Programme détaillé de la 1ère année du second cycle

Semestre 5

Module : Data Mining

Semestre 5 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Fondamentales 5.1	67.5	4.5	1.5		3	4	5

Course Description:
The course introduces basic data mining concepts and techniques for discovering interesting patterns hidden in data including large-scale data sets. Topics covered include feature engineering, association, clustering, and correlation analysis.

Prerequisite : Linear algebra, Probability

Evaluation Method : Coursework (40%) + Final Exam (60%)

Course Content

- Introduction to Data Mining
- Data and Feature Engineering
- Information Theory
- Association Analysis : Frequent itemsets, Association rules
- Clustering of Data : Dissimilarity and scatter. K-means clustering, K-medoids clustering.Hierarchical clustering, interpreting clustering trees, different linkages, top-down and bottom-up. Determining the number of clusters.
- Dimensionality Reduction : Principal component analysis. Directions of maximal variance,or equivalently, approximating a matrix by another matrix with a given (smaller)rank. Interpretation of principal components, usages, limitations. Multidimensional scaling, isomap, local linear embedding.
- Factor Analysis
- Feature Selection : Objective function, methods and algorithms.
- Correlation analysis : Correlation. Canonical correlation analysis. Zero correlation versus independence. Shortcomings of correlation for nonlinear relationships. Rank correlation, maximal correlation, distance correlation.
- Anomaly Detection
- Data Mining Case Studies

References

- Andrew R. Webb, Keith D. Copsey, Statistical Pattern Recognition, 3rd Edition, 2011
- Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, 2000.
- Charu C. Aggarwal, Data Mining: The Textbook, 2015, Springer

Module : Operations Research

Semestre 5 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Fondamentales 5.1	45	3	1.5	1.5		3	4

Course description:
Operations research (OR) has many applications in science, engineering, economics, and industry and thus the ability to solve OR problems is crucial for both researchers and practitioners. Being able to solve real life problems and obtaining the right solution requires understanding and modelling the problem correctly and applying appropriate optimization tools and skills to solve the mathematical model. The aim of this module is to teach the student the techniques of modelling problems by a linear program or a graph, the methods of solving these models and the practical interpretation of the results.

Prerequisite: Linear Algebra. Continuous Mathematics.

Evaluation Mode: Coursework (40%) + Final Exam (60%)

Content of the course

Part 1. Linear Optimization
- Generalities of linear programming
- Simplex algorithm
- Post-optimal analysis
- Duality

Part 2. Graph Theory
- Definitions and basic concepts
- Connectivity in Graphs
- Planar graphs
- Graph Coloration
- Applications of Graph Theory

References

- Frederick Hillier, Gerald Lieberman: Introduction to Operations Research, McGraw Hill, 2020.
- R. J. Vanderbei. Linear Programming: Foundations and Extensions. Kluwer Academic Publishers, 1998.
- Michael W. Carter, Camille C. Price: Operations Research: A Practical Introduction, Routledge, 2001.
- West, D.B. Introduction to Graph Theory (2nd Edition), Prentice-Hall, 2000.
- Wilson, R.J. Introduction to Graph Theory (5th Edition), Pearson, 2010.
- Berge. Graphes. Book . Editions Gauthier-Villars. 1983.
- F.M. Dekking, C. Kraaikamp, H.P. Lopuhaa and L.E. Meester: A Modern Introduction to Probability and Statistics: Understanding Why and How, Springer, 2005.

Module : Stochastic Modelling and Simulation

Semestre 5 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Methodologiques 5.1	60	4	2	1.5	0.5	3	5

Course Description:
This course provides an introduction to the theory and practice of stochastic modelling and simulation. Stochastic modelling is the study of systems subject to random variations, where probability theory provides a powerful tool for modelling the behaviour of such systems.

Prerequisite : Probability and Inference

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content

Part 1: Stochastic Processes and their Classification
- Discrete time Markov chains
- Poisson processes
- Continuous time Markov chains

Part 2: Introduction to Stochastic Simulation
- Pseudo random number generator
- Simulation of random variables
- Simulation of random vectors
- Monte Carlo methods and variance reduction methods
- Simulation of stochastic processes (MCMC, queuing models)

Part 3: Probabilistic Machine Learning
- Bayesian networks
- Hidden Markov Models

References

- S. M. Ross: Introduction to Probability Models. Academic Press; 13th edition, 2023.
- M. A. Pinsky et S. Karlin : An Introduction to Stochastic Modeling. 4th ed. Academic Press, 2011.
- Hossein Pishro-Nik, Introduction to probability, statistics and random processes, Kappa Research, 2014.
- T. Hastie, R. Tibshirani and Friedman, The Elements of Statistical Learning, Springer.
- F. V. Jensen. "Bayesian Networks and Decision Graphs". Springer. 2001.

