République Algérienne Démocratique et Populaire
الجمهورية الجزائرية الديمقراطية الشعبية
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
وزارة التعليم العالي و البحث العلمي

المدرسة الوطنية العليا للإعلام الآلي
(المعهد الوطني للتكوين في الإعلام الآلي سابقا)
Ecole nationale Supérieure d' Informatique
ex. INI (Institut National de formation en Informatique)

Second cycle

ooOoo

Second year Engineering Program in Intelligent Systems and Data

SECOND CYCLE (2nd year)

Table of course distribution: 2nd year (Semester 3)

3- Semester 3: 2nd year of the Second Cycle (2CS)

Teaching Unit EU	Semester volume (15 weeks)					Coef/credits
	Lectures	Tutorial	Practical work	Other	Total	
EU Fundamental						
UEF2.1.1	**67h30**	**52h30**	**30h00**		**150h00**	**11**
Data analysis and mining	30h00	30h00			60h00	4
Advanced Mathematics for Data Science	15h00	22h30			37h30	3
Machine Learning	22h30		30h00		52h30	4
UEF2.1.2	**22h30**	**30h00**			**52h30**	**3**
Complexity and problem solving	22h30	30h00			52h30	3
EU Methodology						
EMU2.1.1	**52h30**	**30h00**	**30h00**		**112h30**	**6**
DBMS and Advanced Databases	30h00	30h00			60h00	3
Intensive computing	22h30		30h00		52h30	3
EMU2.1.2				**30h00**	**30h00**	**2**
Practical training in a company				30h00	30h00	2
Cross-cutting EU						
UET2.1	**45h00**		**60h00**		**105h00**	**8**
Optional teaching units* (optional)	45h00		60h00		105h30	8
Total Semester S3	**202h30**	**120h00**	**120h00**	**30h00**	**450h00**	**30**

(*) The subjects making up this EU are to be chosen from the subjects offered by the institution on a semesterly basis and amount to 8 credits in total

4- Semester 4: 2nd year of the Second Cycle (2CS)

Teaching Unit EU	Semester volume (15 weeks)					Coefficients
	Lectures	Tutorial	Practical work	Other	Total	
EU Fundamental						
UEF2.2.1	**45h00**	**22h30**	**22h30**		**90h00**	**6**
Knowledge representation and reasoning	22h30	22h30			45h00	3
Automatic natural language processing	22h30		22h30		45h00	3
UEF2.2.2	**52h30**	**30h00**	**22h30**		**105h**	**6**
Stochastic Processes, Models and Simulation	30h00	30h00			60h00	3
Optimisation techniques and Artificial Intelligence	22h30		22h30		45h00	3
EU Methodology						
EMU2.2.1	**45h00**	**30h00**	**22h30**		**97h30**	**6**
Distributed Computing and Artificial Intelligence	22h30	30h00			52h30	3
Business Intelligence	22h30		22h30		45h00	3
EMU2.2.2				**60h00**	**60h00**	**4**
Specialty project				60h00	60h00	4
Cross-cutting EU						
UET2.2	**45h00**		**60h00**		**105h00**	**8**
Optional teaching units* (optional)	45h00		60h00		105h00	8
Total Semester S4	**180h00**	**82h30**	**127h30**	**60h00**	**457h30**	**30**

(*) The subjects making up this EU are to be chosen from the subjects offered by the institution on a semesterly basis and amount to 8 credits in total

Detailed program of the 2nd year of the second cycle

2nd year (2 CS) - Semester 3

UEF2.1.1- Analysis and Data Mining

EU Code	Module title	Coefficients/Credits
UEF2.1.1	Analysis and Data Mining	4

Hourly volumes		
Lectures	TD / TP	TOTAL
30	30	60

Semester :	3

Prerequisites	– Statistics and probability, linear algebra, numerical calculation.

OBJECTIVES :

- Present of techniques of descriptions descriptions (reduction, visualisation, clustering,...), statistical modelling (regression, classification)
- Introduce the learning theory used in data mining needed in very diverse fields o f application: industrial, marketing.... The aim is to bring out the relevant information contained in a large mass of data.
- At the end of this course, students will be able to use the appropriate tools to process data and interpret the results of the various measurements they will encounter in the course of their work.

CONTENT OF THE MODULE :

I. Reminders

Linear algebra, descriptive statistics, matrix derivation and function optimisation.

II. Introduction to data mining

1. Definition
2. Data mining process

III. Factor methods (Description, Reduction, Visualisation and Interpretation of data)

1. Principal component analysis.
2. Factor analysis of correspondences
3. Multiple correspondence factor analysis.

IV. Data mining: Supervised and unsupervised classification

1. Classification and Ranking (Prediction) of data
   - **a.** Introduction of the statistical learning principle
   - **b.** Discriminant factor analysis.
   - **c.** Automatic classification.
2. Modelling and forecasting
   - **a.** Simple and multiple regression.
   - **b.** 1-factor and 2-factor ANOVA

PERSONAL WORK

- TD to enable the student to manipulate the tools of data analysis.
- Workshops on data sets and on real data such as (the minutes of the students' deliberations) using appropriate software such as R.

KNOWLEDGE TEST

☐ Continuous assessment

BIBLIOGRAPHY

- L. Bellange. "Data Mining and Statistical Methods Data Analysis & Data Mining with R Software". Paperback - 25 February 2014.
- G. Broc and Benjamin Caumeil. "Data analysis", Deboeck Supérieur, 2018
- R. O. Duda, P.E. Hart, D.G. Stork, "Pattern classification", 2nd edition, Wiley and sons, 2001.
- T. Hastie, R. Tibshirani, J. Friedman, "The elements of statistical learning. Data mining, inference and prediction", Springer, 2001.
- R. A. Johnson, D. W. Wichern. Applied multivariate statistical analysis (Vol. 5, No. 8). Upper Saddle River, NJ: Prentice hall, 2002.
- L. Lebart, A. Morineau, M. Piron, "Statistique exploratoire multidimensionnelle", Dunod, 2006.
- W. McKinney. "Data Analysis with Python - Optimizing Data Preparation with Pandas, Numpy, Jupyter and IPython" O'Reilly Collection. 2021
- G. Saporta, "Probabilites Analyse des Données et Statistique", 3rd edition, Technip, 2011.
- Online resources: http://www.math.univ-toulouse.fr/~besse/teaching.html.

UEF2.1.1- Advanced Mathematics for Data Science

UEF code	Module title	Coef/Credits
UEF2.1.1	**Advanced Mathematics for Data Science**	3

Hourly volumes		
Lectures	**TD / TP**	**TOTAL**
15	**22h30**	**37h30**

Semester :	**S3**

Prerequisites	- Linear algebra - Mathematical analysis. - Numerical analysis

OBJECTIVES: The aim of this course is the presentation of some mathematical foundations for data science and thus of some associated iterative algorithms. The mathematical concepts discussed are essential for solving optimal problems in important machine learning algorithms such as neural networks, SVM, ...
The main learning competency targeted by this course is to provide students with the ability to decide which iterative algorithm to choose for certain data science problems.

CONTENT OF THE MODULE :

1. Introduction
2. Elements of functional and convex analysis
   - Hilbert spaces and dual space
   - Convex sets and functions.
3. Optimization
   - General
   - Convex case
   - Non-convex case
4. Deterministic methods for optimisation
   - Gradient methods
   - Quasi Newton method
   - Proximal methods
5. Stochastic methods for optimisation
   - Stochastic gradient methods
   - Stochastic methods with reduced variance
6. Examples of applications in machine learning

PERSONAL WORK

KNOWLEDGE TEST

1. 2 Reviews

BIBLIOGRAPHY

1. S. Boyd and L. Vandenberghe. Convex optimization. Cambridge University Press, 2004.
2. Dan Simovici. 2018. Mathematical Analysis for Machine Learning and Data Mining. World Scientific Publishing Co, Inc, USA.
3. Borwein, J.M. & Lewis, A.S. (2006). *Convex Analysis and Nonlinear Optimization: Theory and Examples.* Springer.

UEF2.1.1- Machine Learning

EU Code	Module title	Coefficients/Credits
UEF2.1.1	Machine Learning	4

Hourly volumes		
Lectures	TD / TP	TOTAL
22.50	30	52.5

Semester :	3

Prerequisites	– Statistics and probability, linear algebra, numerical calculation, Algorithms.

OBJECTIVES :

- Discovering Data Science
- Understand the data analysis tools of data science to solve practical artificial intelligence problems.

CONTENT OF THE MODULE :

Chapter 1*: Introduction to ML*

- Definition
- Types of learning (supervised, unsupervised, semi-supervised, reinforcement)
- Problems with machine learning

Chapter 2*; Supervised learning*

- Logistic regression
- Naive Bayes
- Decision tree and Random Forest
- Support Vector Machine (SVM)
- Neural networks

Chapter 3*: Unsupervised learning*

1. *Clustering :*
   - Algorithm by partitioning (Kmeans (recall), PAM, Clara,...)
   - DBSCAN (density based),.....

2- Attribute selection

- Filter approach
- Wraparound approach.

