PEOPLE DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

University of 20 Août 1955-Skikda

Faculty of Sciences

Department of Computer Science

MASTER ARTIFICIAL INTELLIGENCE

L.M.D

ACADEMIC

1 – Context and objectives

A–Access Conditions

The Master Artificial Intelligence is accessible to the holders of an academic Bachelor degree in Computer Systems, Information Systems and Software Engineering, or any equivalent degree that meets the required selection criteria, as determined in advance by the training team.

B– Objectives

Over the past decade, Artificial Intelligence (AI) has experienced remarkable progress in both academic and economic/industrial domains. This progress has been largely driven by the emergence of new sophisticated Artificial Learning Models and GPU architectures. These last have revolutionized AI by enabling complex problem solving and significantly enhancing performance, particularly when integrated with parallel and distributed computing. This renewed surge of interest to AI has led to exciting opportunities in scientific research, education, and various computer-related professions.

At the pedagogical level, students undertaking this Master's program in AI will receive comprehensive theoretical knowledge in AI through a well-rounded curriculum. The program focuses on essential subjects that lay the foundation for AI training. Students will investigate various machine learning techniques, with a special emphasis on deep learning. To ensure a hands-on learning experience, laboratory work and engaging mini-projects will be conducted. These activities will leverage cutting-edge GPGPU architectures and dedicated software platforms, enabling students to gain practical proficiency in the field of deep learning and its applications.

The Master's program in AI goes beyond the fundamentals, offering students a comprehensive exploration of additional AI tools and application domains. Concerning the AI tools, the program also includes Evolutionary Algorithms, Fuzzy Logic, Collective Intelligence, Multi-Agent Systems, and Formal Methods for AI. Regarding the application domain, they concern the Recognition, Autonomic Computing, Smart Homes and Cities, Embedded Systems, etc. By delving into these specialized domains, students develop a nuanced understanding of AI and its diverse applications. By engaging with these cutting-edge topics, graduates emerge with a versatile skill set that equips them for thriving careers in both academia and professional spheres. The program empowers students to succeed in the dynamic and ever-evolving field.

C – Professional profiles and skills

In terms of professional skills, graduates will be able to design and implement intelligent systems using well established AI tools, particularly in the abovementioned domains. Nowadays, and in the years to come, AI-related professions will remain highly sought-after due to the mastering of AI models and techniques and the continual exponential growth of the data production resulting from the digitization of nearly all economic and social activities. In the industrial, agricultural, and service sectors, there will be a wealth of data that need to be effectively analysed, allowing individuals to leverage AI models and techniques. With its strong academic foundation, graduates of this program have the opportunity to pursue research positions in research and development departments spanning diverse sectors of activities.

D – Program Update

Periodic internal audits conducted with the participating teachers-researchers as well as with the students enable the measurement of the effectiveness of the teachings and the relevance of the courses and their content material being taught. Updates to the program can be proposed and validated by the teaching team, the educational managers, as well as by the competent scientific and academic bodies.

E – Supervision capacity

The participating Teachers-Researchers are researchers in Artificial Intelligence and they are familiar with the use of AI models and tools in combination with Software Engineering. Considering their number and qualification, it will be possible to accommodate 25 students per cohort.

2 – Available Human Resources

A: Local Teachers-Researchers involved in the specialty:

