Neural Networks
Credit Value	3
Level	4
Pre-requisite	**For 42477:** EIE3124: Fundamentals of Machine Intelligence **For 42470:** AMA2104 Probability and Engineering Statistics
Co-requisite/ Exclusion	Nil
Objectives	This course is for students who would like to equip themselves with cutting edge AI knowledge and knowhow that facilitate them to join the AI profession. Students will learn the foundations of deep learning and understand how to construct deep neural networks for real-world applications and AI systems. Students will also learn the major trends in deep learning and deep neural networks.
Intended Subject Learning Outcomes	**Upon completion of the subject, students will be able to:** Category A: Professional/academic knowledge and skills 1. Understand the benefits of deep learning and deep neural networks. 2. Understand the basic theories in deep learning and adversarial learning. 3. Understand how deep learning and deep neural networks are applied in real-world applications and AI systems. Category B: Attributes for all-roundedness 4. Understand the creative process when designing solutions to a problem.
Subject Synopsis/ Indicative Syllabus	1. A High-Level Perspective of Deep Learning and Deep Neural Networks 1.1 What are neural networks and deep neural networks? 1.2 Relationship among AI, machine learning, deep learning, and DNNs 1.3 Neural networks: From shallow to deep 1.4 How DNNs learn from data? 1.5 Examples of real-life applications 1.6 Pipeline and tools for building AI systems 2. Neural Networks and Deep Neural Networks 2.1 Vectors, matrices, tensors; vector space. 2.2 Perceptrons and multi-layer perceptrons 2.3 Geometric interpretation 2.4 Non-linear activation functions and their roles 2.5 Neural networks for classification and regression 2.6 Autoencoder 2.7 Attention mechanism 3. Deep Learning 3.1 Basic loss functions: MSE and cross-entropy (softmax) loss 3.2 Advanced loss functions: triplet, center, angular, and large-margin softmax loss 3.3 Gradient-based optimization: SGD, AdaGrad, RMSProp, Adam 3.4 Backpropagation 3.5 Weight initialization: pre-training and Xavier 3.6 Batch normalization 3.7 Regularization: Dropout, weight decay, L1 and L2, data augmentation, and early stopping 3.8 Internal representation

	3.9 representation learning 4. Convolutional Neural Networks (CNNs) 4.1 Structure of CNNs 4.2 Why convolution 4.3 Internal representation of CNNs 4.4 Applications of CNNs: object recognition, speech recognition, ECG classification, etc. 4.5 Interpretability and visualization of CNNs 4.6 Time-delay neural networks 5. Recurrent Neural Networks (RNNs) 5.1 Structure of RNNs 5.2 Purpose of recurrent connections 5.3 Long-short term memory (LSTM) 5.4 Gated recurrent unit (GRU) 5.5 Applications of RNNs: machine translation, sentiment analysis, etc. 5.6 Attention in RNN 6. Applications of Deep Learning 6.1 Healthcare 6.2 Finance 6.3 Computer vision 6.4 Natural Language Processing 6.5 Marketing and advertising 6.6 Self-driving cars 7. Software and Hardware Tools 7.1 Software stack: CUDA, cuDNN, Tensorflow, PyTorch, and Keras 7.2 Cloud platforms: Amazon EC2 P3, Azure, Google Cloud, Nvidia GPU cloud, Alibaba Cloud, etc. 7.3 Hardware: GPU, TPU, Nvidia Jetson
Teaching/Learning Methodology	Lectures: The subject matters will be delivered through lectures. Students will be engaged in the lectures through Q&A, discussions and specially designed classroom activities. The background theories on DL and DNNs will be accompanied by various real-applications. Tutorials: During tutorials, students will work on/discuss some chosen topics. This will help strengthen the knowledge taught in lectures. Laboratory and assignments: During laboratory exercises, students will perform hands-on tasks to practice what they have learned. They will evaluate performance of systems and design solutions to problems. The assignments will help students to review the knowledge taught in class. While lectures and tutorials will help to achieve the professional outcomes, the open-ended questions in laboratory exercises and assignments will provide the chance for students to exercise their creatively in problem solving.
Assessment Methods in Alignment with Intended Subject Learning Outcomes	(see table below)

Specific Assessment Methods/Tasks	**% Weighting**	**Intended Subject Learning Outcomes to be Assessed (Please tick as appropriate)**			
		1	**2**	**3**	**4**
1. Continuous Assessment (total: 50%)					
• Homework and assignments	15%	✓	✓	✓	✓
• Tests and Quizzes	20%	✓	✓	✓	
• Laboratory exercises	15%			✓	✓
2. Examination	50%	✓	✓	✓	✓
Total	100%				

	Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes: Assignment, homework and laboratory exercises will require students to apply what they have learnt to solve problems. There will be open-ended questions that allow students to exercise their creativity in making design. Examination and tests: They assess students' achievement of the learning outcomes in a more formal manner.	
Student Study Effort Expected	**Class contact (time-tabled):**	
	• Lecture	24 Hours
	• Tutorial/Laboratory/Practice Classes	15 Hours
	Other student study effort:	
	• Lecture: preview/review of notes; homework/assignment; preparation for test/quizzes/examination	36 Hours
	• Tutorial/Laboratory/Practice Classes: preview of materials, revision and/or reports writing	30 Hours
	Total student study effort:	**105 Hours**
Reading List and References	**Reference Materials:** 1. I. Goodfellow, Y. Bengio and A. Courville, *Deep Learning*, MIT Press 2016 2. M.W. Mak and J.T. Chien, *Machine Learning for Speaker Recognition*, Cambridge University Press, 2020. 3. C.M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006. 4. J. Langr and V. Bok, *GANs in Action*: *Deep Learning with Generative Adversarial Networks (GANs)*, Manning Publications, 2018. 5. F. Chollet, *Deep Learning with Python*, Manning Publications, 2018.	
Last Updated	August 2019	
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