Module : Software Engineering

Semestre 5 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Methodologiques 5.1	67.5	4.5	1.5	1.5	1.5	3	5

Course Description :

Successful software development depends on an in-depth understanding of how the phases and supporting activities of the software development life cycle work together. Each phase of the life cycle contributes to a reliable, maintainable product that satisfies user requirements. The application of good engineering practices throughout the cycle dramatically improves the likelihood of delivering a quality software project on time, in scope and within budget. While there are many rigorous methodologies, in fact most approaches and tools have a mixture of strengths and weaknesses.

The main objectives of the course are as follows:

- Describe and compare various software development methods and understand the context in which each approach might be applicable.
- Develop students' critical skills to distinguish sound development practices from ad hoc practices, judge which technique would be most appropriate for solving large-scale software problems, and articulate the benefits of applying sound practices.
- Expand students' familiarity with mainstream languages used to model and analyse object designs (e.g., UML).

Prerequisite : Introduction to Programming

Evaluation Method : Coursework (40%) + Final Exam (60%)

Course Content

- Introduction
- Software processes
- Agile Methodologies
- Requirements engineering
- System modelling : Behavioural Modelling
- System modelling : Structural Modelling
- Architectural design
- Design and implementation
- Software Testing
- Software Integration and Delivery
- Software Maintenance
- Advanced Topics In Software Engineering

References

- Ian Sommerville. Software Engineering, Pearson Edition, 2015.
- Roger S. Pressman, Bruce Maxim. Software Engineering: A Practitioner's Approach 8th Edition, McGraw Hill, 2014.
- Stephens, Rod. Beginning software engineering, Wrox, a Wiley Brand, 2015.
- Systems Analysis and Design: An Object-Oriented Approach with UML 6th Edition, Alan Dennis, Barbara Wixom, David Tegarden, Wiley, 2020.
- Kim, G., Humble, J., Debois, P., Willis, J., & Forsgren, N. The DevOps handbook: How to create world-class agility, reliability, & security in technology organizations. IT Revolution. 2021

Module: Networks and Protocols

Semestre 5 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Methodologiques 5.1	67.5	4.5	1.5	1.5	1.5	3	5

Course Description:
This course is focusing on fundamental concepts, principles and techniques. The course will introduce basic networking concepts, including: protocol, network architecture, reference models, layering, service, interface, multiplexing, switching and standards. An overview of digital communication from the perspective of computer networking will also be provided.
Topics covered in this course include: Internet (TCP/IP) architecture and protocols, network applications, congestion/flow/error control, routing and internetworking, data link protocols, error detection and correction, channel allocation and multiple access protocols, communication media and selected topics in wireless and data centre networks. It will cover recent advances in network control and management architectures by introducing the concepts of software-defined networking (SDN) and network (function) virtualisation.
Students will gain hands-on experience in network programming using the socket API; network traffic/protocol analysis; and on assessment of alternative networked systems and architectures.

Prerequisite : Information Technology Essentials

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content

- Introduction to Computer Networking and the Internet
- Digital Communication Basics
- The Application Layer with comprehensive treatment of networked applications (incl. multimedia data and applications)
- The Transport Layer
- The Network Layer
- The Data Link Layer
- The Medium Access Control Sub-Layer
- The Physical Layer
- Software-defined networking (SDN)
- Network virtualisation and network function virtualisation (NFV)
- Network management
- Introduction to data centre and wireless networks

References

- J. F. Kurose and K. W. Ross, Computer Networking: A Top-Down Approach (8th Edition), Pearson Education, 2021
- L. L. Peterson and B. S. Davie, Computer Networks: A Systems Approach (6th Edition), Morgan Kaufmann, 2020
- A. S. Tanenbaum, N. Feamster and D. J. Wetherall, Computer Networks (6th Edition), Pearson Education, 2021
- L. Peterson, C. Cascone, B. O'Connor, T. Vachuska, and B. Davie, Software-Defined Networks: A Systems Approach, 2021

Module : Mobile Development

Semestre 5 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Transversales 5.1	67.5	4.5	1.5		3	2	5

Course Description:
Students will learn mobile application development and design by looking at different technological frameworks. Students are expected to design and develop a professional-quality mobile application that addresses a real-world problem in an innovative way. Coursework includes project conception, design, implementation, and pilot testing of mobile phone software applications.

