Semester 5 Modules: Specialization Software Engineering (Génie Logiciel – GL -)

code	Title	type	Coeffi-cients	ECTS	Total work-load	Contact hours	Private study
SE.5.1	Software Reengineering	compulsory	2	2	50	30	20
SE.5.2	Software quality & test	compulsory	2	2	50	30	20
SE.5.3	Mobile Development	compulsory	1	1	25	15	10
SE.5.4	Complex systems engineering	optional	2	2	50	30	20
SE.5.5	Model driven engineering	optional	2	2	50	30	20
ISA.5.1	Big Data	compulsory	2	2	50	30	20
ISA.5.3	Interactive Decision Support Systems	compulsory	2	2	50	30	20
ISA.5.7	Distributed databases	compulsory	1	1	25	15	10
ISA.5.4	Business Intelligence	compulsory	2	2	50	30	20
ISA.5.9	Geographic Information Systems	optional	2	2	50	30	20
ISA.5.2	Data mining	compulsory	2	2	50	30	20
ISA.5.10	Urbanization of information systems	optional	2	2	50	30	20
ISA.5.11	Data Engineering	optional	2	2	50	30	20
ISA.5.6	Text Mining	optional	1	1	25	15	10
ISA.5.8	Advanced BI	compulsory	1	1	25	15	10
AI.5.3	Applied Deep learning	compulsory	2	2	50	30	20
AI.5.1	Multi-agent systems	optional	2	2	50	30	20
DOS.5.1	Cloud computing	compulsory	2	2	50	30	20
DOS.5.2	Blockchain	compulsory	1	1	25	15	10
DOS.5.3	IoT	optional	1	1	25	15	10
	Complementary Module 1		2	2	50	30	20
	Complementary Module 2		2	2	50	30	20
	Complementary Module 3		2	2	50	30	20
	Complementary Module 4		1	1	25	15	10
	Complementary Module 5		1	1	25	15	10
	Complementary Module 6		1	1	25	15	10

SE.5.1 Software Reengineering

Module designation	SE.5.1 Software Reengineering
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Nesrine Ben Yahia
Team	Nesrine Ben Yahia Wala Rebhi
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, projects.
Workload (incl. contact hours, self-study hours)	Total workload: 50H Contact hours: 30h (21H lesson, 09H projects and Exercises). Private study: 20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	SE.3.1 Software engineering, SE.3.2 Object-oriented analysis and design, AP.2.1 Object-oriented programming, DAT.1.1.Database and DBMS
Module objectives/intended learning outcomes	This course aims to make the student aware of software reengineering (SR) principles. It also aims to acquire the different techniques of SR (in the different phases of SR) Thus, the student will be able to propose concrete solutions for reengineering in the professional environment as he will acquire many competencies such as: Become able to apply the different techniques of software reengineering. Apply reverse engineering and design recovery. Apply Test driven development approaches. Master and apply the SOLID principles Produce useful software documentation. Model business processes using BPMN. Competencies: C2, C3, C4, C5, C6, C8, C9

Content	Chapter 1 (04H.5): Introduction to Software Reengineering -Engineering Vs Reengineering -Reengineering Vs Maintenance -Reengineering aims -Reengineering Benefits -Reengineering principles -Categories of Reengineering -Reengineering Problems Chapter 2(09H): Code Reengineering: Refactoring -Problem presentation - Refactoring motivation - Refactoring techniques -Code Smells/anti-pattern -SOLID principles Chapter 3(04H.5): Data Reengineering -Problem presentation -Database Refactoring: database smells/ techniques/ process. -Database migration. Chapter 4(07H.5): Business Process Reengineering (BPR) -Definitions -Types of business processes -BPM - Business process engineering - RPA -Workflows -BPMN Chapter 5(03H): Information Systems Reengineering -Problem presentation -Information system -ERP -ERP and BPR Chapter 6(01H.5): Tools for Software Reengineering -Static Analysers -Dashboards -Converters -Reverse engineering tools
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Ambler, S. W., & Sadalage, P. J. (2006). Refactoring Databases: Evolutionary Database Design. Pearson Education. Fowler, M. (2018). Refactoring: Improving the Design of Existing Code. Addison-Wesley Professional. Martin, R. C. (2000). Design Principles and Design Patterns. Object Mentor, 1(34), 597.

SE.5.2 Software quality & test

Module designation	SE.5.2 Software quality & test
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Narjès Bellamine Ben Saoud
Language	French/English
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, project, seminar.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours: 30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	SE.3.1 Software Engineering
Module objectives/intended learning outcomes	- know the quality management process and its key activities - be aware of the necessity of culture of quality - understand the role of standards in quality management - learn the concept of software metrics and the quality assessment - master software testing techniques: - know the different levels of testing software. - know how to reduce bugs in the software program. - use and apply evaluation tools Competencies: C2, C3, C4, C8
Content	Part 1: Software Quality Management 1. Chapter 1: Software Quality Management 2. Chapter 2: Software Quality Standards 3. Chapter 3: Software measurement and metrics Part 2: Software Testing 1. Chapter 4: Software Testing fundamentals 2. Chapter 5: Functional Testing 3. Chapter 6: Test Automation 4. Chapter 7: Test-driven development 5. Chapter 8: code reviews
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Sommerville, I. (2020). Engineering software products. London: Pearson. Sommerville, I. (2016). Software Engineering (10th Edition). London: Pearson. Pressman, R. S. (2011). Software Engineering: a practitioner's approach (7th Edition).McGraw Hill.

