MASTER IN ARTIFICIAL INTELLIGENCE

Main Language of Instruction:

Français : □	Anglais : ◙	Arabe : □

Campus Where the Program Is Offered: CST

Objectives

The Master's degree in Artificial Intelligence (AI) is a professional program to prepare experts capable of developing intelligent programs and systems to be implemented in different industries for the betterment of mankind. Our graduates have expertise in a wide range of AI-related fields such supervised and unsupervised Machine Learning (ML) and Deep Learning (DL), Reinforcement Learning, Big Data Analysis and Modeling, Data Mining, Statistics as well as the development of parallel and distributed AI-based software. It is a professional master program that meets the needs of the job market but also provides the theoretical basis that enables students to pursue doctoral studies in this field. The program features theoretical & practical lectures, extensive hands on experience and an internship in a company or a research internship leading to the writing of a thesis and a defense. Our graduates are presented with a wide range of opportunities in the fields of Machine Learning (ML), Deep Learning (DL), Computer Vision (CV), Natural Language Processing (NLP), Generative AI (GenAI), Large Language Models (LLM), Internet of Things (IoT) with applications in software development, robotics, healthcare, fintech and others.

Program Learning Outcomes (Competencies)

1. **Acquire and apply advanced knowledge appropriate to the discipline**
   - 1.1. Acquire theoretical and practical concepts appropriate to the discipline
   - 1.2. Demonstrate proficiency in applying theoretical concepts to practical problems within the discipline
2. **Solve critical issues and demonstrate expertise in key areas in the field of study**
   - 2.1. Identify and evaluate key challenges in the field
   - 2.2. Solve critical issues by using advanced mathematics and sciences
   - 2.3. Exhibit depth of knowledge in specialized areas
3. **Apply new and diversified theoretical and experimental methods as appropriate to the discipline**
   - 3.1. Demonstrate the ability to learn and apply new methods and technologies
   - 3.2. Utilize advanced analytical tools and techniques to solve complex issues in the field
   - 3.3. Integrate new technologies into existing systems to improve performance
4. **Communicate, at an advanced level, in oral and written form**
   - 4.1. Prepare clear, concise, and well-organized written reports on complex topics
   - 4.2. Deliver effective oral communications, demonstrating mastery of the subject matter

Admission Requirements

Admission of students is based on their file and an interview might be required.

1- Admission to the first semester of the Master's program (S1)

To be authorized to submit application files, students must satisfy one of the following conditions:

- Hold a Bachelor in Computer and Communications Engineering, Computer Science, or Telecommunications;
- Hold an equivalent degree recognized by USJ.

2- Admission to the third semester of the Master's program (S3)

To be authorized to submit application files, students must satisfy one of the following conditions:

- Hold a Bachelor of Engineering in Computer and Communications Engineering or being a CCE student at ESIB and have earned at least 120 credits in the Engineering Cycle.
- Hold a Master's degree in Computer Science, Computer and Communications, or Informatics.
- Hold an equivalent degree recognized by USJ.

The documents required when submitting the application form are specified in the common admission file specific to the Saint Joseph University of Beirut.

The submitted files will be examined by the Scientific Committee of the Faculty of Engineering and Architecture, which will subsequently establish the list of admitted candidates. For each application, the Scientific Committee will decide on the validated courses according to the program and the obtained previously results. Selected candidates might be interviewed before their final admission. The application file is downloadable from the Saint Joseph University of Beirut's[1] website and is to be submitted at the School of Engineering of Beirut (ESIB) at USJ.

Courses/Credits Granted by Equivalence

Engineers with degrees in computer engineering and/or communications, holders of a Master's degree in computer science or information technology, fifth-year CCE students at ESIB and holders of an equivalent diploma, can validate, by equivalence, a maximum of 60 credits of the program. Upon approval from the Director of the Department of Doctoral Studies, the admissions jury will decide, for each student accepted directly in M3, the set of validated courses and modules based on their background and their results. It will define accordingly their path in the Master's program, possibly including additional prerequisite courses. The validation of previously pursued programs is subject to approval by the USJ Equivalence Commission.

Program Requirements

Required courses (120 credits)

Artificial Intelligence (4 Cr.), Graph Theory and Operations Research (4 Cr.), Mathematics for AI & Machine Learning (4 Cr.), Natural Language Processing (4 Cr.), Optimization for AI (4 Cr.), Programming for AI & Machine Learning (6 Cr.), Statistics for AI & Machine Learning (4 Cr.), AI in Computer Vision (4 Cr.), AI in Financial Technology (4 Cr.), AI in Robotics (4 Cr.), Game Theory (4 Cr.), Foundations of Decision Modeling (5 Cr.), Machine Learning (4 Cr.), Parallel Computing (5 Cr.), AI-Based Control Systems (4 Cr.), AI for Business and Marketing (6 Cr.), AI in Cybersecurity (4 Cr.), Big Data Frameworks (4 Cr.), Generative AI (4 Cr.), Legal, Policy, and Ethical Considerations for Data Scientists and AI (4 Cr.), Software Engineering for AI (4 Cr.), Master's Thesis (30 Cr.).