Prerequisite : Programming

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content
Part 1 : Introduction:
- Why Mobile Apps?
- Technology : Native, Web and Hybrid

Part 2 : App Design Issues and Considerations
- Mobile Development Lifecycle Overview
- Architecture, Design and Engineering Considerations
- Usability and User Interaction Design
- Overarching Design Principles and Guidelines

Part 3: Developing the Mobile App
- Techniques, Methodologies for Mobile Application Development
- Mobile Application Development Frameworks
- Persistent Data in Mobile Apps
- Maps and Location in Mobile Apps
- Access to Hardware and Sensors
- Building Mobile Apps Powered by Enterprise Backend
- Secured Data Store and Synchronisation

Part 4 : Testing and Publishing Apps
- Mobile Application Build and Delivery
- Testing Mobile Applications
- App Distribution Through App Stores
- Monetizing Apps

References

- Catalin Ghita, Kickstart Modern Android Development with Jetpack and Kotlin, 1st ed, 2022
- Shaun Lewis and Mike Dunn “Native Mobile Development: A Cross-Reference for iOS and Android”, 2019

Module: Entrepreneurship and Innovation

Semestre 5 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Transversales 5.1	33.75	2.25	1.5	0.75		1	1

Course Description:
This course is designed to provide students with a comprehensive understanding of innovation and entrepreneurship. The course will begin by exploring the various types of innovation. Then students will learn about the processes and techniques used for developing new products and services and the role of R&D and knowledge management in innovation.The course will then move on to explore the concept of creativity and the different techniques and tools for idea generation. The course will also cover intellectual property and how it can be protected through patents, trademarks, and copyrights.

The second half of the course will focus on entrepreneurship, exploring the key traits and skills of successful entrepreneurs. Students will learn about the different forms of entrepreneurship, including social and civic entrepreneurship, and the opportunities and challenges presented by entrepreneurship in the 21st century.

Prerequisite : Introduction to Business

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content

- Types of innovation and innovation models
- New products and services
- R&D and knowledge management
- Developing creativity & Business Idea
- Intellectual property
- Innovation and entrepreneurship
- Entrepreneurship in the 21st Century
- Social and civic Entrepreneurship

References

- Paul Burns, Entrepreneurship and Small Business: Start-up, growth and maturity, 2011, Pal-Grave.

Semestre 6

Module : Machine Learning

Semestre 6 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Fondamentales 6.1	112.5	7.5	3	1.5	3	4	6

Course Description:
This course provides a broad introduction to machine learning and statistical pattern recognition. Students will be introduced to many machine learning algorithms and methods such as regressions, decision trees and support vector machines. They will understand the mathematical foundations of the different machine learning algorithms as well as acquire practical experience in using them for the different types of data.

Prerequisite : Linear Algebra, Probability and Inference, Programming

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content:

- Introduction to Machine Learning
- Linear models for regression and classification
- Nonlinear regression
- Decision Trees
- Instance-Based Learning
- Support Vector Machine
- Ensemble Methods
- Introduction to Neural Networks
- Performance Analysis
- Case Studies

References

- Andrew R. Webb, Keith D. Copsey, Statistical Pattern Recognition, 3rd Edition, 2011
- Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, 2000.
- C. Bishop : Pattern Recognition and Machine Learning. Springer: New York,2006.
- A. Cornuéjols and L. Miclet : Apprentissage artificiel – Concepts et algorithmes. Eyrolles, 2010.
- T. Hastie, R. Tibshirani and Friedman, The Elements of Statistical Learning, Springer. [ebook]
- G. James, D. Witten, T. Hastie, R. Tibshirani, An Introduction to Statistical Learning, Springer, 2013
- K. P. Murphy : Machine Learning: a Probabilistic Perspective. MIT Press, 2012.
- B. D. Ripley, Pattern Recognition and Neural Networks, Cambridge University Press, 1996. https://www.cs.purdue.edu/homes/clifton/cs490d/

Module: Numerical Methods and Optimisation

Semestre 6 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Fondamentales 6.1	60	4	2	1.5	0.5	3	5

Course Description:
This course in Numerical methods is designed to provide students with a strong foundation in numerical methods and their applications. The course begins with an introduction to the concept of errors in numerical analysis and the importance of using approximate methods. The course then delves into the topic of solving linear systems, polynomial interpolation and the least squares approximation method and its applications in data fitting and curve fitting.
Students will learn about the importance of numerical optimization and the various methods used for one-dimensional optimization, as well as optimization techniques with or without constraints.
Finally, metaheuristics will be introduced, including single-state methods such as simulated annealing and empirical analysis. Students will learn about research space structure and performance, population methods, and random search theory heuristics.