SE.5.3 Mobile Development

Module designation	SE.5.3 Mobile Development
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Sabri ALLANI
Teaching team	Sabri ALLANI
Language	French
Relation to curriculum	Compulsory
Teaching methods	lab works and project.
Workload (incl. contact hours, self-study hours)	Total workload: 25h Contact hours : 15h Private study : 10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	AP.2.1, AP.2.2 and DAT.2.1
Module objectives/intended learning outcomes	Key question: what learning outcomes should students attain in the module? Knowledge: · have a good understanding of the mobile app's context · have a basic knowledge of mobile dev frameworks · have good knowledge of which standards apply to mobile application and related constraints. Competencies: C2, C3
Content	Introduction to mobile mobile app development Learn the basic principles of mobile app development using a cross-platform solution. Project · Project Proposal: Conceptualize and design your project in the abstract and write a short proposal that includes the project description, expected data needs, timeline, and how you expect to complete it. · Analysis and Planning: The application concept begins to develop at this point, after which it becomes a real mission. Definition of use cases and capture of comprehensive functional codes are the first steps in the assessment and planning strategy. · UI / UX Design: A user-friendly interface is included in the UI/UX layout. The goal of the application product is to create a wholly mobile experience that is intuitive and straightforward to employ · App Development: Concurrently with the prototype, the foundation stages of building an app are still essential. Before you begin writing your codes, make sure you've done this: o Specify the product backlog o Select a technology package o Set application's building goals A standard mobile application project consists of three major components: o Back-end/server technology o API(s) o The mobile app front-end

Examination forms	100% project eval
Study and examination requirements	10/20
Reading list	Alessandria, S. (2018). Flutter Projects: A Practical, Project-Based Guide to Building Real-World Cross-Platform Mobile Applications and Games (Vol. 53). Packt Publishing. Nagy, R. (2022). Simplifying Application Development with Kotlin Multi-platform Mobile (Vol. 61). Packt Publishing.

SE.5.4 Complex systems engineering

Module designation	SE.5.4 Complex systems engineering
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Narjès Bellamine Ben Saoud
Language	French/English
Relation to curriculum	Optional
Teaching methods	lesson, lab works, project, seminar.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prereq-uisites for joining the module	SE.3.1 Software Engineering AI.3.1
Module objectives/intended learning outcomes	This module aims to provide engineering students with the means to: - Become familiar with important examples of complex systems across a variety of domains (natural, socio-technical, etc.) - Assimilate key concepts in complex systems (e.g. emergence, self-organization, distributed control, etc.) - Describe, understand and analyze complex systems - Study computer tools for modelling, exploration and construction of complex systems - Learn Systems of Systems basics Competencies: C1, C3, C4, C7
	1. Introduction to Complexity Science 2. - Modeling and Simulation (M&S) of complex systems - agent-based modeling and simulation - Cellular automata 3. Introduction to Systems of Systems - System complexity - System of systems classification - Systems of systems engineering - Systems of systems architecture
Examination forms	35% Continuous evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Sayama, H. (2015). Introduction to the Modeling and Analysis of Complex Systems. Open SUNY. Sommerville, I. (2016). Software Engineering (10th Edition). London: Pearson.

SE.5.5 Model driven engineering

Module designation	SE.5.5 Model Driven Engineering
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Rim Drira
Language	French
Relation to curriculum	Optional
Teaching methods	lesson, lab works, projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	SE.3.1 Software Engineering SE.3.2 OOAD
Module objectives/intended learning outcomes	This course aims to: - Understand the positioning and principles of Model Driven Engineering (MDE) among software engineering approaches. - Detail the model-driven approach MDA (Model Driven Architecture) and OMG (Object Management Group) standards - Develop meta-modelling capabilities. - Master the OCL (Object Constraint Language) constraint expression language - Study the different types and approaches of model transformations - Put into practice the knowledge acquired Competencies: C8, C9

Content	Chapter I: Introduction to Model driven engineering (MDE) - Software Engineering: Reminder - Genesis of the MDE - Definition of key concepts - Model transformation - Approaches of MDE Chapter II: Principles and standards of MDE MDA: the new vision of the OMG From contemplative to productive 4 level hierarchy Concepts: CIM, PIM, PSM MOF (MetaObject Facility) UML profile Chapter III: Object Constraints Language (OCL) Why OCL OCL Syntax Invariant with OCL Pre and Post conditions with OCL Chapter IV: Model transformation Definitions and generalities Why the transformations Endogenous/exogenous transformation Vertical/Horizontal transformation Transformation in MDA Processing categories Transform tools processing techniques Processing Difficulties Example with ATL and Kermeta
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20

Reading list	Miller, J., & Mukerji, J. MDA Guide Version 1.0.1. Retrieved from [On Line]: http://www.omg.org/cgi-bin/doc?omg/03-06-01.pdf Kleppe, A. G., Warmer, J., & Bast, W. (2003). MDA Explained: The Model Driven Architecture: Practice and Promise (1st edition). Addison-Wesley. Blanc, X. (2005). MDA en Action: Ingénierie Logicielle Guidée par les Modèles (Vol. 1). Paris: Eyrolles. Favre, J.-M., Estublier, J., & Mireille, B.-F. (2006). L'Ingénierie Dirigée par les Modèles - Au-delà du MDA (1ère édition). Paris, France: Hermès - Lavoisier. Bézivin, J. (2006). Model Driven Engineering: An Emerging Technical Space. In Generative and Transformational Techniques in Software Engineering (Vol. 4143, pp. 36-64). Allemagne.