First name and last name	Degree	Type of intervention*
Soufiane Boulehouache	MCA	Course / Tutorial / Laboratory Work / Supervision
Smaine Mazouzi	Professor	Course / Tutorial / Laboratory Work / Supervision
Mohammed Redjimi	Professor	Course / Tutorial / Laboratory Work / Supervision
Mehdi Boulaiche	MCA	Course / Tutorial / Laboratory Work / Supervision
Yacine Kissoum	MCA	Course / Tutorial / Laboratory Work / Supervision
Fateh Bougamouza	MCB	Course / Tutorial / Laboratory Work / Supervision
Djamel Zeghida	MCA	Course / Tutorial / Laboratory Work / Supervision
Toufik Laroum	MCB	Course / Tutorial / Laboratory Work / Supervision
Abdelhak Mansoul	MCA	Course / Tutorial / Laboratory Work / Supervision
Abdenacer Nafir	MCB	Course / Tutorial / Laboratory Work / Supervision
Ramdane Chikh	MCB	Course / Tutorial / Laboratory Work / Supervision
Mohammed Cheikh	MCB	Course / Tutorial / Laboratory Work / Supervision
Samira Hazmoune	MCB	Course / Tutorial / Laboratory Work / Supervision
Adel Lahsasna	MAA	Course / Tutorial / Laboratory Work / Supervision
Soumia Rami	MAA	Course / Tutorial / Laboratory Work / Supervision
Abdelouahid Bouhouche	MCB	Course / Tutorial / Laboratory Work / Supervision
Rachid Boutine	MAA	Course / Tutorial / Laboratory Work / Supervision
Mohammed Cheribet	MAA	Course / Tutorial / Laboratory Work / Supervision

*** = Course, Tutorials, Laboratory work, Internship supervision, Thesis supervision**

B: External Teachers-Researchers:

Affiliation institution: 8 May 1945 Guelma University.

First name and last name	Degree	Type of intervention*
Said Brahimi	MCA	Course / Tutorials / Laboratory Work / Supervision

3 – Specific Hardware Available

A-Pedagogical laboratories and equipment:

Laboratory name: General Computer Science Laboratory
Student capacity: 25 Students

N°	Equipment	Number	Observations
01	Micro-Computers	25	Networked
02	Micro-Computers	25	Networked
03	Micro-Computers	25	Networked
04	Micro-Computers	25	Networked

Laboratory name: Processing Center
Capacity: Remote usage

N°	Equipment	Number	Observations
01	HPC	1	Artificial Intelligence Center

Laboratory name: Free Acces
Capacity: 25 Students

N°	Equipment	Number	Observations
01	Micro-computers connected to the INTERNET	1	

B- Internship placements and corporate training opportunities:

Internship Place	Number of students	Period
CP1/K	5	3 months
GL1/K	5	3 months
EPS	3	3 months
Port	4	3 months
Other public and private companies	8	3 months

4 – Semester Teaching Organization Form.

A- Semester 1:

Teaching Unit	SHV	Weekly Hour Volume				Credit weight	ECTS Credits	Assessment mode	
	14-16 week	Course	Tutorial	Lab	Others			Continuous	Exam
Core Teaching Unit									
CTU1(O/P)									
Machine Learning 1	72	1.5	1.5	1.5		3	6	x	X
Evolutionary Algorithms	72	1.5	1.5	1.5		3	6	x	X
Fuzzy systems	72	1.5	1.5	1.5		3	6	x	X
Methodological Teaching Unit									
MTU1(O/P)									
Design of Intelligent Systems	48	1.5	1.5			3	5	x	X
Knowledge Representation Techniques	48	1.5	1.5			2	4	x	X
Discovery Teaching Unit									
DTU1(O/P)									
Pattern Recognition	24	1.5				1	1	x	X
Speech Recognition	24	1.5				1	1	x	X
Transversal Teaching Unit									
TTU1(O/P)									
Ethics of Artificial Intelligence	24	1.5				1	1	x	X
Total of Semester 1	**384**	**12**	**7.5**	**4.5**		**17**	**30**		

B- Semester 2:

Teaching Unit	SHV	Weekly Hour Volume				Credit weight	ECTS Credits	Assessment mode	
	14-16 week	Course	Tutorial	Lab	Others			Continuous	Exam
Core Teaching Unit									
CTU1(O/P)									
Machine Learning 2	72	1.5	1.5	1.5		3	6	x	X
Statistical Artificial Intelligence	72	1.5	1.5	1.5		3	6	x	X
Collective Artificial Intelligence	72	1.5	1.5	1.5		3	6	x	X
Methodological Teaching Unit									
MTU1(O/P)									
Formal Methods in Artificial Intelligence	48	1.5	1.5			3	5	x	X
Agents and Multi-Agents Systems	48	1.5	1.5			2	4	x	X
Discovery Teaching Unit									
DTU1(O/P)									
Autonomic Computing	24	1.5				1	1	x	X
Intelligent Homes and Cities	24	1.5				1	1	x	X
Transversal Teaching Unit									
TTU1(O/P)									
Scientific and Technical Communication	24	1.5				1	1	x	X
Total of Semester 2	**384**	**12**	**7.5**	**4.5**		**17**	**30**		

C- Semester 3:

Teaching Unit	SHV	Weekly Hour Volume				Credit weight	ECTS Credits	Assessment mode	
	14-16 week	Course	Tutorial	Lab	Others			Continuous	Exam
Core Teaching Unit									
CTU1(O/P)									
Deep Learning	72	1.5	1.5	1.5		3	6	x	X
Metaheuristics	72	1.5	1.5	1.5		3	6	x	X
Big Data-oriented techniques	72	1.5	1.5	1.5		3	6	x	X
Methodological Teaching Unit									
MTU1(O/P)									
Embedded Systems and IoT	48	1.5		1.5		3	5	x	X
Facial Recognition Systems	48	1.5		1.5		2	4	x	X
Discovery Teaching Unit									
DTU1(O/P)									
Artificial Intelligence in Medicine	24	1.5				2	2	x	X
Transversal Teaching Unit									
TTU1(O/P)									
Scientific Writing Tools	24	1.5				1	1	x	X
Total of Semester 3	**360**	**10.5**	**4.5**	**7.5**		**17**	**30**		

D- Semester 4:

Final Year Project (PFE) with an Internship in a Company, culminating in a Thesis and a Defense.

	SHV	Credit weight	ECTS Credits
Personal Work	/	/	/
Project	320	9	20
Seminars on Research Topics in AI.	48	5	10
Total of Semester 4	**368**	**14**	**30**

5- Global Overview of the Program

TU / HV	CTU	MTU	DTU	TTU	Total
Course	216	144	120	6	552
Tutorial	216	96	0	3	312
Laboratory	216	48	0	1.5	264
Personal Work	0	320	0	0	320
Other	0	0	48	0	0
Total	648	608	168	72	1424
ECTS Credits	54	47	16	3	**120**
% of Credits for Each Teaching Unit	45%	39.1%	13.3%	2.5%	

Master's title: Artificial Intelligence

Semester: *1*

Teaching Unit: CTU1

Subject title: Machine Learning 1

Credit weight: 3

ECTS Credits: 6

Course Objectives

This course aims to introduce the fundamental concepts and basic techniques of machine learning while developing the necessary skills for students to effectively apply classification and regression algorithms to real-world problems. Students will learn to build, evaluate, and select the most appropriate predictive models for specific situations. In this first part of the Machine Learning course, models will be implemented in Python, which is now the reference programming language in this field.

Recommended Prerequisites

- Basic mathematics: linear algebra, differential calculus, statistics, and probability.
- Python programming.

Course Outline

Chapter 1. Introduction to Machine Learning

1.1. Introduction
1.2. Application domains of machine learning
1.3. Basic concepts of machine learning
    1.3.1. Types of learning
    1.3.2. Supervised learning (Classification, Regression)
    1.3.3. Unsupervised learning (Clustering, Dimensionality Reduction, Association Rules)
    1.3.4. Reinforcement learning
1.4. Challenges in machine learning (Overfitting, Underfitting, Bias-Variance Tradeoff, Hyperparameter Tuning, Model Selection, …)

Chapter 2. Development of a Machine Learning Project

2.1. Development process
    2.1.1. Problem definition
    2.1.2. Data preparation (collection and preprocessing)
    2.1.3. Feature analysis and extraction
    2.1.4. Data splitting
    2.1.5. Model training and hyperparameter optimization
    2.1.6. Testing
    2.1.7. Deployment
2.2. Case study (practical project)