[1] https://usj.edu.lb/esib/diplome.php?diplome=1057

Suggested Study Plan

Semester 1

Code	Course Name	Credits
020IA2ES4	Artificial Intelligence	4
048DSTGM1	Graph Theory and Operations Research	4
020IAMAM1	Mathematics for AI & Machine Learning	4
020IANLM1	Natural Language Processing	4
020OPAIM1	Optimization for AI	4
020IAOOM1	Programming for AI & Machine Learning	6
020IASTM1	Statistics for AI & Machine Learning	4
	Total	**30**

Semester 2

Code	Course Name	Credits
020IACVM2	AI in Computer Vision	4
020IAFIM2	AI in Financial Technology	4
020IAROM2	AI in Robotics	4
020IAGAM2	Game Theory	4
020IADMM2	Foundations of Decision Modeling	5
020MLRES4	Machine Learning	4
020IAPCM2	Parallel Computing	5
	Total	**30**

Semester 3

Code	Course Name	Credits
020IARBM3	AI-Based Control Systems	4
020IABMM3	AI for Business and Marketing	6
020IACSM3	AI in Cybersecurity	4
020BDFRM3	Big Data Frameworks	4
020GAIES5	Generative AI	4
020IALPM3	Legal, Policy, and Ethical Considerations for Data Scientists and AI	4
020IAIDM3	Software Engineering for AI	4
	Total	**30**

Semester 4

Code	Course Name	Credits
020IAINM4	Master Thesis	30
	Total	**30**

Course description

Semester S1 (30 credits)

020IA2ES4 Artificial Intelligence 4 Cr.

This course aims to study artificially intelligent agents. It portrays several methods of implementing these agents: from simple reflex agents to utility-based agents as well as learning agents. We first cover greedy and A* search, the implementation of games through the minimax and expectimax algorithms, Markov Decision Processes (MDP), and Reinforcement Learning (RL). We then introduce Machine Learning (ML) algorithms with some applications.

048DSTGM1 Graph Theory and Operations Research 4 Cr.

This teaching unit introduces students to the graph theory and operational research as modeling and decision-making tools for the data scientist. Therefore, students will learn to make a mathematical and computer representation of graphs, apply the algorithms for traversing the graphs, calculate the shortest path, maximize a flow problem, analyse complex networks, use the NetworkX Python library, use Markov chains to solve real-world problems, understand the Simplex algorithm and linear programming, use numerical tools for solving optimization problems.

020IAMAM1 Mathematics for AI & Machine Learning 4 Cr.

This course is designed to enhance students' mathematical skills, which are essential for other courses in this major. We start with the basics, including scalars, vectors, matrices, and tensors, and then progress to more advanced topics such as the Hadamard product, dot product, and various matrix types including identity, diagonal, symmetric, orthonormal, orthogonal, and inverse matrices. The course also covers solving linear equations, L^p and L^∞ norms, the Frobenius norm, eigen decomposition, diagonalization, singular value decomposition (SVD), the Moore-Penrose pseudoinverse, derivatives, gradients, the chain rule, local and absolute maxima and minima, Lagrange multipliers, and Taylor's Formula. Finally, students are requested to do a project demonstrating how these mathematical concepts can be applied in AI and machine learning.

020IANLM1 Natural Language Processing 4 Cr.

This course aims to dive into the fascinating world of Natural Language Processing (NLP), a cutting-edge field of Artificial Intelligence (AI) that empowers machines to understand, interpret, and generate human language. The course offers a comprehensive exploration of NLP, equipping students with the skills to leverage language technologies in various applications and industries. From another hand, with the rapid advancement in digital technologies and an explosion of research publications, NLP is becoming increasingly pivotal. This course is designed for individuals eager to harness the power of NLP in their careers or research endeavors. Whether Audiences are aiming to enhance customer interactions, analyze sentiment, or detect anomalies, this course will provide them with a competitive edge in today's data-driven world.

020OPAIM1 Optimization for AI 4 Cr.