ISA.5.1 Big Data

Module designation	ISA.5.1 Big Data
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Raoudha Chebil
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, presentations.
Workload (incl. contact hours, self-study hours)	Total workload: 50 hours Contact hours: 30 hours: 20 hours lessons + 10 hours lab works Private study: 20 hours
Credit points	2 ECTS
Required and recommended prereq-uisites for joining the module	Basic knowledge in programming (Python and Java) and relational data-bases
Module objectives/intended learning outcomes	Knowledge: Students: -Master the basic building blocks of the Hadoop platform, namely HDFS and MapReduce, and have an idea of the components of its ecosystem; -Master the MapReduce approach for problem solving; -Understand the limits of the relational model and know the different models of NOSQL databases. CompetenciesC4, C7, C8

Content	Chapter I – Introduction to Big Data 1. Motivations 2. Definition 3. The 3Vs and the additional Vs 4. Benefits and challenges 5. Application examples 6. Stages of a Big Data project 7. New professions 8. Related fields Chapter II – Hadoop: Building Blocks 1. Hadoop presentation 2. Hadoop history 3. Hadoop ecosystem 4. HDFS 5. MapReduce V1 6. MapReduce V2 7. Design Patterns MapReduce Chapter III - Advanced Processing Tools 1. Data processing types 2. MapReduce review 3. Abstraction languages a. Pig b. Hive 4. Apache Spark Chapter IV – NOSQL Databases 1. DBMS strengths 2. DBMS limits 3. BD NOSQL 4. BDR vs BD NOSQL 5. Study of BD NOSQL instances a. Cassandra b. MongoDB Chapter V – Big Data Architectures 1. Motivations 2. Lambda architecture 3. Kappa architecture 4. Other architectures 5. Case study Practical Works 1. Installation and testing of the working environment 2. HDFS 3. MapReduce 4. Pig and Hive 5. Spark 6. HBase
Examination forms	35% continuous evaluation (Lab works, presentations) ; 65% written exam
Study and examination requirements	10/20

Reading list	Mooc – “Fundamentals for Big Data”, Télécom ParisTech – “Introduction to Hadoop and MapReduce”, University Nice Sophia Antipolis Books Bruchez, R. (2015). NoSQL Databases and Big Data: Understanding and Implementing. Editions Eyrolles. Marr, B. (2015). Big Data: Using SMART Big Data, Analytics and Metrics to Make Better Decisions and Improve Performance. John Wiley & Sons. Zikopoulos, P., Eaton, C., et al. (2011). Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data. McGraw-Hill Osborne Media. Classes Nerzic, P. (2016). Hadoop Tools for Big Data. Rennes1 University, France.

ISA.5.3 Interactive Decision Support Systems

Module designation	ISA.5.3 Interactive Decision support systems (SIAD)
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Imen BOUKHRIS
Language	French
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works.
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours: 30h (18h lecture, 9h exercise, 3h lab) Self-study: 20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	MAT.1.1, M.1.2, DAT 2.1
Module objectives/intended learning outcomes	In terms of Knowledge: This course exposes students to the knowledge and skills needed to use computer software to solve business problems, particularly to support decision making. It involves the formalization of a decision problem and its resolution in order to assist decision-makers in their decision-making process in semi-structured tasks. The decision process is defined by the involvement of several variables which makes it very complicated and difficult to manage. The objective of this module is to understand the decision-making process and investigate the different components of a decision support system as well as the different models (e.g., multi-criteria, under risk or uncertainty) in order to be able to apply them according to a given situation (e.g., (individual, group, conflictual decision) as well as to the personality of the decision maker (e.g., optimistic, pessimistic). In terms of competencies: C1, C2, C4, C9
Content	I. Introduction to decision theory (3 h) II. What are decision support systems ? (3 h) - DSS vs Information system - Decision systems classifications - Group decision making - DSS Structures - DSS Architectures III. Multi-criteria decision making (6h) - Pareto-optimality - Analytical Hierarchical Process (AHP) - Analytical Network Process (ANP) IV. Decision making under uncertainty (9 h) - Introduction and definitions - Objective vs subjective probability - Lottery and Utility - Maximax, Wald, Hurwicz, Laplace, Savage criteria V. Decision making under risk (9h) - Introduction and definitions - Raiffa Decision trees - Influence diagrams
Examination forms	100% Final exam

Study and examination requirements	10/20
Reading list	Alter, S. (1977). A taxonomy of decision support systems. Sloan Management Review (pre-1986), 19(1), 39. Sprague Jr, R. H. (1980). A framework for the development of decision support systems. MIS Quarterly, 1-26. Marakas, G. M. (2003). Decision Support Systems in the 21st Century (Vol. 134). Upper Saddle River: Prentice Hall. Marchau, V. A., Walker, W. E., Bloemen, P. J., & Popper, S. W. (2019). Decision Making Under Deep Uncertainty: From Theory to Practice (p. 405). Springer Nature.

ISA.5.7 Distributed databases

Module designation	ISA.5.7 Distributed Databases
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Raoudha KHCHERIF
Language	French
Relation to curriculum	Compulsory
Teaching methods	lecture, lesson, assignment, labs
Workload (incl. contact hours, self-study hours)	Total workload: 25 h Contact hours: 15 h (lecture, exercise, laboratory , etc.): Private study: 10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	DAT.2.1 , DAT.2.2, NET3.1, NET3.2, NET4.1
Module objectives/intended learning outcomes	This course will deal with the fundamental issues in large distributed database systems which are motivated by the computer networking and distribution of processors, and control. The theory, design, specification, implementation, and performance of large systems will be discussed. Competencies:C1, C2, C8, C13
Content	I INTRODUCTION II. BDR DESIGN AND IMPLEMENTATION II. TRANSACTION AND COMPETITOR ACCESS IV. OPTIMIZATION OF DISTRIBUTED QUERIES
Examination forms	100% written Exam
Study and examination requirements	10/20
Reading list	Özsu, M. T., & Valduriez, P. (2011). Principles of Distributed Database Systems. Springer. Rahimi, S. K. (2010). Distributed Database Management Systems. John Wiley & Sons Inc.