3- Rules of association

- Apriori
- Fp-Growth

Chapter 4*: Reinforcement Learning (RL)*

PERSONAL WORK

– Workshops are planned to master the different algorithms seen in the course on R and Python software

- Project: A work is assigned to a pair or group of students on an advanced ML theme to be done on specific datasets.

KNOWLEDGE TEST

- Continuous monitoring
- Final review

BIBLIOGRAPHY

Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach (Pearson Series in Artifical Intelligence). 4th Edition, 2021.

Marc Peter Deisenroth Mathematics for Machine Learning 1st Edition. 2020. Cambridge press.

Richard Sutton. Reinforcement Learning, second edition: An Introduction. Hardcover - 13 November 2018.

Charu C. Aggarwal, Jiawei Han. Frequent Pattern Mining". 2014, Springer Tom M.Mitchell: "Machine Learning", 1997.

Christopher M. Bishop. "Pattern Recognition and Machine Learning. 2006, Springer

UEF2.1.2- Complexity and Problem Solving

EU Code	Module title	Coefficients/Credits
UEF2.1.2	Complexity and Problem Solving	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22.50	30	52.50

Semester :	3

Prerequisites	Algorithms and data structures, Graph theory, Theory of languages.

OBJECTIVES :

- To master the theoretical and practical aspects of complexity and problem solving.
- Introducing the field of artificial intelligence

CONTENT OF THE MODULE :

I. *Introduction to AI*

History, definition

II. *Problem Complexity*

1. Problem modelling
2. Treatment modelling
3. The P and NP classes
4. Polynomial reductions
5. NP-Complete

III. *Problem solving through search space exploration*

1. Decompositional problem solving Divide and Conquer
   Dynamic programming
2. Backtracking (Depth First Search)
   Case of infinite spaces (Breadth First Search)
3. Application to MinMax game problems
   Alpha/Beta pruning
   Example of chess, ...
4. Guided research
   Notions of heuristics
   Searching for solution states
   DFS with Best First Search
   estimation function
   Beam Search
   Search for solution paths
   Branch & Bound (with underestimation / dynamic programming) A* type algorithms

IV. Constraint satisfaction problems

1. Description of the CSPs
2. Exploration by backtracking
3. "Forward checking
4. Consistency of arcs

Management of specific constraints

PERSONAL WORK

- Reading scientific articles
- Experimentation with educational or demonstration software

KNOWLEDGE TEST

- Continuous monitoring

BIBLIOGRAPHY

- Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", Prentice Hall 4Th Edition, 2020.
- Winston, P.H., "Artificial Intelligence", Addison Wesley; Third Edition, 1992.
- Luger, G. F., "Artificial Intelligence - Structures and Strategies for Complex Problem Solving", Addison Wesley, 6th Edition, 2009.
- Poole, D., Mackworth, A, "Artificial Intelligence - Foundations of Computational Agents", Cambridge University Press, Second Edition, 2017.
- Nilsson, N. J, "Artificial Intelligence - A New Synthesis", Morgan Kaufmann, 1998.
- Sanjeev Arora and Boaz Barak, "Computational Complexity: A Modern Approach", Cambridge University Press, 2006.
- Ingo Wegener and R.Pruim, "Complexity Theory: Exploring the Limits of Efficient Algorithms", Springer, 2005.

EMU2.1.1- DBMS and Advanced Databases

EU Code	Module title	Coefficients/Credits
EMU2.1.1	DBMS and Advanced Databases	3

Hourly volumes		
Lectures	TD / TP	TOTAL
30	30	60

Semester :	3

Prerequisites	- Algorithms and data structures - Databases

OBJECTIVES :

The Advanced Databases course introduces advanced concepts in the field of databases. This course allows students to deepen their knowledge of relational databases and to acquire new knowledge of other types of data and data processing, particularly decision support and semi-structured data.

At the end of the course, the student will be able to :

1. Master the advanced concepts of SQL programming
2. Understand the architecture of a relational DBMS
3. Designing and implementing multidimensional DBs.
4. Designing and manipulating semi-structured XML data
5. Have knowledge of the different types of existing databases.

CONTENTS :

- **Architecture of Relational DBMS (1h30)**
  - Overview of DBMS architecture
  - Translation and optimisation of queries
  - Competitive access and transaction management
  - Data storage and indexing structures
- **Advanced SQL Programming (4h30)**
  - Fundamentals of SQL programming
  - The Triggers
  - Stored functions and procedures
  - Error handling and management
- **The Object-Relational model (3h)**
  - Presentation of the Object model
  - Presentation of the Object-Relational model

- RO model concepts (complex types, inheritance...)
- Querying Object-Relational DBs (SQL3)

- **Data warehouses (9 hours)**
  - Introduction to Business Intelligence (BI): Concepts, Architecture and Platforms ;
  - Multidimensional data modelling ;
  - Approaches to building data warehouses ;
  - Creating and manipulating data warehouses with SQL and MDX;
- **Semi-structured databases (9h)**
  - Introduction to XML
  - Structure of XML documents (XML Schema& DTD)
  - Construction and manipulation of XML documents (Parsing, Xlink, XPointer, DOM and SAX)
  - Querying XML documents (XPath and XQuery language)
  - Native XML database management systems
- **Advanced databases (3h)**
  - Distributed DBs
  - Geographic and multimedia databases
  - New Data Trend (The Anti-Relational)

KNOWLEDGE TEST
Written examination on the course Continuous monitoring of the tutorials

BIBLIOGRAPHY

- A. Meier. Practical Introduction to Relational Databases (Second Edition)
- C.Imhoff, J.G. Geiger, N.Galemmo. Mastering DataWarehouse Design Relational and Dimensional Techniques
- S.KorthSudarshan. Database System Concepts, Fourth Edition
- Gunderloy, Mike and Sneath, Tim. SQL Server Developer's Guide to OLAP With Analysis Services. Sybex, 2001. This book is a reference on OLAP programming with SQL Server 2000.

EMU2.1.1-Intensive Computing

EU Code	Module title	Coefficients/Credits
EMU2.1.1	Intensive computing	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22.50	30	52.50

Semester :	3

Prerequisites	– Evolved Computer Architectures - Object Oriented Programming - Operating system I - Operating system II.

OBJECTIVES :

- Identify the different HPC architectures (MultiCore, Cluster, Grid and GPU).
- List the different applications of HPC
- Optimise programs to take advantage of processor architecture features.
- Design, implement and analyse parallel programs with shared memory using OpenMP.
- Design, implement and analyse parallel programs with distributed memory using MPI.
- Implement parallel programs on GPUs using CUDA.

CONTENT OF THE MODULE :

2. *Introduction to High Performance Computing (~6h)*
   1. Motivation and Introduction to Parallel Architectures (MultiCore, Cluster, Grid and GPU)
   2. Different applications of HPC (Scientific Simulation, Economics, Engineering, Operational Research).
   3. Parallel machine models, Flynn and Raina classifications.
   4. Parallel and distributed programming model (task parallelism, data parallelism, level of parallelism, message communication).
   5. Fundamental problems of parallel distributed programming (task/data partitioning, load control, scheduling, fault tolerance, performance measurement, presentation of Amdahl's and Gustafson's laws).
3. *Parallel Programming for Shared Memory Architecture. (~6h)*
   1. Parallel programming with C language POSIX Threads (PThreads). TP (~3h) on the introduction to PThreads.
   2. Parallel Programming with JAVA Threads.3-hour tutorial on the introduction to JAVA Threads.
   3. Parallel programming with OpenMP.
4. *Parallel Programming for Distributed Memory Architecture (~4h)*
   1. Parallel programming with POSIX Threads of the C language (PThreads)TP (~3h): Introduction to PThreads.
   2. Parallel programming with JAVA threads.TP (~3h): Introduction to JAVA threads.
   3. Parallel programming with OpenMP.TP (~3h): Introduction to OpenMP.
5. *Parallel Programming for GPU (Graphical Processor Unit) Architectures (~8h)*
   1. Introduction, history and architecture of GPUs.
   2. Memory models (Global, Local, Shared).TD (~2h): Study of the architecture

GPU.

3. GPU programming with OpenCL.TP (~3h): Introduction to OpenCL.
4. GPU programming with CUDA.TP (~3h): Introduction to CUDA.

