香港城市大學
City University of Hong Kong

City University of Hong Kong
Course Syllabus

offered by School of Data Science
with effect from Semester A 2024/25

Part I Course Overview

Course Title:	Machine Learning and Control Theory
Course Code:	SDSC8015
Course Duration:	One Semester
Credit Units:	3
Level:	R8
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	Nil
Precursors: *(Course Code and Title)*	Nil
Equivalent Courses: *(Course Code and Title)*	Nil
Exclusive Courses: *(Course Code and Title)*	Nil

Part II Course Details

1. Abstract

Machine Learning relies on the theory of optimization. However, the most successful part, which is Deep Learning relies on Control Theory. This is a recent discovery for the Machine Learning community, and it is the object of active research. The deep learning structure is based on a sequence of layers of neural nets. With an infinite number of layers, one obtains a structure amenable to Control Theory. The class will provide all the concepts and methods, in optimization and control theory, which are important and currently used in practice and in research. The models are not simply deterministic. So stochastic control will also be presented. In addition, the connection with the topic of identification of dynamical systems will be explained and developed. Reinforcement learning which is another aspect of Machine Learning, is closely linked with MDP, Markov Decision Processes. We also present Bayesian Learning, with an application ininventory control.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes		
			A1	*A2*	*A3*
1.	Describe the fundamentalknowledge on the mathematical methods of Machine Learning	30	✓		
2.	Obtain the background necessary for research	30		✓	
3.	Explain and identify successful methods	15	✓		
4.	Explain how to deal with Dynamical Systems	15		✓	
5.	Apply knowledges taught to applications	10			✓
		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. Learning and Teaching Activities (LTAs)

LTA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
Lectures	Students will engage in formal presentation of concepts and methods.	✓	✓	✓	✓		
Readings	Students will study the relevant articles and research papers.	✓	✓	✓	✓	✓	
Home Assignments	Students will work on exercises and homework problems to get facilitate and understand the course material.	✓	✓	✓	✓		

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.					Weighting	Remarks
	1	2	3	4	5		
Continuous Assessment: __70__%							
Participation	✓	✓	✓	✓		15%	
Home Assignments : Exercises	✓	✓	✓	✓		35%	
Projects in groups: study more deeply specific topics	✓	✓	✓	✓	✓	20%	
Examination: __30__% (duration: 3 hours)							
						100%	

5. Assessment Rubrics

Applicable to students admitted from Semester A 2022/23 to Summer Term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Participation	Ability to follow the lectures actively, with questions	High	Significant	Basic	Not even reaching marginal levels
2. Exercises	Ability to understand and use the concepts and methods	High	Significant	Basic	Not even reaching marginal levels
3.Projects in groups	Ability to study a specific domain within a group	High	Significant	Basic	Not even reaching marginal levels
4**.** Test	Understanding of lectures	High	Significant	Basic	Not even reaching marginal levels

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Participation	Ability to follow the lectures actively, with questions	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Exercises	Ability to understand and use the concepts and methods	High	Significant	Moderate	Basic	Not even reaching marginal levels
3.Projects in groups	Ability to study a specific domain within a group	High	Significant	Moderate	Basic	Not even reaching marginal levels
4**.** Test	Understanding of lectures	High	Significant	Moderate	Basic	Not even reaching marginal levels

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

1. Keyword Syllabus

Machine Learning
Optimisation
Control Theory
Dynamic Systems
Dynamic Programming
Stochastic Control
Markov Decision Processes
Markov Chains
Gradient- Stochastic Gradient

2. Reading List

2.1. Compulsory Readings

1.	Lecture Notes and Slides

2.2. Additional Readings

1.	Y. LeCunn, Y. Bengio & G. Hinton, "Deep Learning" , Nature, 521 (7553): 436-444, (2015).
2.	Q.Li, L.Chen,C.Tai,W.E, Maximum Principle Based Algorithm for Deep Learning, Journal of Machine Learning Research,18 (2018),1- 29
3.	A, Chiuso , G. Pillonetto, System Identification: A Machine Learning Perspective, Annual Review of Control, Robotics and Autonomus Systems, (2019), 2-281-304
4	A. Bensoussan, F. Gelir, V. Ramakrishna, M-B.Tran, Identification of Linear Dynamical Systems and Machine Learning Journal of Convex Analysis, 28 (2), 2021