Chapter 3. Linear Methods

3.1. Linear methods for regression
3.2. Linear regression (simple, multiple)
3.3. Lasso regression
3.4. Ridge regression
3.5. Elastic-Net regression
3.6. Linear methods for classification
3.7. Logistic regression
3.8. Naive Bayes classifier

3.9. Linear Discriminant Analysis

Chapter 4. Decision Trees

4.1. Introduction
4.2. Definition of a Decision Tree
4.3. Decision tree construction
4.4. Decision tree learning algorithms (CART, ID3, C4.5, etc.)
4.5. Advantages and disadvantages

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Dreyfus, G. (2008). Apprentissage Statistique. Réseaux de Neurones, Cartes Topologiques, Machines à vecteurs supports. Eyrolles.
2. Efron, B., Hastie, T., John stone, I., Tibshirani, R., etal. (2004).Least angle regression. The Annals of statistics, 32(2): 407–499.
3. Friedman, J. H. (1989). Regularized discriminant analysis. Journal of the American statistical association, 84(405):165–175.
4. Hastie, T., Tibshirani, R., and Friedman, J. (2011).The Elements of Statistical Learning. Springer.
5. James, G., Witten, D., Hastie, T., and Tibshirani, R. (2013).An Introduction to Statistical learning, volume 112. Springer.
6. Mitchell, T. (1997). Machine Learning. McGraw Hill.
7. Schapire, R.E. (1990).The Strength of weak Learnability. Machine Learning, 5(2):197–227.
8. Schapire, R. E. and Singer, Y. (1999).Improved boosting algorithms using confidence-rated predictions. Machine learning, 37(3):297–336.

Master's title: Artificial Intelligence

Semester: 1

Teaching Unit: CTU 1

Subject title: Evolutionary Algorithms

Credit weight: 3

ECTS Credits: 6

Course Objectives

This course aims to equip students with the theoretical foundations and practical skills to apply Evolutionary Algorithms (EA) using Python. Students will explore Genetic Algorithms (GA), Evolutionary Strategies (ES), Differential Evolution (DE), and Multi-Objective Evolutionary Optimization (MOEA), implementing them with libraries like DEAP and PyGAD. The course covers optimizing Machine Learning Models, Neural Networks (NeuroEvolution), and Reinforcement Learning through evolutionary techniques. Students will develop hybrid approaches, combining EA with Deep Learning and AI, and evaluate algorithm performance through benchmarking. By the end of the course, students will apply EA to real-world AI problems.

Recommended Prerequisites

Students should be familiar with algorithms, data structures, and basic skills in programing and a solid foundation in linear algebra, probability.

Course Outline

Chapter 1: Introduction to Evolutionary Computation

1.1. Historical background of Evolutionary Algorithms (EAs)
1.2. Biological inspiration and Darwinian principles
1.3. Overview of population-based search methods
1.4. Applications of EAs in Artificial Intelligence

Chapter 2: Genetic Algorithms (GA)

2.1. Representation: Binary, Real, and Permutation Encoding
2.2. Selection Methods: Roulette Wheel, Tournament Selection, Rank-Based Selection
2.3. Genetic Operators: Crossover, Mutation, Elitism
2.4. Fitness Function Design and Constraint Handling
2.5. Case Study: Solving NP-hard problems with GAs (e.g., Traveling Salesman Problem)

Chapter 3: Genetic Programming (GP)

3.1. Evolution of tree-based structures
3.2. Applications in AI: Symbolic Regression, Rule Discovery
3.3. Implementing GP in Python (DEAP library)

Chapter 4: Evolutionary Strategies (ES) and Evolutionary Programming (EP)

4.1. Evolutionary Strategies ($\mu + \lambda$) and (μ, λ) selection
4.2. Self-adaptation of parameters
4.3. Differences between ES, GP, and GA
4.4. Applications in Reinforcement Learning and AI