PERSONAL WORK

- Projet Parallel Programming ~ 30 hours

KNOWLEDGE TEST

- Contrôle continuous

BIBLIOGRAPHY

- P. Pacheco, "An Introduction to Parallel Programming", Morgan Kauffman, 2011
- G. Hager and G. Wellein, "Introduction to High Performance Computing for Scientists and Engineers", Chapman & Hall
- A. Grama, G. Karypis, V. Kumar, and A. Gupta, "Introduction to Parallel Computing", Addison-Wesley, 2003
- C. Lin, L. Snyder, "Principles of Parallel Programming", Addison-Wesley, 2008
- G. S. Almasi and A. Gottlieb. Benjamin Cummings Highly Parallel Computing - Second edition,.
- K. Hwang. McGraw-Hill.Advanced Computer Architecture: Parallelism, Scalability, Programmability,
- I. Foster. Designing and Building Parallel Programs, Addison-Wesley, http://www.mcs.anl.gov/dbpp/.
- H. S. Morse.Practical Parallel Computing, AP Professional.
- M. Cosnard and D. Trystram. Algorithms and Parallel Architectures, Inter Editions.
- CPU Info Center, http ://infopad.eecs.berkeley.edu/CIC/.
- Journal of Parallel and Distributed Computing

EMU 2.1.2- Practical training in a company

EU Code	Module title	Coefficients/Credits	
EMU2.1.2	Practical training in a company	2	
Hourly volumes			30h

Semester :	3

OBJECTIVE OF THE COURSE :

- Immersion in a professional environment
- Study and analyse a real problem in a professional environment and propose improvement scenarios

PROCEDURE :

I. Prospecting for internships

- By students: Encourage students to take an internship as close to home as possible. Help them in this search phase (official letter provided for those who are interested, list of companies in their area)
- By the DREFC: Exploiting the School's network of relations (alumni, partners, etc.) to prepare a range of placements taking into account the diversity of training needs

II. Validation of the course

- The proposed courses will be validated by an ad hoc committee.

I. Assignment of internships

- Students must have chosen their topic by 30 May.
- An internship agreement is issued to each trainee

II. Evaluation of the course

- The student must submit an internship report (20 pages) in accordance with the standardised model provided on the ESI+ website, duly signed by the company representative, before 15 September.
- A 20-minute presentation by the trainees is scheduled before the September deliberations.

Detailed programme of the 2nd year of the second cycle
- Semester 4

UEF2.2.1- Knowledge Representation and Reasoning

EU Code	Module title	Coefficients/Credits
UEF2.2.1	KR - Knowledge Representation and Reasoning	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22.50	22.50	45

Semester :	4

Prerequisites	– Mathematical logic – Probabilities – Complexity and problem solving – Operational research

OBJECTIVES:.

The objective of this course is to give students an overview of the field of symbolic artificial intelligence. Students will study the main ideas and techniques of AI problem solving, knowledge representation (certain and uncertain) and planning.

CONTENT OF THE MODULE :

I. *Logical inference*

1. Reminders: propositional logic and 1st order predicate logic
2. Formal systems
3. Front and rear linkage
4. Unification and Resolution
5. Automatic proof of theorems
6. Logic programming

II. *Semantic networks*

1. Conceptual graphs
2. Description logics
3. Ontologies

III. *Taking account of uncertainty*

1. Non-monotonic logics
2. Representation of the uncertain
3. Uncertainty reasoning (probability theory, possibility theory)
4. Bayesian networks
5. Decision-making in an uncertain environment

IV. *Planning*

1. Planning vs. research
2. STRIPS operators
3. Partial order planning
4. Planning in the real world
5. Conditional planning
6. Replanting

PERSONAL WORK
– TPs

KNOWLEDGE TEST

- Continuous assessment (CA) :
  - ✓ MCQs at the end of the chapter **(10%)**
  - ✓ Time evaluation **(10%)**
- Intermediate Control (IC): **(35%)**
- Final check (FC): **(45%)**

BIBLIOGRAPHY

- G Aldo Antonelli. "Handbook of logic in artificial intelligence and logic programming, Volume 3, Nonmonotonic reasoning and uncertain reasoning, edited by Gabbay Dov M., Hogger C. J., and Robinson J. A., with Nute D., Oxford university Press 1994, doi: 10.2307/420980.

- S Muggleton & L. De Raedt. Inductive logic programming: Theory and methods. Journal of Logic Programming, 1994, 19, 629-679.

- J. F. Sowa, Principles of Semantic Networks, Explorations in the Representation of Knowledge, A volume in The Morgan Kaufmann Series in Representation and Reasoning, Book, 1991.

- J Zalaket, Complex planning in AI, Planning in Artificial Intelligence: advanced concepts, European University Publishing, 2011.

UEF2.2.1-Automatic Natural Language Processing

EU Code	Module title	Coefficients/Credits
UEF2.2.1	Automatic natural language processing	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22.50	22.50	45

Semester :	4

Prerequisites	– Theory of Programming Languages and Applications (TPL) – Probability and statistics – Algebra and analysis – First-order predicate logic – Automatic learning – Programming (mainly in Python and Java)

OBJECTIVES :

- Apply mathematical concepts learned throughout the curriculum to real-life problems in the language
- Learn some language and some philosophy (knowledge representation)
- Discover some TALN tools and resources, and program simple solutions to some problems
- Apply the concepts seen in THP to different languages (natural languages)

CONTENT OF THE MODULE :

I. *Introduction*

1. History
2. Levels of language processing (phonology, morphology, syntax, semantics)
3. Applications of TALN
4. TALN challenges

PART 1. MORPHOLOGY AND LEXICON

II. *Basic text processing*

1. Characters (Regular expressions, Editing distance)
2. Text segmentation
3. Text normalisation and filtering
4. Morphology (word formation, shape reduction)

PART 2. Syntax

III. *Language models*

1. NGram models
2. Neural models
3. Evaluation of models (Perplexity)

IV. *Morphosyntactic labelling*

6. Sequence labelling
7. Description of the task
8. Approaches (Markov, Entropy, Neural Networks)

V. *Syntactic analysis*

1. Syntactic structures (constituent, functional)
2. Constituent analysis (CKY algorithm)

3. Dependency analysis (transition, graph)

PART 3. Semantics

VI. *Lexical semantics*

2. Lexical databases (Wordnet)
3. Vector representation of words (TF-IDF, Word-Word, LSA)
4. Word embedding (word2vec, GloVe, BERT, etc.)
5. Lexical disambiguation (lexical bases, machine learning)

VII. *Sentence semantics*

1. Semantic roles (Roles, FrameNet, PropBank)
2. Semantic role labelling (features, neural networks)
3. Semantic representation of sentences (First order logic, Graphs (AMR))

PART 4. ENUNCIATION AND PRAGMATICS

VIII. *Detection of the coreference*

7. References (Forms, manner and properties)
8. Co-reference resolution (mention detection, linking)
9. Related tasks (Semantic annotation, Named entity recognition)

IX. *Consistency of speech*

4. Discourse relations (RST, PDTB)
5. Analysis based on discourse structure (RST, PDTB)
6. Discourse entity-based analysis (Centeringtheory, EntityGrid Model)

PART 5. SOME APPLICATIONS

X. *Some applications*

7. Transformation (Automatic text translation, Automatic text summarisation)
8. Interaction (Questions/Answers, Dialogue Systems)
9. Classification (Sentiment Analysis, Readability)
10. Speech (Recognition, Synthesis)

PERSONAL WORK

–

KNOWLEDGE TEST

– Continuous monitoring

BIBLIOGRAPHY

- Aries, A. (2020) Towards improved automatic text summarisation. PhD thesis, ESI.
- Black, A. W. and D. Mortensen (2020) Natural language processing. Presentations: Spring 2020.
- Booth, J. D. (2018)Natural Language Processing Succinctly. Syncfusion, Inc.
- Eisenstein, J. (2019)Introduction to Natural Language Processing. Adaptive Computation and Machine Learning series. MIT Press.
- Indurkhya, N. and F. J. Damerau, eds (2010) Handbook of Natural Language Processing. 2nd edition. Chapman and Hall/CRC.
- Jurafsky, D. and J. H. Martin (2019) Speech and Language Processing. https://web.stanford.edu/~jurafsky/slp3/
- Manning, C. and M. Lamm (2020)Cs224n: Natural language processing with deep learning.

Presentations: Winter 2020.

- Mooney, R. J. (2018)Cs 388: Natural language processing. Presentations: Spring 2018.
- Smith, N. (2020)Natural language processing (cse 517). Presentations: Winter 2020.
- Tellier, I. (2008) Introduction to TALN and language engineering. University of Lille3.

UEF2.2.2- Stochastic Processes, Models and Simulation

EU Code	Module title	Coefficients/Credits
UEF2.2.2	Stochastic Model and Simulation	3

Hourly volumes		
Lectures	TD / TP	TOTAL
30	30	60

Semester :	4

Prerequisites	– Basic concepts of probability and statistics,

OBJECTIVES :

This module consists of two main parts: Markovian random processes and simulation.
Each part will contain application models that are important in practice such as: random walks, queuing models, hidden Markov chains, Bayesian networks etc.