This course delves into the mathematical optimization techniques essential for developing and refining machine learning algorithms and AI applications. Focusing on theoretical foundations, this course explores deep neural network initialization, gradient descent techniques, automatic differentiation and backpropagation, and adaptive learning rate algorithms such as Adam and RMSProp. Additionally, it covers principal component analysis (PCA), density estimation algorithms, and support vector machines (SVM). Students will learn to solve unconstrained and constrained optimization problems, apply these methods to neural networks, and enhance model performance. The course provides a comprehensive understanding of optimization's role in AI, equipping students with the theoretical knowledge to tackle complex challenges in various AI domains.

020IAOOM1 Programming for AI & Machine Learning 6 Cr.

The main purpose of this course is to give students the necessary tools for the development of advanced level programs by using the concept of objects in their programs. This program focuses on the fundamental building blocks you will need to learn to become an AI practitioner. Specifically, students will learn programming skills, and essential math for building an AI architecture. They will even dive into neural networks and deep learning.

020IASTM1 Statistics for AI & Machine Learning 4 Cr.

This course provides a basic high-level introduction to the mathematics and statistics that underpin many of the modern machine learning and AI algorithms. The course will cover two broad areas of statistics: inference and prediction. The inference portion introduces statistical concepts to understand populations and test hypotheses (e.g., A/B tests, p-values), while the prediction section covers algorithms from linear regression to more advanced topics like random forests and cross-validation. Real-world examples are drawn from healthcare, genetics, marketing, and manufacturing.

Semester S2 (30 credits)

020IACVM2 AI in Computer Vision 4 Cr.

This course aims to study the image processing techniques: filtering morphology edge detection and segmentation. Then we apply artificially intelligent technique to detect features in images aiming to detect an image in a scene. Then we pass to the

camera to see the calibration and the computer vision. Lab on MATLAB or/and python will be done to explain all AI methodologies. We will finish by the processing of images using Convolutional neural networks.

020IAFIM2 AI in Financial Technology 4 Cr.
Technology is playing an increasingly dominant role in the financial service industry. It is changing how existing players operate and it is creating new ways to deliver core services like saving, investing, borrowing, and transacting. The aim of this course is to develop machine learning and AI techniques to provide solutions in the finance industry, with a focus on credit risk assessment, decision-making, and an introduction to algorithmic trading.

020IAROM2 AI in Robotics 4 Cr.
This course covers the fundamental concepts of game theory and strategic thinking; normal form games; Nash equilibrium; strategies (dominated, pareto-optimal, mixed, max-min, min-max); extensive form games (with perfect/imperfect information); repeated games.

020IAGAM2 Game Theory 4 Cr.
This course covers the fundamental concepts of game theory and strategic thinking; normal form games; Nash equilibrium; strategies (dominated, pareto-optimal, mixed, max-min, min-max); extensive form games (with perfect/imperfect information); repeated games.

020IADMM2 Foundations of Decision Modeling 5 Cr.
Preferences are present and pervasive in many situations involving human interaction and decisions. Preferences are explicitly or implicitly expressed in numerous applications and relevant decisions should be made based on these preferences. This course aims at introducing preference models for multicriteria decisions. It covers concepts and methods for preference modeling and multicriteria decision making, convex optimization as a decision tool, decision under uncertainty, decision trees, expected utility theory and its applications, Markov decision processes and their application.

020MLRES4 Machine Learning 4 Cr.
Machine learning (ML) is a subfield of Artificial intelligence. It is the science of making the machine learn by examples. The goal of ML is to make a computer that can learn from examples autonomously. The main research topics in ML include: Computer Vision (CV) and Natural Language Processing (NLP) and precision medicine for personalized treatments. The main goal of this course is to acquire a basic understanding of ML algorithms as well as hands-on ML engineering experience with regards to its application to realistic datasets through Python implementations that make use of state-of-the-art libraries such as Scikit-learn, Tensorflow and Keras.

020IAPCM2 Parallel Computing 5 Cr.
Parallel architectures – Parallel Computing – Concurrency and Threads – Parallelism in Python & OpenMP – Message Passing Interface (MPI) using mpi4py – Heterogeneous programming and GPUs with CUDA and Python.

Semester S3 (30 credits)

020IARBM3 AI-based Control Systems 4 Cr.
In this course, two intelligent techniques for data processing drawn from complex and imprecise environment are presented and studied. Fuzzy Logic theory is based on the empirical aspect of the human reasoning, and is used in the manipulation of imperfect, imprecise or approximate knowledge. It allows the modeling and processing of very complex systems in which, for example, human factors are present. Theory and applications concerning fuzzy logic exit for more than fifty years. They cover several fields such as artificial intelligence, identification and control of dynamic systems, automatic decision-making in complex systems, and fault diagnosis in industrial processes. On the other hand, Artificial Neural Networks are based on the biological aspect of the human brain. They are currently widely applied in various sectors such as telecommunication systems, automation, robotics, image processing and recognition, artificial intelligence, medicine and economics.

