The Hong Kong University of Science and Technology (Guangzhou)

UG Course Syllabus Template

[Course Title] Learning and Optimization for Artificial Intelligence

[Course Code] AIAA 3225

[No. of Credits] 3

[Any pre-/co-requisites] DSAA 2011 Machine Learning

Teaching team

Instructor 1: Prof. Xin Wang (felixxinwang@hkust-gz.edu.cn), W2-503

Instructor 2: Prof. Zijun Gong (gongzijun@hkust-gz.edu.cn), W4-617

Office hour: Friday 10-12 am, please make an appointment by using KLMS AND sending an email.

Course Description

Learning and optimization serve as the foundational block for many artificial intelligence algorithms. Our initial focus is on convex analysis and on modeling problems as convex problems, while later on in the course we will shift the focus to different algorithms and analysis for convex optimization and non-convex optimization. The techniques and theory introduced in this course will be motivated by needs of problems and applications in Machine Learning. The topics range from foundational knowledge of optimization to cutting-edge trends.

- Week 1 (Wang): General intro to Optimization in Machine Learning.
- Week 2 (Gong): Intro to Convex Optimization and SVM.
- Week 3 (Gong): Linear Programming and Classification. (Practice of convex opt and SVM)
- Week 4 (Gong): Advanced convex optimization. (Practice of LP)
- Week 5: (Wang) Semidefinite programming and duality theory. (Practice of SDP)
- Week 6: (Wang) SDP and its applications in combination optimization. (Practice of SDP for complex problems)
- Week 7: Mid-term Exam
- Week 8: (Wang) Gradient Methods. (Practice of GD methods)
- Week 9: (Wang) Non-convex Optimization in Machine Learning. (Practice of AGD methods)
- Week 10: (Wang) SGD methods. (Practice of SGD in ML)
- Week 11: (Wang) Min-max optimization, neural network optimization. (Practice of deep learning optimization)
- Week 12: (Wang, Flipped Classroom) Geometric Optimization.

- Week 13: (Wang) Generalization Error and Overcome Overfitting, Course summary. (Assignment 4 due, Dec 7)
- Final Exam in December.

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

1. Demonstrate fundamental understanding of optimization problems and optimization procedure
2. Address challenges in the selection of optimization parameters and performance-complexity trade off.
3. Identify and describe different scientific methods to critically evaluate complex, emerging deep learning optimization problems.
4. Recognize the importance of stochastic gradient descent under unknown environments and big data assumptions.
5. Develop a broad interest in the environment and connect the knowledge to their major study.
6. Communicate effectively in written format and programming language to convey scientific knowledge and the application of machine learning techniques.
7. Apply the knowledge in solving engineering and technological challenges.

Final grading rules:

A (A+ A A-): Overall Course Grade $\geqslant$ 80 AND Ranked in the top 45% (A+: Overall Course Grade $\geqslant$ 92 AND Ranked in the top 15%)

B (B+ B B-): Overall Course Grade $\geqslant$ 70 AND Ranked in the top 85%

C (C+ C C-): Overall Course Grade $\geqslant$ 60

D: Overall Course Grade $\geqslant$ 50

F: Overall Course Grade < 50

All subgrades except A+ (e.g. A-, B+, etc.) will be assigned based on the outcome of the overall course grades.

Assessments:

Assessment Task	Contribution to Overall Course grade (%)	Due date
Mid-Term	20%	Tentatively on the 7th week
Final examination	40%	To be determined
Assignments	40%	Refer to the above syllabus, 4 assignments in total

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
Assignments	CILO-1, CILO-2, CILO-3, CILO-4, CILO-5,CILO-6, CILO-7	Through assignments, students will demonstrate fundamental understanding of optimization theory; critically evaluate emerging learning optimization problems using scientific methods; highlight the role of SGD in uncertain settings; connect broad environmental relevance to their majors; develop effective written and programming communication; and apply machine learning to engineering and technological challenges.
Mid-Term	CILO-1, CILO-2, CILO-6, CILO-7	Through the midterm exam, students will demonstrate fundamental understanding of optimization problems and the foundations of convex optimization, address parameter-selection challenges and solve them using software, communicate effectively in writing and programming about machine learning applications, and apply this knowledge to engineering and technological challenges.
Final examination	CILO-1, CILO-2, CILO-3, CILO-4, CILO-5,CILO-6, CILO-7	Through the final exam, students will demonstrate a fundamental understanding of optimization theory for both convex and non-convex problems; critically evaluate emerging learning optimization problems using scientific methods; understand the role of SGD in theory and practice; develop effective written and programming communication; cultivate a broad interest in environmental contexts and connect this knowledge to their major; and apply machine learning to technological challenges.

Grading Rubrics

Grading Rubrics: For each assignment, problems will be assigned specific points. For proof problems, full credit is awarded if the proof is correct; partial credit is awarded if the framework of proof is generally correct with minor mistakes or slips; lesser credit is awarded if framework of proof is wrong with reasonable steps. For calculation and practical problems, full credit is awarded if both the process and the result are correct; partial credit is awarded if the result is correct with minor mistakes or slips on its process; lesser credit is awarded if the result is incorrect with reasonable process.

Final Grade Descriptors:

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Consistently performing at an exceptionally high standard for this level. Has a deep understanding of the knowledge and skills associated with this subject.

B	Good Performance	Consistently performing at a high standard for this level. Has a strong understanding of the knowledge and skills associated with this subject.
C	Satisfactory Performance	Woking at a good standard for this level. Gaining many of the knowledge and skills associated with this subject.
D	Marginal Pass	Woking at a fair standard for this level. Gaining some of the knowledge and skills associated with this subject.
F	Fail	Is currently struggling to master the core skills and understanding associated with this subject at this level.

Course AI Policy

No AI is allowed.

Resubmission Policy

Resubmissions of assignment solutions are not allowed in general, unless strong justifications are provided. Each resubmission will be treated as a new submission. For delayed submission, a penalty of 10% of total points will be incurred per day of delay, unless strong justifications are provided.

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST(GZ)'s Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Regulations for Academic Integrity and Student Conduct for the University's definition of plagiarism and ways to avoid cheating and plagiarism.

Recommended reading material

Convex Optimization, by Stephen Boyd and Lieven Vandenberghe

Lecture Notes: Optimization for Machine Learning, by Elad Hazan