CONTENT OF THE MODULE :

1. Part 1
   a. Markov chains
      i. Classification of states
      ii. Absorbing Markov chains
      iii. Reversible Markov chains
      iv. Ergodic theorems
      v. Application: Random walks
         1. Random walk on Z and ^{Zd}
         2. Asymptotic behaviour
         3. Symmetrical random walks
         4. PageRank algorithm
   b. Poisson process
   c. Birth and death process
      i. Application: Queue models
         1. Markovian Models : Open and closed systems
         2. Model M/M/1
         3. Model M/M/s
         4. Models M/M/S/L, M/M/S/S and M/M/∞
2. Part 2
   a. Simulation
      i. Random number generators
      ii. Generation of discrete and continuous random variables according to different laws
      iii. Rejection method
      iv. Estimation of an integral by the Monte Carlo method
      v. Preferential sampling (Importance sampling)
      vi. Variance reduction techniques
   b. MCMC methods
      i. Gibbs sampler
      ii. CBM sampler
   c. Optimisation
      i. Simulated annealing algorithm
      ii. EM and Monte Carlo EM algorithms, Gaussian mixture models
   d. Hidden Markov Chains HMM
      i. Inference in HMM
      ii. Forward- Backward methods, Viterbi algorithm, BaumWelch algorithm
   e. Bayesian networks
   f. Simulation of Spatial Point Processes
      i. Poisson point process (PPP)
      ii. Hard Core Poisson Process (HCPP)

iii. Clustered Poisson processes
PERSONAL WORK
TD and TP proposed, on Python, R, Matlab, Scilab or other. -

KNOWLEDGE TEST
Written examination and practical work

BIBLIOGRAPHY

- Geoffrey Grimmett, David Stirzaker, et al. Probability and random processes. Oxford university press, 2001.
. Delmas, J. F., & Jourdain, B. (2006). Random models, volume 57 of Mathematics & Applications (Berlin) [Mathematics & Applications].
. Pierre Brémaud. Introduction to Probability: and Markov Chains. Springer Science & Business Media, 2009
- Lefebvre, M. (2007). Applied stochastic processes. Springer Science & Business Media.
- Del Moral, P., Vergé,C. (2014) Stochastic models and methods: An introduction with applications (vol. 75) Springer Science & Business Media.
- Robert, C. P. (2004). Casella: Monte Carlo Statistical Methods. Springer verlag, New York, 3.
- Robert, C. P., Casella, G., & Casella, G. (2010). Introducing Monte Carlo methods with r (Vol. 18). New York: Springer.
- Dagpunar, J. S. (2007). Simulation and Monte Carlo: With applications in finance and MCMC. John Wiley & Sons.
- Rubinstein, R. Y.,& Kroese, D. P. (2016). Simulation and the Monte Carlo method (Vol. 10). John Wiley & Sons.
Diaconis, P. (2009). The Markov chain Monte Carlo revolution. Bulletin of the American Mathematical Society, 46(2), 179-205.
- Purnamrita Sarkar and Andrew W Moore. Random walks in social networks and their applications: a survey. In Social Network Data Analytics, pages 43-77. Springer, 2011
- Naïm, P., Wuillemin, P. H., Leray, P., Pourret, O., & Becker, A. (2011). Bayesian networks. Editions Eyrolles.
- Ruegg, A. (1989). Stochastic processes: with applications to expectation and reliability phenomena (Vol. 6). PPUR Polytechnic Press.
- Sakarovitch, M. (1977). Mathematical techniques of operations research.

ENSIMAG

UEF2.2.2- Optimisation Techniques and Artificial Intelligence

EU Code	Module title	Coefficients/Credits
UEF2.2.2	Optimisation techniques and Artificial Intelligence	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22.5	22.5	45

Prerequisites	Operations research; Graph theory; Matrix analysis; OGTT

Semester :	4

OBJECTIVES :

- Study methods for solving combinatorial optimisation problems, ranging from simple methods to advanced techniques using machine learning, including parallel and hybrid methods
- To show the effective applicability of the methods presented to practical problems. To be aware of the limits of each family of optimisation methods and their dependence on the various input parameters, hence the need to propose new paradigms (hybrid, parallel, hyper-heuristic, machine learning methods)

CONTENT OF THE MODULE :

I. *Introduction to combinatorial optimisation*

1. Combinatorial optimisation problems
2. Classification of optimisation problems (according to their complexity)
3. Some NP-hard problems
4. Touring problems (PVC, scheduling, vehicle touring)
5. Assignment problems (Max-Sat, Backpack, Bin Packing, colouring)

II. *Incomplete methods. Advantages and limitations*

1. Limitations of full methods (instance size)
2. Approximate (incomplete) methods
3. Specific features
4. One-solution metaheuristics
5. Population-based metaheuristics
6. Limitations of incomplete methods (parameter and instance dependency)

III. *Hybrid and Parallel Methods*

1. Introduction: Why hybrid methods?
2. Classification of Hybridization Schemes
3. Some examples of hybrid methods

IV. *Hyperheuristics*

1. Introduction: Why hyperheuristics?
2. Hyperheuristics by generation
3. Hyperheuristics by separation
4. Hyperheuristics with learning

V. *Optimisation and Machine Learning*

1. Synergy between optimisation and machine learning
2. Metaheuristics with Machine Learning
3. Optimisation for machine learning

VI. *Multi-lens optimization*

1. Introduction: Why multi-objective optimisation?
2. Classification of multi-objective optimisation methods
3. Some known MO algorithms (NSGA-II, SPEA)

VII. *Game theory*

1. Principle of game theory
2. Game theory and MO optimisation

PERSONAL WORK

A project in the form of a classroom course whose objective is to develop an application for solving difficult combinatorial optimisation problems. This application must be flexible in the sense that new methods of solution and new problems can be added to it as and when required. Another important objective is to show the limits of exact methods, the effective applicability of approximate methods to difficult real-world problems and their dependence on the instances and parameters used, as well as the impact of artificial intelligence techniques such as machine learning, to improve the performance of these methods

KNOWLEDGE TEST

Contrôle continuous

BIBLIOGRAPHY

- Gendreau, M., & Potvin, J. Y. (Eds.). (2010). *Handbook of metaheuristics* (Vol. 2, p. 9). New York: Springer.
- Talbi, E. G. (2009). *Metaheuristics: from design to implementation* (Vol. 74). John Wiley& Sons.
- Calvet, L., de Armas, J., Masip, D., & Juan, A. A. (2017). Learnheuristics: hybridizing metaheuristics with machine learning for optimization with dynamic inputs. *Open Mathematics*, *15*(1), 261-280.
- Birattari, M., &Kacprzyk, J. (2009). *Tuning metaheuristics: a machine learning perspective* (Vol. 197).
- Mirjalili, S., & Dong, J. S. (2020). *Multi-objective optimization using artificial intelligence techniques*. Springer.
- Hao, J. K., &Solnon, C. (2014). Meta-heuristics and artificial intelligence.
- Talbi, E. G. (2002). A taxonomy of hybrid metaheuristics. *Journal of heuristics*, *8*(5), 541-564.
- Rao, S. S. (1987). Game theory approach for multiobjective structural optimization. *Computers & Structures*, *25*(1), 119-127.
- Burke, E. K., Gendreau, M., Hyde, M., Kendall, G., Ochoa, G., Özcan, E., &Qu, R. (2013). Hyper-heuristics: A survey of the state of the art. *Journal of the Operational Research Society*, *64*(12), 1695-1724

EMU2.2.1-Distributed Computing and Artificial Intelligence

EU Code	Module title	Coefficients/Credits
EMU2.2.1	Distributed Computing and Artificial Intelligence	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22H50	30	52h50

Semester :	4

Prerequisites	– Statistics and probability, linear algebra, numerical calculation. – Centralized systems – Networks – OOP programming

OBJECTIVES :

- Mastering the distribution aspects of systems
- Developing distributed systems
- Addressing distributed problem solving
- Addressing the tools of Distributed Artificial Intelligence (DAI)
- Become familiar with DIA applications

CONTENT OF THE MODULE :

I. *Introduction to distributed systems (DS)*

Linear algebra, descriptive statistics, matrix derivation and function optimisation.

II. *Distributed organisation models*

- Client-server model
- Model code on demand
- Remote evaluation model:
  - Remote procedure and method calls
  - Service Oriented Architectures and Micro-services
- Mobile agent model

III. *Distributed programming model*

5. Sockets (TP)
6. CPR (TP)
7. Java RMI (TP)

IV. *Middleware*

1. JRMI
2. CORBA
3. DCOM
4. Web services (SOAP, REST)

V. *Distributed Artificial Intelligence (DAI)*

1. Distributed problem solving
2. Distributed decision making
3. Communication
4. Negotiation

5. Planning
6. Learning
7. Notion of agent (TP: programming an agent with Java and JADE)
8. Multi-agent systems
   - FIPA
   - MASIF
9. Agent platforms

PERSONAL WORK

- Distributed Problem Solving Project
- Multi-agent systems project
- Distributed programming project: DCOM/JRMI

KNOWLEDGE TEST

- Continuous monitoring

BIBLIOGRAPHY

- A. Silberschatz, P. B. Galvin , G. GAGNE, "Principles of Operating Systems", 7th edition, Addison-Wesley, 2012
- S. Ghosh, "Distributed Systems: An Algorithmic Approach", hapman& Hall/CRC, 2007.
- A. S. Tanenbaum, M. V. Steen, "Distributed Systems Principles and Paradigms", (2nd Edition) Prentice Hall, 2006
- N. A. Lynch, "Distributed Algorithms", Morgan Kaufmann Publishers, 1996
- Jacques Ferber, Les Systèmes multi-agents : Vers une intelligence collective, InterEditions, 1995, 522 p. (ISBN 2-7296-0665-3)
- Michael Wooldridge, An Introduction to MultiAgent Systems, Wiley and Sons, 2002, 348 pp. (ISBN 0-471-49691-X)
- Gerhard Weiss, Multiagent Systems, A Modern Approach to Distributed Artificial Intelligence, Cambridge (Mass.)/London, MIT Press, 1999

EMU2.2.1- Business Intelligence

EU Code	Module title	Coefficients/Credits
EMU2.2.1	Business Intelligence	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22h50	22h50	45

Semester :	4

Prerequisites	– Database – Advanced database.