ISA.5.4 Business Intelligence

Module designation	ISA.5.4 Business intelligence
Semester(s) in which the module is taught	S5
Person responsible for the module (co-ordinator)	Manel BenSassi
Language	French
Relation to curriculum	Optional
Teaching methods	lesson, lab works.
Workload (incl. contact hours, self-study hours)	Total workload: 50H Contact hours:30h (21H lesson, 09H Lab works). Self study: 20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	DAT.1. Database and DBMS
Module objectives/intended learning outcomes	This course refers to technologies, applications and practices of heterogeneous data integration, storage, multidimensional analysis, and visualization to support business decision making. Thus, the student will be able to propose concrete conceptual and technological architecture for the integration od heterogenous data in the professional environment as he will acquire many competencies such as: - Become able to evaluate the technologies that make up BI (data Warehousing, OLAP) - Become able to plan the implementation of a BI architecture. Learning outcomes: C1, C2, C3, C4, C8, C9
Content	Chapter 1 : Understanding Business intelligence - The challenge of decision making - What is business intelligence - The BI value chain and value Chapter 2: Data Integration - Data integration motivation - ETL Process - ETL techniques Chapter 3: Data Storage: Data Warehousing - What is data warehousing? - Data Marts and analytical Data - Organization of DataWarehouse - Data access Chapter 4: Multi dimensional Analysis with OLAP - Definitions - OLAP vs OLTP - Operational data stores - Multi-Dimensions techniques - OLAP architecture Chapter 5 : MDX Language - Problem presentation - MDX Syntax and Request
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20

Reading list	Fernandez, A. (2013). Les nouveaux tableaux de bord des managers: le projet Business Intelligence clés en main (6ème édition). Eyrolles. Fernandez, A. (2013). L'essentiel du tableau de bord: Concevoir le tableau de bord de pilotage avec Microsoft Excel (4ème édition). Galzy, C., Girona, P., Martin, B., Nicoloso, C., & Vandermoere, J. (May 2010). La Business Intelligence, Livre Blanc.

ISA.5.9 Geographic Information Systems

Module designation	ISA.5.9 Geographic Information Systems
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Sabri ALLANI
Teaching team	Sabri ALLANI
Language	French
Relation to curriculum	optional
Teaching methods	Lesson, lab works and project.
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours: 30h (5h lecture, 10h lab work and 15h project) Private study: 20h
Credit points	2 ECTS
Required and recommended pre-requisites for joining the module	AP.2.1, AP.2.2 and DAT.2.1
Module objectives/intended learning outcomes	Key question: what learning outcomes should students attain in the module? Knowledge: · have a good understanding of the elements a GIS consists of has in-depth knowledge of various data-bases, especially related to nature management and area planning · have good knowledge of different methods of collec-tion, processing, analysis and presentation of site-based information · have good knowledge of GIS software and how these can be used to solve tasks · have good knowledge of which standards apply to geographic information Skills: Competencies: C2, C3

Content	Chapter 1 – Introduction to GIS Mapping Explore the world of spatial analysis and cartography with geographic information systems (GIS) Chapter 2- Formats, conception et qualité de données SIG We will go in-depth with common data types (such as raster and vector data), structures, quality and storage Chapter 3- Geospatial and Environmental Analysis Apply your GIS knowledge in this course on geospatial analysis, focusing on analysis tools, 3D data, working with rasters, projections, and environment variables. Chapter 4 -Spécialisation GIS, Mapping, and Spatial Analysis In this course, you will apply everything you have learned by designing and then completing your own GIS project. You will plan out your project by writing a brief proposal that explains what you plan to do and why. GIS project · Project Proposal : Conceptualize and design your project in the abstract, and write a short proposal that includes the project description, expected data needs, timeline, and how you expect to complete it. · Workflow Design : Develop the analysis workflow for your project, which will typically involve creating at least one core algorithm for processing your data. The model need not be complex or complicated, but it should allow you to analyze spatial data for a new output or to create a new analytical map of some type. · Implimentation and data analysis : Obtain and preprocess data, run it through your models or other workflows in order to get your rough data products, and begin creating your final map products and/or analysis. · Web and Print Map Creation: Complete your project by submitting usable and attractive maps and your data and algorithm.
Examination forms	35% project eval +65% final exam
Study and examination requirements	10/20
Reading list	Dorman, M. (2020). Introduction to Web Mapping. CRC Press. https://doi.org/10.1201/9780429352874 McHaffie, P., Hwang, S., & Follett, C. (2018). GIS: An Introduction to Mapping Technologies. CRC Press. https://doi.org/10.1201/9780429441028 Karimi, H. A., & Karimi, B. K. (2020). Geospatial Data Science Techniques and Applications. CRC Press.

ISA.5.2 Data mining

Module designation	ISA.5.2 Data mining
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Fadoua Ouamani
Language	English
Relation to curriculum	Compulsory
Teaching methods	lecture, Programming labs, hands-on exercises and presentations
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours: 30h (20h lessons + 10h lab works) Private study: 20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	MAT.1.1 Probability and Statistics AI.3.1 AI & Machine learning
Module objectives/intended learning outcomes	Objectives: at the end of the course, student will be able to 1. Differentiate between the existing paradigms related to data mining, namely machine learning, data analytics, data analysis, Knowledge discovery in databases and data science 2. Understand the basic principles for data cleaning and data transformation and apply typical methods of data cleaning and transformation in the context of data mining 3. Understand the basic principles for frequent patterns mining and apply typical methods for effective data mining 4. Understand the basic principles for classification and apply typical classification methods for effective data mining 5. Understand the basic principles for clustering and apply typical clustering methods for effective data mining 6. Understand the advantages of using data visualization in a data mining context and use data visualization techniques to graphically represent data and models Competencies: C1, C2, C3, C4, C5

