City University of Hong Kong
Course Syllabus

offered by School of Data Science
with effect from Semester A 2022/23

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:	Nil
Precursors:	Nil
Equivalent Courses:	Nil
Exclusive Courses:	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 (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Knowledge on mathematical methods of Machine Learning	30	✓		
2.	Obtain the background necessary for research	30		✓	
3.	Identify successful methods	15	✓		
4.	Deal with Dynamical Systems	15		✓	
5.	Be well prepared for 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. Teaching and Learning Activities (TLAs)

TLA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
Lectures	Presentation of concepts and methods	✓	✓	✓	✓		
Readings	Study of relevant articles	✓	✓	✓	✓	✓	
Home Assignments	Exercises to facilitate understanding	✓	✓	✓	✓		

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

(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. 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

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

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