Chapter 5: Differential Evolution (DE)

4.5. Mutation and recombination in DE

4.6. Selection strategies
4.7. DE for continuous optimization problems
4.8. Case Study: Hyperparameter optimization of Neural Networks using DE

Chapter 6: Multi-Objective Evolutionary Algorithms (MOEA)

6.1. Pareto Dominance and Pareto Front
6.2. Multi-Objective Optimization (NSGA-II, SPEA2)
6.3. Applications in AI: Neural Architecture Search, Hyperparameter Optimization

Chapter 7: Hybrid Evolutionary Algorithms in AI

7.1. Combining EAs with Reinforcement Learning (RL)
7.2. Hybridizing EAs with Deep Learning (NeuroEvolution)
7.3. Evolutionary Hyperparameter Optimization
7.4. Case Study: Using EAs to evolve AI agents in games

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. De Jong, K. (2017, July). **Evolutionary Computation: a Unified Approach.** In Proceedings of the Genetic and Evolutionary Computation Conference Companion (pp. 373-388).
2. Goldberg, D. E. (1989). **Genetic Algorithm in Search, Optimization and Machine Learning**, Addison. Wesley Publishing Company, Reading, MA, 1(98), 9.
3. Mirjalili, S. (2019). **Genetic Algorithm.** Evolutionary Algorithms and neural networks: Theory and applications, 43-55.
4. Negnevitsky, M. (2005). **Artificial Intelligence: a Guide to Intelligent Systems.** Pearson Education.
5. Deb, K. (2011). **Multi-objective Optimisation using Evolutionary Algorithms: an Introduction**. In Multi-Objective Evolutionary Optimisation for Product Design and Manufacturing (pp. 3-34). London: Springer London.
6. Wirsansky, E. (2020). **Hands-On Genetic Algorithms with Python: Applying Genetic Algorithms to Solve Real-World Deep Learning and Artificial Intelligence Problems**. Packt Publishing Ltd.

Master's title: Artificial Intelligence

Semester: *1*

Teaching Unit: CTU 1

Subject title: Fuzzy systems

Credit weight: 3

ECTS Credits: 6

Course Objectives

The course aims to provide a comprehensive understanding of Fuzzy Sets, Fuzzy Logic, and Fuzzy Systems, focusing on their definitions, characteristics, and practical applications. Students will learn to construct and implement Mamdani and TSK Fuzzy Systems and explore advanced techniques like the Wang and Mendel Algorithm. Additionally, the course covers hybrid fuzzy systems, including Genetic-Fuzzy and Neuro-Fuzzy Systems, enhancing problem-solving capabilities in complex domains.

Recommended Prerequisites

Knowledge acquired during a Bachelor's degree program in Computer Systems (SI), Information System and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: Fuzzy Sets

1.1. Definition of a fuzzy set
1.2. Characteristics of a fuzzy set
1.3. Operations on fuzzy sets
1.4. Types of membership functions

Chapter 2: Fuzzy Logic

2.1. Introduction
2.2. Linguistic variables
2.3. Fuzzy propositions
2.4. Fuzzy implications

Chapter 3: Fuzzy Systems

3.1. General definition of a Fuzzy System
3.2. Mamdani Fuzzy System
3.3. Building Mamdani Fuzzy System in Matlab
3.4. Takagi-Sugeno-Kang (TSK) Fuzzy System
3.5. Building TSK Fuzzy System in Matlab
3.6. Construction of Fuzzy Systems by Learning -Wang and Mendel Algorithm

Chapter 4: Hybrid Fuzzy Systems

4.1. Introduction
4.2. Ishibuchi Algorithm
4.3. Genetic-Fuzzy Systems
4.4. Neuro-Fuzzy Systems

Evaluation Criteria

- Examination (60%),

- Continuous Assessment (40%).