OBJECTIVES :

- Understanding a decision support system
- Designing a multi-dimensional data model
- Creating a Datawarehouse
- Understand the concept of Business Intelligence and its architecture
- Understanding OLAP analytical queries
- Become familiar with analysis, reporting and ETL tools
- Developing BI projects

CONTENT OF THE MODULE :

I. *Introduction to decision support systems*
II. *Decision Support Information System*
III. *Design and implementation of a data warehouse*
IV. *Multi-Dimensional Modelling*
V. *The MDX Language*
VI. *Data integration*
VII. *ETL*
VIII. *BI applications*
IX. *Scorecards*

PERSONAL WORK

- TD on theoretical aspects
- Practical work: Practical work with OpenSource tools (Talend, Pentaho, Jasper, ...)
- Final project to design a small SIAD with dashboards.

KNOWLEDGE TEST

- Continuous monitoring

BIBLIOGRAPHY

- L. Corr, J. Stagnitto. Agile Data Warehouse Design, Collaborative Dimensional Modeling, from Whiteboard to Star Schema, Decision 1 Press, 2013.
- R. Kimball, Laura Reeves, Margy Ross, Warrren Thornthwaite, "Le Data Warehouse, Guide de conduite de projet", Eyrolles, 2005.
- R. Kimball, M. Ross. The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, 3rd Edition, Wiley, 2008.

- R. Kimball, J. Caserta. The Data Warehouse ETL Toolkit: Practical Techniques for Extracting, Cleaning, Conforming and Delivering Data, Wiley, 2004.
- Inmon W.H., "Building the Data Warehouse", Wiley Computer Publishing2005.
- E. Turban, R. Sharda, D. Delen, D. King. Business Intelligence, Analytics and Data Science: A Managerial Perspective, 4th Edition, Pearson, 2018.

UEM2.2.2- Specialty Project

EU Code	Module title	Coefficients/Credits
EMU2.2.2	Specialty Project	4

Hourly volumes		
Lectures	TD / TP	TOTAL
	60	60

Semester :	4

Prerequisites	– Data analysis, Machine learning – Algorithms, Complexity and Problem Solving

OBJECTIVES :

To apply the knowledge and skills acquired during the course, in terms of programming, design and development of intelligent systems, analysis of real world data, which are usually very large and may consist of several heterogeneous knowledge bases.

CONTENT OF THE MODULE :

The project consists of two parts:

- The first part of the project is in a practical and pedagogical context of solving NP-hard combinatorial problems, including those in the real world, using intelligent optimisation techniques via the data mining part. This part of the project allows the implementation of intelligent optimisation techniques, as well as data analysis and Big Data.
- The second part consists of developing a resolution approach based on Machine Learning.

KNOWLEDGE TEST

The evaluation of the project will be based on the following criteria:

- A note per session will validate the objectives set for each week.
- One mark for each of the two deliverables requested.
- A mark for the presentation and demonstration of the proposed and implemented solutions.

Optional courses in the 2nd year of the second cycle (*)

(*) The map of optional courses will be added to as we go along

UET2- Digital Image

EU Code	Module title	Coefficients/Credits
UET2.*	Digital Image	4

Hourly volumes		
Lectures	TD / TP	TOTAL
22h30	30	52h30

Semester :	3 or 4

Prerequisites	– Image processing, ANAD.

OBJECTIVES :

Acquire the essential basics of digital image processing and analysis and pattern recognition. Apply the graphic techniques used in virtual reality and augmented reality applications

CONTENT OF THE MODULE :

I. Image processing

1. Image definition, purpose of image processing...
2. Scanning and binarisation of the image,
3. Image formats (bit-map, vectorised)
4. Basic image processing techniques: (histograms, point operations...)
5. Image pre-processing and filtering
6. Segmentation (studies of different approaches: region, borders, etc.).
7. Notion of movement in a sequence of images.

II. Pattern recognition

1. Introduction to pattern recognition: (definition and scheme of a recognition system and its applications - acquisition - processing - post-processing).
2. Feature extraction.
3. Classification (Bayesian decision theory, hyperplanes, neural networks, etc.).
4. Recognition and interpretation

III. *Still image compression*

1. Definition,
2. Compression and decompression methods: lossy and lossless, accuracy/space/computation time trade-off, standards.
3. Different coding and quantification.
4. Standard JPEG and JPEG2000.
5. 2D and 3D transformations -Rasterisation and GPU programming

PERSONAL WORK

- Image processing (digitisation, histogram display, binarisation, edge detection, median and average filters, etc.)
- Image restoration.
- Classification and recognition (recognition of single characters, analysis of complex documents, recognition of single handwritten numbers, etc.).
- Image compression (Image compression using DCT, ACP, ...)

KNOWLEDGE TEST

- Continuous assessment

BIBLIOGRAPHY

- R. O. Duda, P.E. Hart, D.G. Stork, "Pattern classification", 2nd edition, Wiley and sons, 2001.
- T. Hastie, R. Tibshirani, J. Friedman, "The elements of statistical learning. Data mining, inference and prediction", Springer, 2001.

- L. Lebart, A. Morineau, M. Piron, "Statistique exploratoire multidimensionnelle", Dunod, 2006.
- G. Saporta, "Probabilites Analyse des Données et Statistique", 3rd edition, Technip, 2011.
- Online resources: http://www.math.univ-toulouse.fr/~besse/teaching.html.
- José M.Bernardo and Adrian F.M.Smith Bayesian Theory, John wiley, new york, NY, 1996
- Richard O.Duda, Peter E.Hart, David G.Stork Pattern classification first and second edition
- G. Dreyfus, et al, Neural networks: methodologies and applications. Ed. Eyrolles
- M. Crucianu, J.-P. Asselin de Beauville, R. Boné Factorial methods for data analysis: linear methods and non-linear extensions. Ed. Hermès
- G. Saporta Probabilités, analyse des données et statistique. Ed. TECHNIP
- D.J. Hand, H. Mannila, P. Smyth Principles of Data Mining (Adaptive Computation and Machine Learning). Ed. Bradford Book
- BELAID Abdel, BELAID Yolande, "Reconnaissance des formes : Méthodes et applications". Inter Editions, 1992
- DUBUISSON Bernard, "Diagnostic et reconnaissance des formes". Hermes, 1990
- FU King-Sun, "Syntactic Methods in Pattern Recognition". Academic Press, 1974
- GAILLAT Gérard, "Méthodes statistiques de reconnaissance des formes". ENSTA publication, 1983
- MICLET Laurent, "Méthodes structurelles pour la reconnaissance des formes". Eyrolles and CNET - ENST, 1984
- PAVLIDIS T., "Structural Pattern Recognition". Springer Verlag, 1982
- SIMON Jean-Claude, "La reconnaissance des formes par algorithmes". Masson, 1984
- WATANABE Satosi, "Knowing and Guessing". John Wiley, 1969
- DUDA Richard, HART Peter, "Pattern Classification and Scene Analysis". John Wiley & Sons, 1973
- Computer Graphics: Principles and Practice (2nd Ed.), J.D.Foley, A. van Dam, S.K. Feiner, J.F. Hughes, Addison-Wesley 1990, ISBN 0-201-12110-7

UET2- Signal Processing

ETU code	Module title	Coefficients/Credits
UET2.*	Signal Processing	4

Hourly volumes		
Lectures	TD / TP	TOTAL
30	30	60

Semester :	3 or 4

Prerequisites	Mathematics programme

OBJECTIVES :

This module presents the basics of signal processing theory. It will enable them to acquire the notions necessary to master the algorithms and architectures of signal and image processing. These concepts are applied in various fields such as telecommunications, multimedia, robotics, etc.

KEYWORDS :

Fourier transforms, orthogonal functions, convolution, distributions, linear systems, discrete systems, signal, filtering. Wavelets.

CONTENT OF THE MODULE :

I. Space of continuous deterministic signals

1. Fourier Transform
2. Definition of continuous TF
3. Spectrum of a deterministic continuous signal
4. Linear and invariant systems
5. Convolution
6. Correlation
7. Sampling and SHANNON's theorem
8. Reconstruction of sampled signals

II. Discrete systems

1. Discrete Fourier Transform
2. Definition, fast algorithms of DFT calculation (FFT...)
3. Spectrum of periodic signals and real signals
4. Sampling
5. Z-transform
6. Discrete Fourier Transform

III. Filters

1. Filtering of a signal, main families of filters, transfer function, convolution, stability.
2. RIF and RII filters

IV. Orthogonal transforms

1. Discrete cosine transform (DCT)

2. Wavelet transform

V. Random signal space

1. Signal filtering, random
2. Discrete random signal
3. Spectral analysis of random signals

PERSONAL WORK

- Digitization, Fourier series decomposition, sampling and signal restitution, Filters
- Image compression by DCT and wavelets

KNOWLEDGE TEST

- Continuous assessment 15%, lectures and practical work 15% and final exam 70%.