Content	Chapter 1: Introduction to data mining 1. Motivation: Why data mining 2. What is (and what is not) Data mining? 3. On what kind of data and on what kind of knowledge representation? 4. Basic tasks and methods of data mining 5. Examples of applications of data mining 6. Confluence of multiple disciplines Chapter 2: Data preprocessing 1. Know your data 2. Why data preprocessing? 3. Basic forms of data preprocessing 4. Data cleaning 5. Data integration 6. Data reduction 7. Data transformation and discretization Chapter 3: Frequent patterns mining and association rules 1. Motivation: what is pattern discovery? Why is it important? 2. Basic concepts related to pattern discovery 3. Frequent itemset mining methods 4. Pattern evaluation methods Chapter 4: Classification 1. Basic concepts 2. Decision tree-based classification 3. Bayesian classification 4. Model selection and evaluation Chapter 5: Clustering 1. Basic concepts 2. Partitioning methods 3. Hierarchical methods 4. Density-based methods 5. Grid-based methods 6. Evaluation of clustering Chapter 6: Data visualization 1. What data visualization is? 2. Pixel-oriented visualization techniques 3. Geometric projection visualization techniques 4. Icon-based visualization techniques 5. Hierarchical visualization techniques 6. Visualizing complex data and relations Programming labs. with Python 1. Get to know your data 2. Prepare your data before the mining step 3. The mining step: clustering to classification 4. Data visualization with python 2 sets of hands-on exercises 2. Preprocessing step exercises 3. Mining step exercises
Examination forms	35% in-class evaluation (project, quizzes, presentations, programming labs completion, homeworks) ; 65% written exam
Study and examination requirements	10/20

Reading list	Han, J., Pei, J., & Kamber, M. (2012). Data Mining: Concepts and Techniques (3rd ed.). Elsevier. ISBN 978-0-12-381479-1. Witten, I. H., Frank, E., & Hall, M. A. (2012). Data Mining: Practical Machine Learning Tools and Techniques (3rd ed.). Elsevier. ISBN 978-0-12-381479-1. Layton, R. (2017). Learning Data Mining with Python: Harness the Power of Python to Analyze Data and Create Insightful Predictive Models (2nd ed.). Packt Publishing.

ISA.5.10 Urbanization of information systems

Module designation	ISA.5.10 Urbanization of information systems
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Amina Sayeb
Language	French
Relation to curriculum	Optional
Teaching methods	lesson, lab works, projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	SE.3.1 Software Engineering
Module objectives/intended learning outcomes	This course aims to: - Present the organization of activities, architecture and modes of architecture governance within the company - Understand the governance issues in the control of business activities - Know the best practices in IS Governance - Give a vision of the components of the digital company and the architectural questions they raise Learning outcomes: C2, C3, C4, C5, C8, C9

Content	Chapter I Enterprise architectures: modeling to decide Section I: Presentation of the domain of EA 1. Definitions 2. Business modeling 3. Enterprise architecture frameworks (Zachman, TOGAF, Urbanization, …) Section II: Architecture of the digital enterprise 1. Intangible economy 2. The dematerialized company 3. Decision-making systems, 4. Business risks (solvency, fraud, errors, exceptions, attacks) Chapter II The governance of the company's IS Section I: IS governance 1. Introduction 2. Characteristics of IS governance (knowing and anticipating, deciding, communicating and follow, adapt) 3. Evolution of the IS strategic approach 4. Definition of the governance of information systems (cross-functional requirements: business, functional, data) Section II: Foundations of an IS governance model 1. Strategic alignment 2. Value creation 3. Risk management 4. Resource management 5. Performance measurement Master's Guide Form version of 08/25/2021 64 Section III: Key Initiatives 4.1. Organizations (ISACA, AFAI, itSMF, SEI, ITGI) 4.2. Best practice repositories (Cobit, ITIL, CMMI, etc.)
Examination forms	35% Continues evaluation + 65% Final project
Study and examination requirements	10/20
Reading list	Weill, P., & Ross, J. W. (2004). IT Governance: How Top Performers Manage IT Decision Rights for Superior Results. Harvard Business School Press. Weill, P., & Ross, J. W. (2009). IT Savvy: What Top Executives Must Know to Go from Pain to Gain. Harvard Business School Press. Betz, C. T. (2011). Architecture and Patterns for IT Service Management, Resource Planning, and Governance. Morgan Kaufmann. Club URBA-EA. (2010). Urbanisme des SI et gouvernance: Bonnes pratiques de l'architecture d'entreprise (2ème édition). Dunod. Bouchez, J.-P. (2016). L'entreprise à l'ère du digital: Les nouvelles pratiques collaboratives (1re Édition). MÉTHODES & RECHERCHES.

ISA.5.11 Data Engineering

Module designation	ISA.5.11 Data Engineering
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Manel Ben Sassi
Language	French
Relation to curriculum	Optional
Teaching methods	lesson, lab works, projects.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	DAT.1.1 Database and DBMS
Module objectives/intended learning outcomes	the objectives of this course are to guide the learner to: - Know the different data engineering phases, tools and processes. - Implement the Data Access Object (DAO) design pattern to access data sources from a programming language (Persistence) - Implement the methods, use the languages and the tools allowing the modeling, the efficient management and the exploitation of highly structured data as well as the transformation of the models (Modeling and data exchange) - Know the approaches and metrics to set up and monitor a data Competencies: C8, C9
Content	Chapter 1. Data Engineering: Key Concepts, Ecosystem and Life Cycle 1. key roles and tasks of a data engineering life cycle. 2. Data typology 3. Types of data repositories 4. Different data platform architectures, data store Chapter 2. Data Engineering: Approaches, Methods and Techniques 1. The process, steps and tools 2. ETL and ELT processes, data pipelines and data integration* 3. Complexity reduction approaches, distribution 4. Search by similarity: Application to recommender systems 5. Application to graph mining Chapter 3. Data Quality Metrics 1. Components of data quality and methods of validation 2. Data Persistence 3. Modeling and data exchange 4. Data wragling Chapter 4. Monitoring and Improving Data Quality 1. Data profiling 2. Master data management (MDM)
22222222222222222222Examination forms	35% Continues evaluation + 65% Written exam

Study and examination requirements	10/20
Reading list	Ryza, S., Laserson, U., Owen, S., & Wills, J. (2014). Advanced Analytics with Spark. O'Reilly. Rajaraman, A., & Ullman, J. D. (2014). Cambridge University Press. New York, NY, USA.