020IABMM3 AI for Business and Marketing 6 Cr.
This course explores the integration of artificial intelligence tools and techniques in business and modern marketing practices. Students will delve into the utilization of AI algorithms, machine learning models, and data analytics to optimize marketing strategies across various digital channels and business decision-making. Through real-world applications and hands-on experience, students will learn to personalize content, enhance customer engagement, and drive ROI through targeted advertising and dynamic pricing. The course emphasizes ethical considerations and responsible AI usage, empowering business to leverage technology effectively while maintaining integrity and trust.

020IACSM3 AI in Cybersecurity 4 Cr.
This course provides a comprehensive overview of the intersection between artificial intelligence (AI) and cybersecurity.We will explore the fundamental principles of AI, its applications in both offensive and defensive cyber operations, and the potential risks associated with AI in the cybersecurity landscape.

020BDFRM3 Big Data Frameworks 4 Cr.

This course introduces students to distributed computing paradigms and big data processing techniques. It focuses on data parallel processing using MapReduce and Apache Spark. Students will gain hands-on experience in managing and analyzing large-scale datasets in distributed environments.

020GAIES5 Generative AI 4 Cr.

This course aims to immerse students in the transformative field of Generative AI, a groundbreaking area of Artificial Intelligence focused on creating content, models, and solutions that mimic human-like creativity and intelligence. The course offers a comprehensive introduction to generative models, equipping you with the knowledge and skills to harness the power of AI to generate text, images and more. Generative AI is at the forefront of technological innovation, enabling new forms of creativity and automation. This course is designed for professionals, researchers, and enthusiasts eager to explore the cutting-edge of AI and its potential to revolutionize various domains. This course covers the principles, methodologies, and applications of generative models, equipping students with the knowledge and skills to utilize these technologies in various domains of technology.

020IALPM3 Legal Policy and Ethical Considerations for Data Scientists and AI 4 Cr.

The purpose of this course is to give the audience, a general understanding of regulations on AI (existing and under development): the principles, standards and policies adopted by the different regulators when issuing such rules, how these are applied and how they will evolve. Throughout the course we will be addressing the general legal provisions and framework which accompanying the different regulations while focusing on the applicability of such regulations (within the relevant jurisdictions and abroad), the need for standardization processes (namely through international forums such as the UN and the OECD), the effectiveness of such regulations and the importance of ethics in the "AI world" from legal and compliance perspectives.

020IAIDM3 Software Engineering for AI 2 Cr.

The Software Engineering for AI course provides a comprehensive exploration of software engineering principles tailored for AI applications. It covers the entire software development lifecycle (SDLC) for AI projects, including requirements engineering, design patterns for machine learning applications, and software design for AI systems. The course delves into development tools and techniques essential for AI software development, and emphasizes machine learning operations (MLOps) such as model training and deployment pipelines, model monitoring and performance evaluation, version control and management of machine learning models, and responsible AI practices focusing on bias, fairness, and explainability.

Semester S4 (30 crédits)

020IAINM4 Master Thesis 30 Cr.

During the 4th semester, students must complete a professional project in a company or research work in a laboratory for 4 months on an AI-related topic.

- They have the choice between:
  - A professional project in a company lasting 3 to 4 months, on a theme related to AI, concluded by writing and defending a professional report.
  - A research topic lasting 3 to 4 months in a laboratory recognized by the Scientific Committee, concluded by writing and defending a research paper.
- The projects will take place in companies in Lebanon or abroad. The scientific responsibility for the project is provided jointly, by the company and an instructor from USJ or a partner university. This project, of a minimum of one semester, aims to develop all the skills necessary for an AI specialist:
  - Bibliographic search.
  - Study of the state of the art.
  - Proposal and implementation of solutions.
- The research takes place in a laboratory either in Lebanon or in an external institution. Scientific responsibility for this research is provided by the research professor(s) who supervise them. This work, of a minimum duration of one semester, aims to develop the necessary skills to carry out research work:
  - Bibliographic search.
  - Critical analysis of the state of the art.
  - Proposals and implementations of solutions.
  - Proposals and outlets for thesis work.
- The project or research work is the subject of a report or a written dissertation and a public defense. Students who have validated the theoretical modules of semesters 1, 2, and 3 are authorized to submit the project report and possibly the research paper.

  The thesis or report includes a bibliographic part and a technical part. The evaluation of the project or research work considers three elements:
  - Evaluation of the trainee's scientific initiative.
  - Evaluation of the written brief or report.
  - Evaluation of the oral defense.