City University of Hong Kong
Course Syllabus

offered by Department of Electrical Engineering
with effect from Summer Term 2024

Part I Course Overview

Course Title:	Applied Deep Learning
Course Code:	EE5438
Course Duration:	One Semester (13 weeks)
Credit Units:	3
Level:	P5
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	Nil
Precursors: *(Course Code and Title)*	[MA2001 Multi-variable Calculus and Linear Algebra]; and [MA3160 Probability and Stochastic Processes]; and [EE3206 Java Programming and Applications]
Equivalent Courses: *(Course Code and Title)*	Nil
Exclusive Courses: *(Course Code and Title)*	EE4016 Engineering Applications of Artificial Intelligence

Part II Course Details

1. Abstract

The purpose of this course is to familiarize students with state-of-the-art deep learning techniques adopted by the industry, such as MPL, CNN, LSTM, Transformer, BERT, GPT-3, VAE, GAN, CLIP, DALL-E 2, and more. Students will learn theoretical and practical concepts of deep neural networks, including optimization, inference, architecture, and applications. After completing this course, students should be able to develop and train deep neural networks, reproduce research results, and conduct original research. Additionally, students will use the Python programming language to implement deep learning applications through the TensorFlow Keras or PyTorch packages.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Explain the major technology trends driving deep learning.		✓	✓	
2.	Determine when a deep neural network would be a good choice for a particular application.		✓	✓	
3.	Understand the state-of-the-art deep learning techniques employed in the industry.		✓	✓	
4.	Build, train and apply deep learning models for different types of application.		✓	✓	
5.	Apply deep learning to practical problems.				✓
		100%			

A1: *Attitude*
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: *Ability*
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to self-life problems.

A3: *Accomplishments*
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

3. Teaching and Learning Activities (TLAs)

(TLAs designed to facilitate students' achievement of the CILOs.)

TLA	Brief Description	CILO No.						Hours/week (if applicable)
		1	2	3	4	5		
Lectures	Key mathematical, algorithmic and system concepts are described and illustrated. These concepts are also worked out based on examples and exercise	✓	✓	✓	✓			3 hrs/wk
On-line learning	Key mathematical, algorithmic and system concepts concepts are demonstrated with Google CoLab exercises	✓	✓	✓	✓			
Computer projects, demo and presentation	Key concepts are applied to solve real-world problems					✓		

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.						Weighting	Remarks
	1	2	3	4	5			
Continuous Assessment: 70%								
Test	✓	✓	✓	✓	✓		10%	
#Assignments	✓	✓	✓	✓	✓		20%	
Course Project/Oral Presentation/Reports	✓	✓	✓	✓	✓		40%	
Examination: 30% (duration: 1.5 hrs , if applicable)								
Examination	✓	✓	✓	✓	✓		30%	
							100%	

Remark:

To pass the course, students are required to achieve at least 30% in course work and 30% in the examination.

may include homework, tutorial exercise, project/mini-project, presentation

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B,)	Marginal (B-, C+, C)	Failure (F)
1. Examination	Achievements in CILOs	High	Medium	Low	Not even reaching marginal level
2. Coursework	Achievements in CILOs	High	Medium	Low	Not even reaching marginal level

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Examination	Achievements in CILOs	High	Significant	Moderate	Basic	Not even reaching marginal level
2. Coursework	Achievements in CILOs	High	Significant	Moderate	Basic	Not even reaching marginal level

6. Constructive Alignment with Programme Outcomes

PILO	How the course contribute to the specific PILO(s)
1, 2	By taking this course, students will first learn the relationships between AI, machine learning and deep learning for identify the advantages on using deep learning approach for different applications.
3	Students will learn advanced deep learning models and its applications, including classic neural network architectures of MLP, CNN and RNN and advanced architectures of Transformers, GANs and Self-Supervised Learnings for various applications in Computer Vision (CV) and Natural Language Processing (NLP).
4	Students will be able to design and train different types of deep learning architecture using Python programming language and deep learning frameworks such as Google's TenorFlow Keras or PyTorch.
5	Students will be able to develop deep learning based solutions for real world problems. For example, student can be asked to do a project on image classification, object detection, image segmentation, or face recognition. This requires research and development of efficient network architecture and the knowledge gained in this course can help student achieve the goals.

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

Machine Learning Background for Deep Learning
Relationships between AI, Machine Learning and Deep Learning; Regression and Classification problems; Traditional Neural Networks; Why Deep Learning?

Neural Network Basics
Perceptions and Multilayer Perceptron (MLP);
Activation Functions: Sigmoid, Rectified Linear Unit (ReLU), Softmax;
Regularizations: L1 (Lasso) and L2 (Ridge) and Dropout;
Loss Functions: Mean Square Error, Root Mean Square Error and Cross Entropy Loss.

Training of Neural Networks
Backpropagation: classic backpropagation, momentum backpropagation, batch and online backpropagation stochastic gradient descent, and other techniques;
Cross-Validation, Early Stopping and the best weights and managing hyperparameters;
Confusion Matrix, ROC Curve and Lift Curve;
TensFlow Keras or Pytorch;

Convolutional Neural Networks (CNNs)
CNN basics, Tricks for improving test accuracy, Feature scaling and batch normalization, Advanced topics on CNNs, Popular CNN architectures (AlexNet, VGG, GoogleNet, ResNet, DenseNet, MobileNet and EfficientNet).

Recurrent Neural Networks (RNNs)
Simple RNN, Long and Short Term Memory (LSTM), Gate Recurrent Unit (GRN), Stacked RNN, Bidirectional RNN;

RNN Applications: Sentiment Analysis, Text Generation, Machine Translation, Image Caption Generation.

Transformer Models
Attention, Self-attention, Transformers, Pretrained Language Models, BERT, GPT-3, Vision Transformer (ViT).

Generative Models
Autoencoders (AEs), Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), DCGAN, Conditional GANs, CycleGAN, StyleGAN, Fréchet Inception Distance (FID).

Self-Supervised Learning (SSL)
Self-Prediction Algorithms: Image Rotation, Relative Patch Position, Jigsaw Puzzle, Colorization and Super-resolution Pretext Tasks;
Contrastive Learning Algorithms: MoCo, MoCo v2, MoCo v3, SimCLR, SimCLR v2, BYOL, SimSiam, DINO.

Text-to-Image Generation Models
Diffusion Models, DALL-E, CLIP, GLIDE, DALL-E 2, and Google Imagen.

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

1.	Ian Goodfellw and Yoshua Bengio and Aaron Courville, "Deep Learning", An MIT Press book. http://www.deeplearningbook.org/ .

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

	Nil