ISA.5.6 Text Mining

Module designation	ISA.5.6 Text mining
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Fadoua Ouamani
Language	English
Relation to curriculum	Compulsory
Teaching methods	lecture, Programming labs, hands-on exercises and presentations
Workload (incl. contact hours, self-study hours)	Total workload: 30h Contact hours: 15h (10h lessons + 5h lab works) Private study: 20h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	ISA.5.2 Data Mining
Module objectives/intended learning outcomes	Objectives: 2. Discuss fundamental problems in text mining research 1. Building blocks of text mining algorithms 2. Wide coverage of many applications (document classification/clustering, topic modeling, sentiment analysis) 3. Get hands-on experience using some tools and real data 4. Prepare student for doing cutting-edge research in text mining and related fields Competencies: C1, C2, C3, C4

Content	Chapter 1: Introduction to text mining 1. What is text mining? 2. Why is text mining important? 3. Text mining and natural language processing Chapter 2: Document representation 1. Structuring text data 2. Vector space model 3. Bag of words 4. Bag of n-grams 5. Programming lab. 1 Chapter 3: Document categorization 1. Document categorization issues 2. What document categorization is? 3. Supervised classification 4. Case study: Sentiment Analysis 5. Programming lab.2 Chapter 4: Topic modeling 1. Introduction 2. Topic modeling versus clustering 3. Topic modeling methods 4. Topic modeling versus document categorization Programming Labs. A python programming lab per chapter using Jupyter notebook to the available python libraries to explore and prepare text data, build/train some models and evaluate them and use some visualization techniques for both data understanding and model displaying In-class exercises: working on some programming problems Homework: preparation for programming problems
Examination forms	100% in-class evaluation (project, quizzes, presentations, programming labs completions, homeworks)
Study and examination requirements	10/20
Reading list	Weiss, S. M., Indurkhya, N., & Zhang, T. Fundamentals of Predictive Text Mining. Bengfort, B., Bilbro, R., & Ojeda, T. Applied Text Analysis with Python.

ISA.5.8 Advanced BI

Module designation	ISA.5.8 Advanced Business intelligence
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Manel BenSassi
Language	French
Relation to curriculum	Optional
Teaching methods	lesson, lab works.
Workload (incl. contact hours, self-study hours)	Total workload: 25H Contact hours: 15h (9H lesson, 6H Lab works). Self study: 10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	ISA.5.4 Business intelligence
Module objectives/intended learning outcomes	This course refers to new technologies, applications and practices of Big and heterogeneous data integration, storage, multidimensional analysis, and visualization to support business decision making in a distributed environment. Thus, the student will be able to propose concrete conceptual and technological architecture for the integration of big data in the professional environment as he will acquire many competencies such as: - Become able to evaluate the technologies that adapt BI concept to new data challenges (datalake, real time datawarehousing, ect) - Become able to plan the implementation of a Big data based BI architecture. Learning outcomes: C1, C2, C3, C4, C8, C9
Content	Chapter 1: Understanding Business intelligence - The challenge of Business Intelligence Chapter 2: Data Storage: DataLake and NoSQL datawarehousing - Limits of classical storage - Data lake and data Acess - NoSQL DataBase: document, key-value, column and graph database Chapter 3: Data integration and analysis - ETL vs ELT - ELT Process and techniques - OLAP in NoSQL dataBase Chapter 4: Graph analytics techniques - Presentation of Neo4j Chapter 5 : Introduction to recommender system with graph - Concept presentation - Evaluation and metrics
Examination forms	30% Continues evaluation + 70% Written exam
Study and examination requirements	10/20

Reading list	Fernandez, A. (2013). Les nouveaux tableaux de bord des managers: le projet Business Intelligence clés en main (6ème édition). Eyrolles. Bruchez, R. (2021). Les Bases de Données NoSQL: Comprendre et Mettre en Œuvre (3ème édition) [E-book]. Snowflake & Talend. Construire un Data Lake dans le Cloud: Livre Blanc.

AI.5.3 Applied Deep learning

Module designation	AI.5.3 Applied Deep learning
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Nesrine Ben Yahia
Language	French/English
Relation to curriculum	Compulsory
Teaching methods	lesson, lab works, project, seminar.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	MAT.1.1 Probability and Statistics MAT.4.1 Stochastic processes AI.3.1 AI & Machine learning
Module objectives/intended learning outcomes	- Students know the basics and the different types of deep learning - Students use and apply some supervised and unsupervised deep learning algorithms Competencies: C1, C2, C3, C4

Content	Chapter 0. Machine Learning Basics 1. Machine Learning types 2. Overfitting and Underfitting 3. Hyperparameters and Parameters 4. Estimators, Bias and Variance 5. Gradient-Based Learning 6. Stochastic Gradient Descent 7. Challenges Motivating Deep Learning Chapter 1. Introduction to deep learning 1. What is deep learning? 2. Machine learning VS deep learning? 3. Artificial neural networks (ANN) 4. Deep neural networks (DNN) 5. Back-Propagation Algorithms 6. Regularization for deep learning 7. Optimization for training deep models 8. Typology 9. Applications Chapter 2. Recurrent neural networks (RNN) 1. Definition 2. Algorithms 3. LSTM 4. GRU 5. Practical: LSTM with python Chapter 3. Feed-Forward Neural Network (FFNN) 1. Definition 2. Example: Learning XOR 3. Algorithms 4. MLP 5. CNN 6. Practical: CNN with python Chapter 4. Autoencoders (AE) 1. Definition 2. Encoders & Decoders 3. Applications of Autoencoders 4. Practical: AE with python Chapter 5. Deep Generative Models 1 Restricted Boltzmann Machines 2. Deep Belief Networks 3. Deep Boltzmann Machines 4. Convolutional Boltzmann Machines Chapter 6. Introduction to Federated learning
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press. Chollet, F. (2017). Deep Learning with Python.

