ISM UNIVERSITY OF MANAGEMENT AND ECONOMICS

APPROVED BY
THE STUDY COMMISSION
Minutes No. 02-12-2023-11
as of 29th August 2023

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Course code	*IT102*
Compulsory in the programmes	*Economics and Data Analytics*
Level of studies	*Undergraduate*
Number of credits	*6 ECTS (48 in-class hours + 2 hours of consultations + 2 hours of examination, 108 individual work hours)*
Course coordinator (title and name)	*Jevgenij Gamper*
Prerequisites	*Statistical Data Analysis, Mathematical Analysis, Computer Programming*
Language of instruction	*English*

THE AIM OF THE COURSE:

Whether you are speaking to government officials or corporate managers, startup founders, investors or employees, seasoned researchers or industry data scientists you're likely to hear a range of claims about what AI/ML can/will do. These discussions are frequently motivated by reciting recent breakthroughs in predictive modeling. From seminal work in applying deep convolutional neural networks to image classification (see *Krizhevsky et al. (2012)*). Leading to an industry wide AI revolution among big tech companies (see *The Secret Auction That Set Off the Race for AI Supremacy*). To breakthroughs in protein structure prediction (see Jumper et al. (2021)). Empowering researchers that seek cures for diseases and pursue solutions to other big problems facing humankind – such as antibiotic resistance, or microplastic pollution (see *Putting the power of AlphaFold into the world's hands*). To large language and image generation models, inspiring writers, artists and designers (see *Deep Learning for Art, Aesthetics, and Creativity*, *COSMOPOLITAN*).

Yet, despite all the progress, what these systems cannot do? Or should not do?

The goal of this course is to provide you with the necessary technical expertise to critically reflect on the problems that AI systems are meant to be solving, to identify the strengths and weaknesses of existing AI systems, and to build impactful AI systems yourself. Specifically, the course covers three broad topics: (1) Linear and shallow models to develop enough philosophy and critical thinking about practical problem formulation skills, complex modeling objectives and computational frameworks; (2) Expanding these to deep and non-linear models such as convolutional neural networks, and transformers; (3) Deep understanding of latest iteration of transformer based models such as ChatGPT, Claude, Bard, Lamma. All three topics will be heavily relying on writing code, as well as critically reviewing various literature sources from industry and academia.

The course heavily focuses on using Python and Github. Foundational knowledge in statistics, mathematical analysis, and Python programming and Version Control is assumed.

MAPPING OF COURSE-LEVEL LEARNING OUTCOMES (OBJECTIVES) WITH DEGREE LEVEL LEARNING OBJECTIVES (See Annex), ASSESSMENT AND TEACHING METHODS

Course level learning outcomes (objectives)	**Degree level learning objectives (Number of LO)**	**Assessment methods**	**Teaching methods**
CLO1. Using linear models develop intuition on generative thinking and Direct Acyclic Graphs (DAGs) for problem formulation and its implication on model construction and objective metrics. Develop critical thinking towards formulating problems from unstructured domain knowledge. Develop critical thinking towards scientific literature.	ELO1.1 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work

CLO2. Write clear, reproducible, and well-documented code in Python and the associated machine learning packages, such as, jax, pytorch, botorch, weights and biases.	ELO1.1 ELO3.1 ELO3.2 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work
CLO3. Learn how to systematically and reproducibly produce AI modeling results, collaborate on AI model building in teams, and communicate AI systems capabilities and limitations.	ELO1.1 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work
CLO4. Develop intuition on theory and gain practical experience with deep and non-linear models. Revisit classical statistical assumptions about bias-variance tradeoff.	ELO1.1 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work
CLO5. Develop intuition on theory, and gain practical experience with neural network based models.	ELO1.1 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work
CLO6. Develop intuition on theory, and gain practical experience with transfer learning using deep neural networks architectures such as convolutional neural networks, transformers, and their generalizations.	ELO1.1 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work
CLO7. Develop intuition on theory, and gain practical experience with Causal Diagrams and explore-exploit problems.	ELO1.1 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work
CLO8. Develop intuition on theory, and gain practical experience with ethics concerning AI systems and their implications on society.	ELO1.1 ELO3.1 ELO3.2 ELO4.3	Final exam, Mid-term exam, group project	Lectures, seminars, independent work

ACADEMIC HONESTY AND INTEGRITY

The ISM University of Management and Economics Code of Ethics, including cheating and plagiarism, is fully applicable and will be strictly enforced in the course. Academic dishonesty and cheating can and will lead to a report to the ISM Committee of Ethics. With regard to remote learning, ISM reminds students that they are expected to adhere to and maintain the same academic honesty and integrity that they would in a classroom setting.