BIBLIOGRAPHY

- M. Kunt, "Techniques Modernes de Traitement Numérique des Signaux", Presse Polytechniques et Universitaires Romandes, Lausanne, 1991
- M. Kunt, "Traitement numérique des signaux", Eyrolles, 1996
- L. R. Rabiner, R. W. Schafer, "Digital processing of speech signals", Prentice Hall, 1978
- M. Bellanger, "Traitement numérique du signal", 8th edition, Dunod, 2006
- J. Max, "Méthodes et techniques de traitement du signal et application aux mesures physiques", Masson, 1981
- E. Roubine, "Introduction à la théorie de la communication", Masson, 1980
- A. V. Oppenheim, R. W. Schafer, "Digital signal processing", Prentice Hall, 1975
- K. Kpalma, V. Haese-Coat, "Traitement Numérique du Signal: théorie et applications", Eyrolles, 2003.
- B. P. Lathi, "Linear Systems and Signals", 2nd edition, Oxford University Press, 2005

UET2- Virtual Reality

EU Code	Module title	Coefficients/Credits
UET2.*	Virtual Reality	4

Hourly volumes		
Lectures	TD / TP	TOTAL
22h30	30	52h30

Semester :	3 or 4

Prerequisites	– Image processing, optics.

OBJECTIVES :

- List the basic concepts of virtual reality and augmented reality
- Describe the operation of input and output devices used in virtual and augmented reality applications
- Explain the graphic techniques used in virtual and augmented reality applications
- Developing 3D virtual environments
- Developing 3D virtual environments
- Developing virtual reality applications with immersion
- Developing applications with augmented reality

CONTENT OF THE MODULE :

I. Introduction to virtual and augmented reality and their applications

II. Input devices: Trackers, Navigation, Gesture interfaces

III. Output devices: Graphics, 3D audio, and multimodal display (haptic, tactile, tangible)

IV. Architectures for VR/AR: Visualization Pipeline, Graphics Architecture, Distributed Architecture

V. Modelling: Geometry, Kinematics, Physics, and Behaviour

VI. Programming: Toolkits, Java 3D, Vuforia, UNITY 3

VII. Human Factors: Health and safety issues, VR/AR and society

VIII. Applications: Medical, Education, Entertainment, Military, Manufacturing, Robotics, Information Visualisation

PERSONAL WORK

- TD to enable the student to manipulate the tools of data analysis.
- Workshops on datasets and real data such as (the minutes of the students' deliberations) using appropriate software such as R.

KNOWLEDGE TEST

- Continuous assessment

BIBLIOGRAPHY

- R. O. Duda, P.E. Hart, D.G. Stork, "Pattern classification", 2nd edition, Wiley and sons, 2001.
- T. Hastie, R. Tibshirani, J. Friedman, "The elements of statistical learning. Data mining, inference and

prediction", Springer, 2001.

- L. Lebart, A. Morineau, M. Piron, "Statistique exploratoire multidimensionnelle", Dunod, 2006.
- G. Saporta, "Probabilites Analyse des Données et Statistique", 3rd edition, Technip, 2011.
- Online resources: http://www.math.univ-toulouse.fr/~besse/teaching.html.

UET2- Human-Computer Interface

EMU Code	Module title	Coefficients/Credits
UET2.*	Human-Computer Interface	2

Hourly volumes		
Lectures	TD / TP	TOTAL
15	15	30

Semester :	3 or 4

Prerequisites	– OOP, GL

OBJECTIVES :

- Raising students' awareness of the importance of HMIs in an interactive application
- To introduce the basic concepts of Human-Computer Interaction (HCI) and to give a comprehensive view of all aspects related to HCI, including cognitive science and ergonomics.
- Mastering user-centred design of HMIs, from analysis, design, prototyping to evaluation of HMIs.
- Acquire the necessary skills for the development of HMIs.

CONTENT OF THE MODULE

CONTENT OF THE MODULE :

I. *Introduction to HMIs*

1. Objectives of HMIs
2. Design approaches
3. Why study HMIs
4. History of HMIs: past, present, future.
5. Description and content of the HMI module

II. *Basic knowledge of cognitive science*

1. Introduction: why approach cognitive science?
2. Definition and background
3. Descriptive models:
4. Human processor model MPH (the sensory, cognitive and motor subprocessors)
5. Norman's action model

III. *Interface ergonomics*

1. Cognitive ergonomics
2. Ergonomics and usability
3. Analytical and normative ergonomics
4. Ergonomic benchmarks
5. Bastien and Scapin criteria
6. Nelson's Heuristics
7. Scheidemann's quality criteria
8. Golden rules of COUTAZ
9. Practical guides for designing ergonomic interfaces

IV. *HMI development process :*

1. HMI development cycle
2. Rules for success
3. Analysis phase

a. User analysis
b. Activity analysis
c. Contextual analysis

4. Design phase
a. Interface specification
b. Interface design Card
sorting Prototyping
c. Interface development tools

V. *HMI software architectures*

1. Language models
a. SEEHEIM model
b. Model ARCH
2. Agent-based models
c. SVM model
d. PAC model

VI. *Evaluation of HMIs*

1. Importance of evaluation in the HMI development process
2. Evaluation methods
3. Static assessment VS dynamic assessment
4. Analytical evaluation VS empirical evaluation

PERSONAL WORK

You will be asked to analyse, design, prototype and evaluate an HMI for a new system or an existing system whose HMI is not adapted to its use.

KNOWLEDGE TEST

– Continuous monitoring

BIBLIOGRAPHY

– Ludovic Cinquin, Erika Duriot, EricGroise, Olivier Mallassi, André Nedelcoux, David Rousselie, Vanessa Vimond "Les dossiers de l'écran : Utilisabilité et technologies IHM Editons OCTO, technologist 2010

– G. Calvary, "Ingénierie de l'interaction homme-machine: rétrospective et perspectives, Interaction homme-machine et recherche d'information" Traité des Sciences et Techniques de l'Information, Lavoisier, Hermès, 2002, pp 19-63

– J. Coutaz, "Interface Homme-Ordinateur" Dunod, 1990.

– C. Kolski, "Analyse et conception de l'IHM, Interaction homme-machine pour les Systèmes d'Information" Editions Hermès, May 2001

– C.Kolski " Environnements évolués et évaluation de l'IHM, Interaction pour les Systèmes d'Information " Editions Hermès, May 2001

– J.F. Nogier " De l'ergonomie du logiciel au design des sites Web ", Dunod 2001.

– D. Norman "The Psychology of Everyday Things", Basic Books, 1988.

– J. Preece, "Computer Human Interaction", Addison Wesley.

– Dan Olsen, "Developing User Interfaces

– JefRaskin, "The Humane Interface" Card, Moran, Newell, "Psychology Of Human Computer Interaction"

UET2- Advanced Geographic Information Systems

EMU Code	Module title	Coefficients/Credits
UET2.*	Advanced Geographic Information Systems	4

Hourly volumes		
Lectures	TD / TP	TOTAL
22.50	30	52.50

Semester :	3 or 4

Prerequisites	– Knowledge of databases and information systems

OBJECTIVES :

- To clarify the concept of spatial positioning and to provide a method for spatial analysis of map data.
- To study the acquisition, organisation and storage in specific databases of space, satellite or field images.
- Modelling geo-spatial or simply geographical data in 2D and 3D for decision support.

CONTENT OF THE MODULE :

I. *Introductions to GIS*

1. Definition of a GIS
2. History and development ofGIS
3. Geographic information, territory, geography and cartography
4. Geomatics and geodetic reference systems
5. Use and challenges of GIS (customers, finance, decision-making, human resources, etc.)
6. Comparison of GIS, CAD
7. Areas of application

II. *Representations and projections of the earth*

1. Shape of the earth
2. Altitude calculation
3. Ellipsoids and Datum (Case of Algeria)
4. Geographical coordinates and the sexagesimal system
5. Reminder; time calculation, scale and legend
6. Projection systems (Case of Algeria)
7. The UTM system
8. Deformations caused by the projections and their quality

III. *Vector mode*

1. Vectorisation principle
2. Types of storage
3. What is georeferencing?
4. Entity class principle and generated files
5. Topological model in GIS

IV. *Raster mode*

1. Reading the satellite image
2. Principle of ortho rectification of an image
3. Support points and mosaic
4. Resolution and image format in GIS
5. Mixed mode data vector traster
6. Semantic component

7. Advantages and disadvantages vsraster vector
8. Launch of the lectures and the practical work

V. *Data in GIS*

1. Source and structure of the data
2. Spatial databases "SGBDS".
3. Security and integrity of DBMS
4. Indexing and Spatial Joins
5. MADS" formalism
6. Importance of metadata

VI. *Topographic maps and contour lines*

1. Measurements apart from the meter
2. Isolines and side points
3. Equidistance, slope and spacing
4. Generation of topographic profiles

VII. *Digital Terrain Models and TINs*

1. Definition and format of a DTM
2. Principle of LIDAR
3. Transition from a DTM to a 3D relief
4. Delaunay triangulation