AI.5.1 Multi-agent systems

Module designation	AI.5.1 MultiAgent Systems
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Narjès Bellamine Ben Saoud
Language	French/English
Relation to curriculum	Optional
Teaching methods	lesson, lab works, project, seminar.
Workload (incl. contact hours, self-study hours)	Total workload:50h Contact hours :30h Private study:20h
Credit points	2 ECTS
Required and recommended prereq-uisites for joining the module	SE.3.1 Software Engineering AI.3.1
Module objectives/intended learning outcomes	- Master the concepts of agent and multi-agent systems - Study and apply a design methodology for a multi-agent system. - Learn the development of a multi-agent system - Explore complementary research questions Competencies: C1, C7
Content	Chapter 1: Introduction to MAS Chapter 2: Intelligent Agents Chapter 3: Agents architectures Chapter 3: Methodologies for developing multi-agent systems Chapter 4: MAS Development environments & case study
Examination forms	35% Continues evaluation + 65% Written exam
Study and examination requirements	10/20
Reading list	Ferber, J. (1995). Les Systèmes Multi-Agents. InterEditions. Wooldridge, M. (2002). An Introduction to MultiAgent Systems. Wiley. Russell, S., & Norvig, P. (2006). Intelligence Artificielle (2ème Chapitre). Pearson Education France. Russell, S., & Norvig, P. (2020). Artificial Intelligence: A Modern Approach (4th Edition). Pearson.

DOS.5.1 Cloud computing

Module designation	DOS.5.1 Cloud Computing
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Mehrez Essafi
Teaching team	-
Language	French
Relation to curriculum	Compulsory
Teaching methods	· Lesson · Lab work
Workload (incl. contact hours, self-study hours)	Total workload: 50h Contact hours: 30h (24h lessons, 6h lab work) Private study: 20h
Credit points	2 ECTS
Required and recommended prerequisites for joining the module	OS.2.1 Introduction to Operating systems and Unix environment NET.3.1 Local Networks NET.4.1 Computer Networks SE.4.2 Software Architecture SEC.4.1 Cybersecurity & cryptography
Module objectives/intended learning outcomes	• Introduce cloud computing as the provision of computing resources. • Expose modern systems architectures and software development kits that, together, provide cloud-computing frameworks. • Learn about different aspects of the design, development, provisioning and management of cloud-based applications. • Gain a sound understanding of cloud-based computing and the opportunities that it provides for a diverse range of computing applications. • Make a special attention to security of cloud-based applications and the different strategies that are available in these deployments. By the end of the course, students are expected to be able to: • Apply services and architectures offered by virtualisation and cloud platforms • Explain how cloud platforms can be used by organizations to achieve efficiencies in developing, operating and scaling modern applications • Propose new ways of modifying, extending or combining existing methodologies and implementation techniques • Apply international standards documents and application programming interface documentation • Examine the potential for, and practicality of, developing cloud computing architectures for specific applications. Competencies: C2, C4, C5, C6, C7, C9, C10

Content	Unit 1 – Cloud Computing: main concepts • General introduction • Historical overview • Cloud characteristics • Business model • Advantages and limits Unit 2 – Data-centres • Definitions • Main components • Green Computing • Security • High Availability Unit 3 – Cloud Services and deployment models • IaaS (Infrastructure as a Service) • PaaS (Platform as a Service) • SaaS (Software as a Service) • FaaS (Function as a Service) • Other services • Public Cloud • Private Cloud • Hybrid Cloud • Community Cloud • DevOps approach Unit 4 – Virtualization • Definitions • Architectures • Solutions • Servers virtualization • Containers • Storage virtualization Unit 5 – Containerization and Orchestration
Examination forms	· 20% labs · 80% written examination
Study and examination requirements	Student must achieve an overall minimum module mark of 10/20

Reading list	Mell, P., & Grance, T. (2011). The NIST Definition of Cloud Computing (800-145). National Institute of Standards and Technology (NIST). Duncan, C. H. (2017). Cloud Computing Gateway, Cloud Computing Hypervisor, and Methods. International Conference on Cloud Computing. Hennion, R., Tournier, H., & Bourgeois, E. (2014). Cloud Computing: Décider - Concevoir - Piloter – Améliorer. Plouin, G. (2014). Cloud Computing: Sécurité, Stratégie d'Entreprise et Panorama du Marché. Collection InfoPro, Dunod. Rapport Cigref. (2013). Fondamentaux du Cloud Computing: Le Point de Vue des Grandes Entreprises. Moyer, C. M. (2011). Building Applications in the Cloud: Concepts, Patterns, and Projects. Addison-Wesley. Marks, E. A., & Lozano, B. (2010). Executive's Guide to Cloud Computing. Wiley. Kshirsgar, P. (2021). Green Computing in Cloud Technology. Linguistica Antverpiensia, 2797 - 2806. Hausenblas, M. Container Networking: From Docker to Kubernetes. O'Reilly.

DOS.5.2 Blockchain

Module designation	DOS.5.2 Blockchain
Semester(s) in which the module is taught	S5
Person responsible for the module	Mohamed Houcine Hdhili, Hanen Idoudi
Teachers team	Hanen Idoudi
Language	French
Relation to curriculum	Compulsory
Teaching methods	Lesson, Lab works
Workload (incl. contact hours, self-study hours)	Total workload:25h Contact hours : 15h (12 lesson, 3h lab works) Private study: 10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	SEC.4.1 Cybersecurity and Cryptography
Module objectives/intended learning outcomes	Knowledge: After completing this course, students should be able to: • Explain blockchain and how it is applied across industries. • Describe key principles of blockchain technology and the benefits and value that they bring to enterprises. • Explain the role of a shared ledger. • Explain fundamental concepts in Hyperledger Fabric. • Describe the elements of a business network, the role of channels, and how the world state is maintained. • Develop, test, debug, and deploy chaincode with IBM Blockchain Platform Extension for Visual Studio Code • Apply concepts of blockchain security, identity and access control, and data privacy to blockchain solutions. • Write applications that interact with a blockchain network. • Describe patterns, best practices, and reference architectures for integration from enterprise applications to blockchain networks. Competencies: C6, C13
Content	Unit 1. Blockchain overview Unit 2. Introduction to chaincode development Unit 3. Chaincode query methods Unit 4. Best practices for writing, testing, and debugging chaincode Unit 5. Identity and access control Unit 6. Data privacy Unit 7. Basics of application development Unit 8. Blockchain integration and advanced application development
Examination forms	100% Continuous evaluation
Study and examination requirements	10/20
Reading list	IBM Blockchain Developer – Official course material