Prerequisite : Continuous Mathematics 1,2, 3, Operational Research

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content

Part 1 Numerical Analysis

- Notions of errors in numerical analysis
- Approximate resolution of nonlinear equations of type f(x)=0
- Solving linear systems: Direct methods
- Solving linear systems: Iterative methods
- Polynomial Interpolation
- Least Squares Approximation
- Digital Integration

Part 2 Optimisation

- One-dimensional optimization
- Optimization without constraints
- Optimization with constraints
- Special cases and approximation

Part 3 Metaheuristics

- Definition of Metaheuristics
- Combinatorial Optimization Problems
- Trajectory Methods
- Population-based Methods
- Hybrid approaches

References

- M. Atteia. M. Pradel : Eléments d'analyse numérique. Ceradues-Editions.
- Curtis F. Gerald. P. O. Wheatdey : Applied Numerical Analysis. Addison-Wesley Pub. Company.
- E. K. P Chong, S. M. Zak : An introduction to optimization. Second edition- John Wiley and Sons. New York. 2001.
- P.E. Gill. W. Murray, M. H. Wright : Practical optimization. Academic Press, 1981.

- J. Nocedal and S. J. Wright. Numerical Optimization. Springer-Verlag. New York. 1999.
- A. Eiben, J. E. Smith : Introduction to Evolutionary Computing. Springer, 2003.
- H. Hoos, T. Stützle : Stochastic Local Search: Foundations and Application. Morgan Kaufmann; 1st edition, 2004.
- S Luke : Essentials of Metaheuristics, 2010. Second edition, available at http://cs.gmu.edu/~sean/book/metaheuristics/

Module: Computer and Network Security

Semestre 6 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Methodologiques 6.1	67.5	4.5	1.5	1.5	1.5	3	5

Course Description :
This course presents the foundations of information security, cybersecurity, computer security, and network security. It consists of four main parts. The first part presents an introduction to information security and cybersecurity, and discusses the various security principles and real-life paradigms that exist in our cyber-physical and intelligent systems. The second part introduces cryptography as a strong and versatile mathematical tool to implement security mechanisms and protocols. The third part covers computer security by going through the different security threats and vulnerabilities related to computer hosts and operating systems and how computers thwart cyberthreats. The last part, covers security of networks, which covers network threats, large-scale cyber attacks, and security mechanisms (firewalls, IDS, honeypots, etc).

Prerequisite : Databases, Operating Systems

Evaluation Method : Coursework (40%) + Final Exam (60%)

Course Content

Part 1: Introduction to Information security

- Overview of information security and cybersecurity.
- Information security principles and terminologies.
- Threats, vulnerabilities, exploits, attacks, cyberattacks, intrusions, and countermeasures.
- Importance of information, computer, network, and cybersecurity.
- Ethics: security mindset, security engineering, and ethical hacking.

Part 2: Cryptography

- Introduction to cryptography.
- Classical and modern cryptography.
- Cryptanalysis and formal analysis of cryptographic protocols.
- Hash function and Message Integrity.
- PKI infrastructures, digital certificates, and digital signatures.
- Key Management Algorithms.
- Elliptic curve cryptography [and Zero-Knowledge algorithms].
- Security protocols and authentication mechanisms.
- Formal analysis of security protocols.

Part 3: Computer Security

- Operating system security.
- Hardware security (PUFs, BIOS poisoning, Firewire threads, DMA threads, etc.).
- Malware (viruses, worms, backdoors, trojans, spyware, rootkits, keyloggers).
- Security mechanisms for computer security (antimalware, firewall, HIDSs, etc)
- Buffers overflow on the stack and on the heap.
- Web security: SQL-injection, session hijacking, XSS, and more.

Part 4: Network Security

- Network threats (Following Stalling's classification).
- Firewalls and network security mechanisms.
- Intrusion detection and prevention systems.
- Wireless network security (e.g., Wi-fi, bluetooth, and RFID security).

References

- William Stallings and Lawrie Brown. Computer Security: Principles and Practice, Pearson Education, 2012.
- David Wagner, Nicholas Weaver, Peyrin Kao, Fuzail Shakir, Andrew Law, and Nicholas Ngai. https://textbook.cs161.org/
- Michael Goodrich and Roberto Tamassia. Introduction to Computer Security, Pearson, 2010.