VIII. *Digital Elevation Models (DEM)*

1. Definition
2. Volume representation by Boolean modelling
3. Concept of LOD
4. Complex buildings

IX. *B.I.M*

1. BIM and digital mock-up
2. Exchanges through BIM
3. The IFC file format

X. *GIS and 3D representation*

1. Basics of 3D projections
2. Perspective projections and leakage points
3. 3D object to 2D image transformation chain
4. Transformation matrices

XI. *Textures and lighting*

1. Mapping principle
2. Procedural textures
3. Bump treatment
4. Components of light
5. Some lighting models

PERSONAL WORK

– Application to be developed or Research work related to GIS

KNOWLEDGE TEST

- Continuous assessment

BIBLIOGRAPHY

– Patrick Bouron, "Manuel de cartographie rapide "Bernard Lortic-IRD-,Institut de Recherche pour le Développement 2011 "Cartographie Lecture de cartes"-ENSG, National School of Geographical Sciences 2005

- Dominique Schneuwly, Regis Caloz, "Basic Spatial Concepts", Geographic Information Technology Training Alliance (GITTA)
- "Geographic Information Systems, Archaeology and History", 2004.
- LauriniR.and Thompson D. "Fundamentals of spatial systems". London Acedemic.Press1992
- Henry Pornon, "The geographical dimension of the information system" 2011, www.geoinformatics.com

UET2- Advanced Machine Learning

EU Code	Module title	Coefficients/Credits
UET2.*	Advanced Machine learning	3

Hourly volumes		
Lectures	TD / TP	TOTAL
22,5	30	52,5

Semester :	3 or 4

Prerequisites	Machine Learning, Mathematics (Analysis, Linear Algebra), Statistics, Probability.

OBJECTIVES :

Addressing very recent machine learning techniques
Competing algorithms
Implementation on Python

CONTENT OF THE MODULE :

- *Deep learning*
  - CNN Architecture
  - Architecture RNN, LSTM....
- *Reinforcement learning (RL)*
  - **V.** LR approaches
  - ***VI.*** Q learning algorithm.....
- *Transfer Learning*
- *Distributed learning (Federated learning)*
- *Interpretation*
- Deep neural networks
- Clustering

Practical work: Practical work is planned to master the different algorithms seen in the course on R and Python software

PERSONAL WORK

- Tps on a specific architecture and domain

KNOWLEDGE TEST

- Continuous monitoring
- Final check.

BIBLIOGRAPHY

- Qiang Yang, Yang Liu, Yong Cheng, Yan Kang, "Federated Learning", Morgan and Clayfool Publishers, December 2019.
- Qiang Yang, Yu Zhang, Wenyuan Dai, SinnoJialin Pan, "Transfer Learning", Cambridge University Press, 13 February 2020
- Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", November 2016
- Richard S. Sutton, Andrew G. Barto. "Reinforcement Learning, second edition: An

Introduction". Hardcover - 13 November 2018

UET2- Time series analysis

EU Code	Module title	Coefficients/Credits
UET2.*	Time series analysis	2

Hourly volumes		
Lectures	TD / TP	TOTAL
15	22h30	37h30

Semester :	3 or 4

Prerequisites	Mathematics (Analysis, Linear Algebra), Statistics, Probability.

OBJECTIVES :

Define time series

Learn to analyse time series

Implementation on Python or R.

CONTENT OF THE MODULE :

- *Introduction to the Time Series (CS)*
  - ***VII.*** *Concepts*
  - ***VIII.*** *Decomposition of a CS*
- *SC analysis : Probabilistic approach*
  - **3.** *Model AR, MA*
  - **4.** *ARMA model,ARIMA,....*
- *SC analysis : Deep learning approach; LSTM*
- *SC analysis : Topological approach*
- *Exponential smoothing*

Practical work: Practical work is planned to master the algorithms seen in the course on datasets related to different cases of application: stock market, electricity consumption, weather, ... on R and Python software

PERSONAL WORK

- Tps on specific data to detect breaks, predict new values ....

KNOWLEDGE TEST

- Continuous monitoring
- Final check

BIBLIOGRAPHY

- Wei William W. S. "Multivariate Time Series Analysis and Applications". Wiley Series in Probability and Statistics Series
- Aileen Nielsen. "Practical Time Series Analysis: Prediction With Statistics and Machine Learning. Paperback 2019.

UET2- Smart Government

EU Code	Module title	Coefficient/Credits
UET2.*	Smart Government	**2**

Hourly volumes		
Lectures	**TD / TP**	**TOTAL**
15	**15**	**30**

Semester :	**3 or 4**

Prerequisites	– Information Systems Analysis – Analysis of Organisations.

OBJECTIVES :

- Explain the challenges of digital transformation in organisations in general.
- Analyse best practices related to the development of e-government projects in various POs.
- Aligning e-government information systems with public policies.
- Understand the issues of the movement (Open Government) and the Open Government Data (OGD) to strengthen government intelligence.
- Analyse the potential of Crowdsourcing/Crowfunding for a more greater citizen participation.

CONTENT OF THE MODULE :

I. *Introduction: Towards the digital transformation of organisations (2 sessions)*

1. Reminder of basic concepts: Information (knowledge) society / IT / IT Governance / digital divide / digital divide
2. Changing concerns of organisations in relation to digitalisation;
3. Digital transformation of organisations: Which approach(es) to follow?

T.D (2 sessions) : *Exchanges via video clips, testimonies, ..), SWOT analysis*

II. *e-Government: Why and How (3 sessions)*

1. Introduction to e-government.
2. Potential benefits of e-government for key stakeholders
3. Types of Services. G2C, G2B, G2G services.
4. Enterprise architecture for government systems.
5. Guidelines for successful implementation of e-government projects.

TD (3 sessions): *Case study (Smart city, ..), Panel "Exchange with professionals*

III. *Open Government: Issues and Challenges (2 sessions)*

1. Introduction to Open Government: Foundations and Objectives
2. ICT influencing open government and stakeholders.
3. Opening and re-use of government data :
4. Open public data ?
5. Benefits, obstacles and negative effects of open public data cases.
6. Technological aspects (metadata, portals, technologies to link open big data).
7. Transparency and privacy in the context of open government.

TD (2 sessions*) : Work on monitoring the movements of SGOs in the most important countries.*

prolific in terms of publications and exploitation of these data

IV. *Towards greater citizen participation: (1 session)*

1. Expectations/ constraints
2. Contribution of Crowdsourcing / Crowdfunding

TD (1 session): *Case study (citizen participation)*

PERSONAL WORK

–

KNOWLEDGE TEST

- Intermediate control in TD (50%) :
- Final Examination (50%)

BIBLIOGRAPHY

- A reflection on business in the digital world, by CIGREF: www.entreprises-et-cultures-numeriques.org
- Attard, J, F. Orlandi, and S. Auer. Auer (2016) "Data Driven Governments: Creating Value Through Open Government Data." Transactions on Large-Scale Data-and Knowledge-Centered Systems XXVII. Springer, 84-110.
- Attard, J., Orlandi, F., Scerri, S., & Auer, S. (2015). A systematic review of open government data initiatives. Government Information Quarterly, 32(4), 399-418.
- EY, White Paper "Digital transformation at the level of organisations".
- Clarinval, A., Simonofski, A., Vanderose, B., & Dumas, B. (2020). Public displays and citizen participation: a systematic literature review and research agenda. Transforming Government: People, Process and Policy.
- B. Moulin, D. Kettani, "E-government and good governance in developing countries", Presses Universitaires de l'Université Laval, 2014.
- https://www.data.gov/open-gov/

UET2- Visualisation of information

EMU Code	Module title	Coefficients/Credits
UET2	Information visualisation	2

Hourly volumes		
Lectures	TD / TP	TOTAL
15	15	30

Semester :	3 or 4

Prerequisites	– Statistics and probability, linear algebra, numerical calculation.

