MNE4121: MACHINE LEARNING AND QUANTUM COMPUTATION

Effective Term
Semester A 2022/23

Part I Course Overview

Course Title
Machine Learning and Quantum Computation

Subject Code
MNE - Mechanical Engineering

Course Number
4121

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MNE2036 Engineering Computing

Precursors
It is ideal for students to have some programming skills and computational knowledge, such as the MNE2036 course.

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

Machining learning and artificial intelligence play more and more important roles in current engineering disciplines. This course will introduce the basics of machine learning and explore how such advanced techniques can be applied in the mechanical engineering field. Students will learn the art and science of Machine Learning from the fundamentals to state-of-the-art models. A strong emphasis is put on students learning the principles of engineering problem solving, and how these techniques can be used to tackle practical engineering problems. The students will complete the course with the confidence to explore these topics further and apply them to other areas of interest themselves.

Students should have some programming background to understand the course content. We will use Matlab as medium to implement the machine learning models.

Quantum computer can perform computations much faster than classical computer on certain type of problems, which starts a new page in computation history. Many problems that are intractable on classical computers may be tractable with the aid of quantum computing. This course will introduce the fundamental knowledge of superposition and entanglement to explain how a quantum computer bit (qubit) works. Famous quantum algorithms such as Shor’s algorithm for cryptography, Grover's algorithm for searching problem, variational quantum eigensolver for materials simulation, quantum Fourier transform algorithm for engineering mathematics…etc, all will be introduced in details. In advance, quantum machine learning is also been widely studied with success in computational applications. With these new tools and knowledge, quantum computers will become a powerful tool for our students to face the rapid changing challenges in this whole new era.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Identify the nature of engineering problems that can be solved through machine learning and quantum computation.		x	x	
2	Describe the principles of machine learning/ quantum computation and core models.		x	x	
3	Apply the basic concepts of machine learning/ quantum computation and models to a specific engineering problem.			x	x
4	Analyze the machine learning/quantum computation model and evaluate its accuracy and applicability.			x	x
5	Use Matlab and Qiskit to implement the basic machine learning/quantum computation models.			x	x

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 real-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.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Lecture on the topics of advanced structured rationale.	1, 2, 3, 4, 5	30 hrs
2	Presentation	Students presenting and defending their work.	3, 4, 5	3 hrs
3	Lab	Students hands-on training with practical ML models.	5	6 hrs

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignment	1, 2, 3, 4, 5	20	
2	Presentations	1, 2, 3, 4, 5	20	
3	Final project	2, 3, 4, 5	30	

Continuous Assessment (%)

70

Examination (%)

30

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Assessment Rubrics (AR)

Assessment Task

1. Assignment

Criterion

Capacity to understand and implement a particular model in engineering problems.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task
2. Presentations

Criterion
Capacity of self-directed learning to conceptualise a solution to a given problem.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
3. Final project

Criterion
Demonstrate the mastery of all CILOs.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
4.Examination

Criterion
Capacity to understand the concept and apply the knowledge in engineering problems as appropriate.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Additional Information for AR

Note: For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Part III Other Information

Keyword Syllabus

Machine learning, artificial intelligence, deep learning, supervised learning, non-supervised learning, classification, regression, data gathering, preprocessing, data visualization, Probability Theory, decision tree, neural network, kernel methods, model training, validation, and testing.

Quantum computation, Shor’s Algorithm, variational quantum eigensolver, quantum Fourier transform, Grover's algorithm, quantum machine learning.

Reading List

Compulsory Readings

	Title
1	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer.
2	Tom Mitchell, Machine Learning, McGraw Hill.
3	Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall.
4	Quantum Computation and Quantum Information, Isaac Chuang and Michael Nielsen, Cambridge University Press.

Additional Readings

	Title
1	Richard Sutton and Andrew Barto, Reinforcement Learning: An Introduction, MIT Press.