DOS.5.3 Internet of Things

Module designation	DOS.5.3 Internet of Things
Semester(s) in which the module is taught	S5
Person responsible for the module (coordinator)	Hanen Idoudi
Language	French
Relation to curriculum	Compulsory
Teaching methods	lecture, project
Workload (incl. contact hours, self-study hours)	Total workload: 25h Contact hours: 15h Private study: 10h
Credit points	1 ECTS
Required and recommended prerequisites for joining the module	Existing competences in networking
Module objectives/intended learning outcomes	The purpose of this course is to study the fundamental concepts of Internet of Things. At the end of the course, the students will be able: 1. Understand the basic concepts of Internet of Things (IoT) 2. Identify the main components of the IoT ecosystem 3. Explore the major applications in IoT 4. Understand the architecture and protocol stack proposed for IoT 5. Set up the specific requirements to design the logic and network architectures of an IoT application Competencies: C2, C3, C9

Content	Chapter I – Introduction to the Internet of Things - - The inception of IoT - - Basic concepts : smart objects, global connectivity, sensors, etc. - - IoT Ecosystem - - IoT challenges Chapter II – IoT Applications and architectures - - IoT Applications - - IoT architecture layers - - Connectivity models in IoT Chapter III – Networks technologies in IoT - IoT networks technologies classification - Long range communication networks overview - Short range communication networks overview Chapter IV – Middelwares and Application protocols for IoT - Web of Things: concepts and communication's models - WoT : Data Standards - IoT middelwares - Publish/subscribe model - WoT : Data exchange protocols - MQTT - CoAP Practical Work (personal project) : Design of a simple IoT application
Examination forms	Oral presentation of the personal project.
Study and examination requirements	To acquires at least 10/20 in the oral of the personal project
Reading list	Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (January 2015). Internet of Things: A Survey on Enabling Technologies, Protocols and Applications. IEEE Communications Surveys & Tutorials.

AI.5.17 Quantum Artificial Intelligence

Module designation	*AI.5.17*
Semester(s) in which the module is taught	*S5*
Person responsible for the module	*Nesrine Ben Yahia*
Language	*English*
Relation to curriculum	*Optional*
Teaching methods	*lesson, seminar, projects, workshops*

Workload (incl. contact hours, self-study hours)	*(Estimated) Total workload: 30h* *Contact hours: 15h (10h lessons, 5h labs)* *Private study including examination preparation, specified in hours[2]:* *15h*
Credit points	*1.5*
Required and recommended prerequisites for joining the module	*Python* *AI.1.1 Formal logic* *AI.3.1 Artificial Intelligence & Machine learning* *AI.5.3 Applied deep learning*
Module objectives/intended learning outcomes	*Students have a general overview of quantum computing and its key concepts* *Students identify opportunities in machine learning for using quantum advantages and resources.* *Students implement quantum enhanced machine and deep learning models in Python* *Students are able to:* *C1. To master in depth the basic sciences, in particular computer science and mathematics, essential for the design and production of computer applications.* *C8. Master good practices in terms of software development as well as applicable standards and regulations.* *C9. Make complex decisions based on incomplete or limited information.* *C13. Become aware of the need to constantly update your knowledge and, if necessary, to undertake additional studies.*

[2] When calculating contact time, each contact hour is counted as a full hour because the organisation of the schedule, moving from room to room, and individual questions to lecturers after the class, all mean that about 60 minutes should be counted.

Content	***CHAPTER 1: INTRODUCTION TO QUANTUM COMPUTING*** *1. What is Quantum computing (QC) and why?* *2. QC principles* *2.1 Superposition* *2.2 Entanglement* *2.3 Decoherence* *3. Quantum computing fundamentals?* *3.1 Qubit* *3.2 Quantum sates* *3.3 Quantum gates* *3.4 Quantum algorithms* *4. QC in industry* *5. Practical Hands-on experiments for quantum circuits using Cirq* ***CHAPTER 2: QUANTUM MACHINE LEARNING (QML)*** *1. Quantum data & models* *2. Hybrid quantum-classical models : Parameterized quantum gates, variational quantum algorithm* *3. Quantum ML approches* *4. Supervised learning with quantum classifiers* *5. Unsuprevisedlearning using quantum resources* *5. Parametrized Quantum Circuits for Reinforcement Learning* ***CHAPTER 3: QUANTUM MACHINE LEARNING (QML) TOOLS*** *1. GOOGLE Quantum AI* *2. IBM Quantum* *3. Amazon Braket* *4. Microsoft Azure Quantum* *5. Practical Hands-on session* ***CHAPTER 4: QUANTUM NEURAL NETWORKS*** *1. Quntum deep learning* *2. Quantum CNN* *3. Quantum generative adversarial networks* *4. Practical Hands-on session using TensorFlow Quantum (TFQ)*
Examination forms	*100% continuous assessment (project)*
Study and examination requirements	*10/20*
Reading list	*Rietsche, R., Dremel, C., Bosch, S. et al. Quantum computing. Electron Markets 32, 2525–2536 (2022). https://doi.org/10.1007/s12525-022-00570-y* *Biamonte, J., Wittek, P., Pancotti, N. et al. Quantum machine learning. Nature 549, 195–202 (2017). https://doi.org/10.1038/nature23474* *Schuld, M., Sinayskiy, I., Petruccione, F. An introduction to quantum machine learning, Contemporary Physics, 56:2, 172-185, (2015) DOI: 10.1080/00107514.2014.964942*