OBJECTIVES :

- Identify the scientific basis of Infovis
- Build visualizations for various problems or data
- Analysing automatic learning models using visualisations
- Choose the visual coding for each type of data and each associated problem
- Linking your research tomorrow with the infovis domain
- Evaluate different types of visualisations

CONTENT OF THE MODULE :

I. *Introduction*

1. Objective
2. Definition
3. History
4. Visual perception
5. Parallel property extraction
6. Sequential processing - goal-directed
7. The parallel process of generating InfoVis
8. Visual Coding
9. Interactions

II. *Types of views*

1. Scientific visualization
   - **a.** Simulation
   - **b.** Image segmentation
2. Visualisation of information
   - **a.** Abstract data
   - **b.** Spatio-temporal data
3. Analytical visualisation

III. *Analytical Visualisation (AV)*

1. Definition
2. IL process

a. Model

b. Infovis

c. Data analysis

IV. *Analytical visualization with AI*

1. NLP: Visualisation of feelings (Multistream)

2. ML

a. VA for ML

b. Size reduction (mds, acp, svm, ...)

c. Clustering/Classification

d. Active Learning

e. ML for VA: Visual Coding Choice

3. Optimisation: Removal of text overlap

a. Graph

b. Mapping

4. Data Stream

a. Dynamic visualization

b. Understanding Apache Spark streaming

V. *Graph drawing*

1. One dimension: Arc diagrams

2. Two dimensions : Noued-link diagram

3. Hierarchical

a. Trees

b. Tree map by Ben Shneiderman

4. Size reduction (MDS)

VI. *Topic Visualisation*

1. LDA

2. LDA with pre/post analysis

VII. *Visualisation of spatio-temporal data:* When (time)/Where (location)/What (subject)

1. Spatial visualization (Where / What)

2. Time-oriented visualisation (When / What)

3. Spatio-temporal visualisation (When / Where / What)

VIII. *Evaluation of the types of visualizations (2H)*

1. Nested model

2. Experimentation

3. Approaches based on domain problems (domain-driven visualisation)

- Visualisation of animal epidemiology

4. Approaches based on visual coding (technique-driven visualisation)

a. Overlap removal of nodes on arc diagram

b. Text arrangements around the circles

Practical work :

- Tp1: create shapes in observable using d3.js
- Tp2: create static diagrams
- Tp3: create representations for textual data

PERSONAL WORK

Project :

- Visualisation of twitter data sentiments

KNOWLEDGE TEST

Contrôle continuous

BIBLIOGRAPHY

- Fekete, J.-D., Wilk, J. J., Stasko, J. T., & North, C. The Value of Information Visualization. Theoretical
- Foundations of Information Visualization. In Information Visualization: Human Centered Issues and Perspectives, 2008
- Keim, Daniel, et al. "Visual analytics: Definition, process, and challenges." Information visualization. Springer, Berlin, Heidelberg, 2008. 154-175.
- Meyer, Miriah, Michael Sedlmair, and Tamara Munzner. "The four-level nested model revisited: blocks and guidelines." Proceedings of the 2012 BELIV Workshop: Beyond Time and Errors-Novel Evaluation Methods for Visualization. 2012.
- Dewar, Mike. Getting Started with D3: Creating Data-Driven Documents. "O'Reilly Media, Inc. 2012.

UET 2 - Embedded Systems

ETU code	Module title	Coef
UET2	Embedded Systems	4

Hourly volumes		
Lectures	TD / TP	TOTAL
22h30	30	52h30

Semester :	3, 4

Prerequisites	– Computer architecture 1 – Computer architecture 2 – Computer architecture 3

OBJECTIVES :

The objectives of this course are to familiarize the student with real-time and embedded systems:

- He/she should be familiar with the three layers of such systems: the architecture, the operating system and the application.
- he must be confronted with the constraints of real-time and embedded systems which are very different from those of the systems usually used by computer engineers.
- He/she must be able to design, develop and use: embedded software, real-time applications and embedded systems using a unified methodology.

CONTENT OF THE MODULE :

- **Integrated circuit design**: **(3h)**
  - Evolution of integrated circuits
  - Design process
  - Design steps,
  - Manufacturing, testing and packaging
- **Real-time and embedded systems: (3h)**
  - History and growth of the microprocessor market
  - General information on embedded systems
  - Examples of embedded systems
  - Characteristics of embedded systems
  - Block diagram of embedded systems
  - Architecture of embedded systems
- **Processors and circuits for embedded systems: (3h)**
  - Instruction set processors
  - DSP
  - FPGA
  - ASIC
  - Socs
- **Design methods for embedded systems: (1h)**
  - Classical approach
  - Introduction of codesign
- **Different stages in the design of an embedded system: (7h)**
  - Co-specification of embedded systems
  - Modelling of embedded systems
  - Partitioning and scheduling of embedded systems

- Embedded systems synthesis
- Verification of embedded systems
- Testability of embedded systems

- **Multiprocessor chips (MPSoCs): (3h)**
  - Multiprocessors and the evolution of MPSoCs
  - MPSoCs applications and architectures
  - Architectures for low power real-time systems
  - Interconnection network in MPSoCs: NOCS (Network On Chip)
  - Computer-aided design and MPSoCs
- **Platforms and operating systems for embedded systems: (4h)**
  - Embedded application development platforms
  - Functionality of operating systems and their implementation on existing systems.
- **Fault tolerance and safety in embedded systems (2h)**
- **Examples of interlocking systems: (2h)**
  - Sensor networks
  - RFID systems
  - Internet of Things

PERSONAL WORK

c. Integrated circuit design :

Objective: to familiarise the student with tools to assist in the design of circuits.

I.1. Design and development of a system for hardware implementation on FPGA.

Tools :

I. Software: ISE from Xilinx, Modelsim simulator.

II. Hardware: FPGA board.

Specification, with hardware description languages (VHDL or verilog).

3. Initiation, presentation of the language.

4. Example of a circuit description.

5. Presentation of the Xilinx ISE tool. **Synthesis,** RTL level, logic gate level. **Simulation and validation**, ISE simulator or Modelsim. **Mapping, floorplanning, placement and routing.**

Design implementation, FPGA programming and testing.

I.2. Drawing of Layouts :

Tool: MicroWind Simulator (MW) :

2. Presentation of circuits based on transistors, resistors and parasitic capacities.
3. The transition to different layout layers with different materials.
4. Presentation of the MW simulator, drawing rules.
5. Creation of the layout.

6. Simulation and testing.

I.3. Embedded systems design methods:

Objective: to familiarise the student with tools to assist in the design of embedded systems.

Tools :

- SystemC and KDE from Xilinx,
- ESI FabLab equipment (Arduino Raspberry Pi development boards, micro-sensors, RFID components, etc.).

KNOWLEDGE TEST

1. 2 scheduled written tests
2. Practical note
3. Individual and team projects.

BIBLIOGRAPHY

- John L. Hennessy and David A. Patterson, "Computer Architecture: A Quantitative Approach", Sixth Edition, The Morgan Kaufmann Series in Computer Architecture and Design, 2017.
- W. Stallings, "Computer organization and Architecture, Designing for performance", Eleventh edition, Pearson, 2018.
- W. Wolf, A. Amine Jerraya, and G. Martin, Multiprocessor System-on-Chip (MPSoC) Technology, 2008.
- Alan C. Shaw, "Real-Time Systems and Software", Wiley Publishers, ISBN: 0-471-35490-2, 2001.
- F. Vahid, T.D. Givargis, Embedded System Design: A Unified Hardware/Software Introduction, ISBN: 0-471-38678-2, Wiley Publishers, October 2001.
- I. Englander, The Architecture of Computer Hardware and System Software: An Information Technology Approach, Third Edition, ISBN: 0-471-07325-3, Wiley Publishers, 2003.
- A.M.K. Cheng, Real-Time Systems: Scheduling, Analysis, and Verification, ISBN: 0- 471-18406-3, Wiley Publishers, July 2002.
- S. Sriram, S.S. Bhattacharyya, Embedded Multiprocessors, Scheduling and synchronization, Signal Processing and Communications Series, 2000.
- J. BHASKER, A systemC primer, Star Galaxy Publishing, ISBN: 0-9650391-8-8, 2002.
- T. Grötker, S. Liao, G. Martin, S. Swan, System design with SystemC, Thorsten Grötker, Stan Liao, Grant Martin, Stuart Swan, Kluwer Academic Publishers, 2002
- H. Bhatnagar, Advanced Asic Chip Synthesis: Using Synopsys Design Compiler, Physical Compiler, and Primetime, Kluwer Academic Publishers, Kluwer Academic Publishers, ISBN: 0792376447, January 2002.
- M. Tien-Chien Lee, High-Level Test Synthesis of Digital VLSI Circuits, Artech House Publishers, ISBN: 0890069077, February 1997.

UET2 - Agile Methods

EU Code	Module title	Coef/Credits
UET2.*	Agile Methods (MAGL)	2

Hourly volumes		
Lectures		TOTAL
15		15

Semester :	3, 4

Prerequisites	6. IGL 7. CPROJ

OBJECTIVES :

- A development methodology is a conceptual model for defining the phases and stages of a software development project from its initiation and feasibility study phase to final deployment.
- This module complements the IGL module of the 3rd year where the methodologies were introduced. UP was used as a template to define the different development activities from requirements expression to testing.
- The module will introduce software development using methods that are increasingly adopted in the professional world, namely agile methods.
- The application of the principles acquired during this module will be carried out during the course of the two projects of the speciality.

CONTENTS :

- **Agile Manifesto**
  - Introduction
  - Presentation of the Agile manifesto
  - Agile Principles Journey
- **eXtremeProgramming (XP)**
- Introducing XP
- XP and best development practices
- **Implementation of SCRUM**
- Application of Scrum in a development project Support
- tools
- Agile practices
- Continuous
- delivery
- Refactoring

KNOWLEDGE TEST

2. Written examination on the course
3. Continuous monitoring

BIBLIOGRAPHY

2. Augustine, Sanjiv. 2005. Managing Agile Projects: Prentice Hall; illustrated edition.
3. Schiel, James. 2009. Enterprise-Scale Agile Software Development: Taylor and Francis.
4. Schwaber, Ken, and Mike Beedle. 2002. Agile software development with scrum: Prentice Hall.

IV- Agreements / Conventions