Palaiseau, June 7, 2022

CURRICULUM UE

I, the undersigned Pauline JUBIN, Dean of Studies, hereby certify that Mrs GEBRAN Hanady has followed these courses for 2019/2020 and 2020/2021 academic years at École polytechnique, in the "Ingénieur" Program:

Programme of study: Diplôme d'ingénieur (Master level)

ECTS	Course Title	Numerical Grade	Letter Grade	Course description
5	INF442 Algorithm for Data Analysis in C++	16.9	A	Modern data analysis relies on the use of high-level languages such as Python or R for data handling and processing. However, behind standard libraries like Scikit-Learn hide core implementations in low-level languages such as C or C++, for faster execution and optimized resources management. Hence the utility of this course, the goal of which is twofold: first, to get acquainted with some of the standard techniques in data analysis and machine learning; second, to acquire some expertise in C/C++ programming, so that students can then adapt existing low-level implementations to their needs. Note that the programming paradigms seen in this course are almost exclusively sequential, concurrent programming being addressed only marginally during the last session and being the subject of other courses. **Topics of the sessions (data analysis / C++):** 1. Short introduction to data analysis / C++ as C (1/2) 2. Nearest neighbors search and retrieval in databases / C++ as C (2/2) 3. k-means / structs and classes (1/2) 4. Hierarchical clustering / structs and classes (2/2) 5. Density estimation / inheritance 6. k-NN classification and regression / genericity

				7. Linear models for regression / STL 8. Linear models for classification / C++11 9. Feature extraction / - Neural networks / multithreading
6	INF473V Modal d'informatique - Deep Learning in Computer Vision	16.2	A	This practical course (modal) aims to introduce the students to recent methods for analyzing and processing images, based on Deep Learning and more specifically Convolutional Neural Networks (CNNs). These methods have recently seen a surge in popularity and have largely contributed to the advances in problems as diverse as: image classification, segmentation and comparison, object and person (e.g. face) detection and recognition, video analysis, detection of anomalies, super-resolution et even analysis of style in images, among myriad others. This course will introduce the main concepts used in these methods and will concentrate on practical aspects of putting them in place, including: The choice of architecture for CNNs 1. Practical approaches involved in their training, such as back-propagation and stochastic gradient descent. 2. Training CNNs on modern hardware, including GPUs. 3. Use pre-trained models efficiently in practice. The final goal will be to work on a project in groups of 2-3 students, in which the knowledge gained during the course will be used to solve a practical problem at medium to large scale. Possible project ideas include: automatic image colorization, recognition of emotion in photos, motion tracking in images, etc. **Note:** The majority of the lectures will be given in English.

5	INF569 Decision theory, with applications to energy systems	20	A	Management of energy systems is one of the biggest challenges of our time. The daily demand for energy increases constantly for many reasons, including the worldwide spreading of the electrification/decarbonization of vehicles used for public and private transportation. Moreover, the wide use of renewable energies, also aimed at limiting polluting emissions, can create instability in the networks and uncertainty in energy production. The current production sources and the current infrastructure for transmission and distribution are likely to soon become insufficient to cope

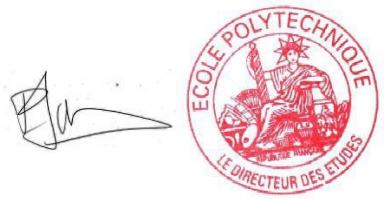
				with these changes. Decision makers will, thus, need efficient and effective tools aimed at helping them to optimize operational and strategic decisions to be taken in the short, medium, and long term. This course aims at providing the students with the background in mathematical optimization needed to play a fundamental role in the decision-making processes in energy systems. Mathematical optimization allows to formally state an extremely large variety of optimization problems as a so-called mathematical formulation. Once the problem is formalized, its optimal solution can be found by properly using mathematical optimization solvers or devising algorithms tailored for the specific problem. In this course, we will code the formulations and run solvers thanks to the modeling language AMPL. Each of the lectures will focus on a particular optimization aspect and one or more energy applications. The applications covered will be: production, transmission, distribution of energy; energy markets; renewable energies; smart grids. All these problems are challenging because they include technical, economic, political, and ethical issues. Warning #1: this is a course offered by the Computer Science Department. Basic knowledge of Unix OS and of shell commands is requested. Warning #2: the course might be proposed as a hybrid one, i.e., - lectures will be proposed as videos to watch, available one week before the planned lecture - during the time window of the lectures, Questions & Answer session face-to-face (with all the students or one-to-one, based on the week) will be organized (NB. the total duration of videos and Q&A session will not exceed 2 hours unless several questions will be asked by the students) - face-to-face exercise sessions will be offered
5	INF581 Advanced Machine Learning and Autonomous Agents	17.8	A	Driven by recent breakthroughs, rapidly growing collections of data, and a plethora of exciting applications, artificial intelligence is experiencing massive interest and investment from both the academic and industrial scene.