Module : Advanced Databases

Semestre 6 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Methodologiques 6.1	67.5	4.5	1.5	1.5	1.5	3	5

Course Description :
The objective of this course is to teach students advanced concepts of databases. Students will learn to optimise and tune databases before and after going into production. Students will learn how to design, manipulate and optimise distributed databases across a network. The course also focuses on specific kinds of databases such as data warehouses used for decision support as well as the new NoSQL databases used to overcome the scalability problems of relational databases. At the end of the course, the student will be able to easily administer and secure a database to protect it from the most dangerous threats.

Prerequisite : Databases, Operating Systems

Evaluation Method : Coursework (40%) + Final Exam (60%)

Course Content

- Database Performance Tuning and Query Optimization
- Distributed databases
- Business Intelligence and Data Warehouses
- NoSQL Databases
- Database Administration and Security

References

- Carlos Coronel and Steven Morris. Database Systems: Design, Implementation, & Management, 13th Edition, 2018.
- Raghu Ramakrishnan, Johannes Gehrke. Database Management Systems, McGraw-Hill Higher Education; 3rd edition. 2002
- Ramez Elmasri, Shamkant B. Navathe. Fundamentals of Database Systems, Pearson; 7th edition, 2015.

Module : Time Series Analysis and Classification

Semestre 6 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Methodologiques 6.1	52.5	3.5	1.5	1.5	0.5	3	5

Course Description:
This course will provide an introduction to time series analysis and its applications in various fields such as finance, engineering, and economics. We will first explore the fundamental concepts and techniques used to analyse time series data, including time series models, spectral analysis, time-frequency representation, and multivariate time series.
We will then discuss time series classification as well as pattern recognition and anomaly detection. We will explore different methods such as Graphical models, dynamic time warping (DTW).
Overall, this course will provide a comprehensive overview of time series analysis and its applications, including both theoretical and practical aspects of the subject matter.

Prerequisite : Probability and Statistical Inference, Machine Learning

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content

Part 1 Time series Analysis
- Introduction
- Time Series Models
- Spectral analysis
- Time-frequency representation
- Multivariate Time Series

Part 2 Time Series Classification
- Pattern Recognition and Detection
- Feature Extraction and Selection
- Models and Representation Learning
- Data Enhancement and Preprocessings
- Change-Point and Anomaly Detection

References

- Box G.E., Jenkins G.M., Reinsel G.C, Time series analysis: forecasting and control, John ,2011, Wiley & Sons.
- P. J. Brockwell; Davies R.A. Introduction to Time Series and Forecasting. 2nd ed. Springer. 2002
- Percival D.B., Walden A.T. , Wavelet methods for time series analysis , 2000, Cambridge university press.
- Lütkepohl H., New Introduction to Multiple Time Series Analysis, 2006, Springer
- Charu C. Aggarwal, Data Mining: The Textbook, 2015, Springer

Module : Group Project

Semestre 6 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire				Coef	Crédits
			C	TD	TP	Travail Personnel		
UE Methodologiques 6.1	22.5	1.5			1.5	3	2	2

Course Description: Students are given a topic where they can develop a software solution using various slack of technological tools. Students would put in practice all the notions and theories learnt across different modules into practice from analysing the application domain of the selected topic into developing a fully functional software application.
The project will be supervised by an academic staff with the recommendation to conduct the project as part of an internship within a company.

Prerequisite : Software Engineering, Advanced Programming, Database, Mobile App Development, Web Development

Evaluation Method : Project Report (35 %) + Implementation (40%) + Demonstration & Questions Answering (35%)

Module: Project Management

Semestre 6 SC	VHS C/TD/TP	VHH Total C/TD/TP	V.H. Hebdomadaire			Coef	Crédits
			C	TD	TP		
UE Transversales 6.1	30	2	1.5	0.5		1	2

Course Description:
Reinforcement Learning (RL) is a general framework that can capture the evolving and unpredictable learning environment and has been used to design intelligent agents that achieve high level performances on challenging tasks. This course will provide a solid introduction to the field of reinforcement learning and students will learn about the core challenges and approaches, including generalisation and exploration.

Prerequisite : Linear algebra, probability, programming.

Evaluation Method : Coursework (40 %) + Final Exam (60%)

Course Content

- The world of project management;
- The Manager the Organisation and the Team;
- Project Activity and Risk Planning;
- Budgeting the Project;
- Scheduling the Project;
- Allocating Resources to the Project;
- Monitoring and Controlling the Project;
- Evaluating and Closing the Project.

References

- Jack R. Meredith, Scott M. Shafer, Samuel J. Mantel Jr., Margaret M. Sutton: Project Management in Practice, 7th Ed, Wiley, 2020