COURSE OUTLINE

Week	Topic	In-class hours	Readings
I. Foundation for problem solving using AI/ML systems			
1.	1. Introduction and motivation: AI/ML application opportunities, engineering and ethical challenges. Modelling as storytelling: DAGs & linear regression. Exam questions presentation. Project ideas and structure presentation.	4	Will be provided during the lectures
2.	2. More DAGs and more motivating examples. Metric mismatch.	4	Will be provided during the lectures

3.	3. From linear regression to stochastic gradient descent. Modeling as storytelling - classification. Generative vs discriminative.	4	Will be provided during the lectures
II. Deep Learning Models			
4.	4. Deep dive into deep learning neural network development. Learning Pytorch, and the modular construction of neural networks.	4	Will be provided during the lectures
5.	5. Pytorch fundamentals - dataloading, datasets, stochastic gradient descent intuition, loss functions, optimisation.	4	Will be provided during the lectures
6.	6. Convolutional neural networks and transfer learning.	4	Will be provided during the lectures
7.	*Midterm exam*	2	
8.	7. Introduction to transformer architecture - first steps at developing chatGPT from scratch	4	Will be provided during the lectures
9.	8. Completing ChatGPT development from scratch and training on shakespeare poem generation	4	Will be provided during the lectures
10.	9. Introduction to reinforcement learning from human feedback (RLHF) - aligning methods for foundational models such as chatGPT.	4	Will be provided during the lectures
11.	10. Implementing RLHF from scratch.	4	Will be provided during the lectures
12.	11. Studying Llama2 paper and other pieces of literature on the up and coming developments in AI.	4	Will be provided during the lectures
		Total: 48 hours	
	CONSULTATIONS	6	
	FINAL EXAM	2	

FINAL GRADE COMPOSITION

Type of assignment	**%**
Group Components 50%	
Group project	50%
Individual Components, 50%	
Mid-term exam	25%
Final exam	25%

Total:	**100**

DESCRIPTION AND GRADING CRITERIA OF EACH ASSIGNMENT

Group project. In the group project, students will have to prepare a report detailing the experiments they have performed and the conclusions they reach. The report will be written as a NeurIPS style article, and will have to be on par with scientific publication standards. The report will include a link to a repository with fully reproducible results and figures included in the report. The framework and instructions for the task will be provided by the lecturer during class. The group sizes are expected to be between 2-3 people. There will be one such project worth 50% of the final grade.

Mid-term exam. The mid-term exam will be held during the midterm exam session. The instructions as well as the topics for the mid-term exam will be provided by the lecturer during class. The midterm will consist of theoretical, multiple-choice and open questions, practical and coding problems. It tests critical thinking, conceptual, analytical, and numerical skills.

Final exam. The instructions as well as the topics for the final term exam will be provided by the lecturer during class. The final exam will consist of theoretical, multiple-choice and open questions, practical and coding problems. It tests critical thinking, conceptual, analytical, and numerical skills. The final examination will take place during the final examination session.

Retake exam. Students who receive a failing final grade shall have the right to the retake exam, which will comprise 50% of the final grade and cover all topics of the course. Midterm exam and final exam results will be annulled.

REQUIRED READINGS

Rogers, Simon, and Mark Girolami. A first course in machine learning. Chapman and Hall/CRC, 2016.

Zhang, Aston, et al. "Dive into deep learning." (2021).

ADDITIONAL READINGS

- For python version management we will be using *pyenv*.
- For python package management we will be using *poetry*.
- Please make sure to setup your own computing devices.

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ANNEX

DEGREE LEVEL LEARNING OBJECTIVES

Learning objectives for the Bachelor of Business Management
Programmes:
International Business and Communication,
Business Management and Marketing,
Finance,
Industrial Technology Management,
Entrepreneurship and Innovation

Learning Goals	Learning Objectives
Students will be critical thinkers	BLO1.1. Students will be able to understand core concepts and methods in the business disciplines
	BLO1.2. Students will be able to conduct a contextual analysis to identify a problem associated with their discipline, to generate managerial options and propose viable solutions
Students will be socially responsible in their related discipline	BLO2.1. Students will be knowledgeable about ethics and social responsibility
Students will be technology agile	BLO3.1. Students will demonstrate proficiency in common business software packages
	BLO3.2. Students will be able to make decisions using appropriate IT tools
Students will be effective communicators	BLO4.1. Students will be able to communicate reasonably in different settings according to target audience tasks and situations
	BLO4.2. Students will be able to convey their ideas effectively through an oral presentation
	BLO4.3. Students will be able to convey their ideas effectively in a written paper

Learning objectives for the Bachelor of Social Science
Programmes:
Economics and Data Analytics,
Economics and Politics

Learning Goals	Learning Objectives
Students will be critical thinkers	ELO1.1. Students will be able to understand core concepts and methods in the key economics disciplines
	ELO1.2. Students will be able to identify underlying assumptions and logical consistency of causal statements
Students will have skills to employ economic thought for the common good	ELO2.1.Students will have a keen sense of ethical criteria for practical problem-solving
Students will be technology agile	ELO3.1. Students will demonstrate proficiency in common business software packages
	ELO3.2. Students will be able to make decisions using appropriate IT tools
Students will be effective communicators	ELO4.1.Students will be able to communicate reasonably in different settings according to target audience tasks and situations
	ELO4.2.Students will be able to convey their ideas effectively through an oral presentation
	ELO4.3. Students will be able to convey their ideas effectively in a written paper