				This course selects a number of advanced topics to explore in machine learning and autonomous agents, in particular: Probabilistic graphical models (Bayesian networks, ...) Multi-output and structured-output prediction problems Deep-learning architectures Methods of search and optimization (Beam search, epsilon-approximate search, stochastic optimization, Monte Carlo methods, ...) Sequential prediction and decision making (HMMs, Sequential Monte Carlo, Bayesian Filtering, MDPs, ...) Reinforcement learning (Q-Learning, Deep Q-Learning, ...) Although these topics are diverse and extensive, this course is developed around a common thread connecting them all, such that each topic builds off the others. Lectures will cover the relevant theory, and labs will familiarize the students with these topics from a practical point of view. Several of the lab assignments will be graded, and a team project on reinforcement learning will form a major component of the grade - where the goal is to developing and deploy an agent in an environment and write a report analyzing the results.
5	INF580 Programmation mathématique	18	A	Mathematical Programming (MP) is a formal language for defining and solving optimization problems. A mathematical program consists of parameters (the input), decision variables (the output), one or more objective functions, and zero or more constraints given in either explicit or implicit (e.g. integrality constraints on the decision variables) form. Objectives and explicit constraints are expressed as functions of parameters adn variables. Mathematical programs can be passed to one of many existing "generic solvers", which provide the solution. Thus, MP shifts algorithmic and implementation difficulties in optimization to modelling issues. MP is very much present in industry: production, logistics, resource management (whether the resources be human, financial,

				energetic or others), telecommunications, etc. MP can also be found in hi-tech IT firms: Google, Microsoft, Yahoo, Huawei currently employ many mathematical programmers. IBM actually has a whole MP team! This programming paradigm gives rise to a family of complex and powerful algorithms, including the solution of whole optimization problems (by means of MP) as "elementary steps". This paradigm is at the basis of the vast majority of modern Machine Learning (ML) techniques, from clustering to natural language processing. Course evaluation: either a project or an oral exam. Language: French and English
5	INF554 Machine and Deep Learning	15,9	B	**General Introduction to Machine Learning** - Machine Learning paradigms - The Machine Learning Pipeline **Supervised Learning** - Generative and non generative methods - Naive Bayes, KNN and regressions - Tree based methods **Unsupervised Learning** - Dimensionality reduction - Clustering **Advanced Machine Learning Concepts** - Regularization - Model selection - Feature selection - Ensemble Methods **Kernels** - Introduction to kernels - Support Vector Machines **Neural Networks** - Introduction to Neural Networks - Perceptrons and back-propagation **Deep Learning I** - Convolutional Neural Networks - Recurrent Neural Networks - Applications **Deep Learning II** - Modern Natural Language Processing - Unsupervised Deep Learning - Embeddings, Auto-Encoders, Generative Adversarial Networks

				Reinforcement Learning
5	MAP557 Recherche opérationnelle : aspects mathématiques et applications	16	A	a recherche opérationnelle est un ensemble de techniques permettant de formaliser et de résoudre les problèmes d'organisation et de décision qui se posent dans le monde de l'entreprise. On peut citer les problèmes de transport, de localisation d'entrepôt, de tournées de véhicule, d'emploi du temps, de gestion de stock ou de réserve énergétique (hydraulique, gaz, combustible nucléaire), mais aussi des applications particulières, telles que la conception de circuits ou de câblages, l'allocation de fréquence, etc..., qui conduisent à étudier des problèmes d'optimisation fondamentaux, souvent de nature combinatoire. Le cours présente quelques grandes familles de méthodes mathématiques utiles en recherche opérationnelle, afin de donner la capacité de modélisation, et de permettre de reconnaître les problèmes pour lesquels des algorithmes rapides de résolution existent. On met l'accent sur les techniques issues de la programmation linéaire ou convexe, qui sont souvent à l'origine de tels algorithmes. Il n'y a pas de pré-requis, hormis une familiarité avec les mathématiques appliquées, qui a pu être acquise en suivant l'un des cours de ce domaine en seconde année. Signalons que la recherche opérationnelle est aussi abordée en programme d'approfondissement d'informatique de second semestre, dans les cours traitant d'analyse d'algorithmes et de programmation par contraintes, qui apportent un éclairage complémentaire sur la discipline. Le présent cours peut être suivi de manière indépendante, ou bien en association avec ceux-ci. Principaux concepts développés dans le cours : - Modélisation de problèmes combinatoires, points entiers de polyèdres, matrices totalement unimodulaires. - Problèmes de flots. Rappels de dualité. Algorithmes. - Multiflots : communications, transport. Flots potentiels, - Génération de colonnes et algorithme de Dantzig-Wolfe

				- Algorithmes polynômiaux en optimisation convexe. Points intérieurs. - Le problème du voyageur de commerce. Séparation et évaluation. Principe des relaxations et coupes. - Coupes de Chvátal et Gomory - Relaxation lagrangienne. Optimisation non différentiable : plans sécants. Décomposition de Benders. - Coloriage et coupes de graphes : l'approche par programmation semidéfinie. - Programmation dynamique. Modalités : 9 blocs, 36 heures, 4 ECTS Stéphane Gaubert



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