Recommended Readings

1. Casillas, J., Cordon, O., Del Jesus, M. J., & Herrera, F. (2005). **Genetic Tuning of Fuzzy Rule Deep Structures Preserving Interpretability and its Interaction with Fuzzy Rule Set Reduction**. Fuzzy Systems, IEEE Transactions on, 13(1), 13-29.
2. Chiu, S. L. (1994). **Fuzzy Model Identification Based on Cluster Estimation**. Journal of intelligent and Fuzzy systems, 2(3), 267-278.
3. Cordon, O. (2011). **A Historical Review of Evolutionary Learning Methods for Mamdani-Type Fuzzy Rule-Based Systems: Designing Interpretable Genetic Fuzzy Systems**. International Journal of Approximate Reasoning, 52(6), 894-913. doi: DOI 10.1016/j.ijar.2011.03.004
4. Cordón, O., Del Jesus, M. J., & Herrera, F. (1999). **A Proposal on Reasoning Methods in Fuzzy Rule-based Classification Systems**. International Journal of Approximate Reasoning, 20(1), 21-45.
5. Dubois, D., & Prade, H. (1980). **Fuzzy Sets and Systems: Theory and Applications**. (Vol. 144): Academic press.
6. Dubois, D., & Prade, H. (1996). **What are Fuzzy Rules and how to Use them**. Fuzzy Sets and Systems, 84(2), 169-185. doi: http://dx.doi.org/10.1016/0165-0114 (96)00066-8
7. Guillaume, S. (2001). **Designing Fuzzy Inference Systems from Data: an Interpretability-Oriented Review**. Fuzzy Systems, IEEE Transactions on, 9(3), 426-443.
8. Herrera, F. (2008). **Genetic Fuzzy Systems: Taxonomy, Current Research Trends and Prospects**. Evolutionary Intelligence, 1(1), 27-46. doi: 10.1007/s12065-007-0001-5
9. J. S. R. Jang, C. T. Sun, and E. Mizutani, **Neuro-Fuzzy and Soft Computing—A Computational Approach to Learning and Machine Intelligence**— (Englewood Cliffs, NJ: Prentice-Hall, 1997).

Master's title: Artificial Intelligence

Semester: *1*

Teaching Unit: MTU 1

Subject title: Design of Intelligent Systems

Credit weight: 3

ECTS Credits: 5

Course Objectives

The aim of this course is to provide students with the methods and tools for the design and verification/validation of Intelligence Systems in order to guarantee the Quality Requirements.

Recommended Prerequisites

Knowledge acquired during a Bachelor's degree program in Computer Systems (SI), Information System and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: Introduction to Intelligent Systems

1.1. History of Intelligent Systems
1.2. Basic concepts

Chapter 2: Intelligent Systems Architectures

2.1. Rule-Based Systems
2.2. Schema-Based Systems
2.3. Case-Based Systems

Chapter 3: Development Tools

3.1. Approximate Reasoning
3.2. Fuzzy Inference
3.3. Evolutionary Algorithms
3.4. Neural Networks

Chapter 4: Verification and Validation

4.1. Verification tools for intelligent systems
4.2. Validation tools for intelligent systems

Chapter 5: Examples

5.1. SmartGrids
5.2. Intelligent Cars and Intelligent Transport (VANETs)
5.3. Industry 4.0

Assessment Method

- Examination (60%),
- Continuous assessment (40%).

Recommended Readings

1. ALEKSANDER Igor. **Introduction à la Conception des Systèmes Intelligents**, Hermès Science - Editions

Lavoisier, 02-1985

2. Karray, Fakhreddine, Fakhreddine O. Karray, and Clarence W. De Silva. **Soft Computing and Intelligent Systems Design: Theory, Tools, and Applications**. Pearson Education, 2004.
3. Truemper, Klaus. **Design of Logic-based Intelligent Systems**. John Wiley & Sons, 2004.
4. Sabonnadière, Jean-Claude, ed. SmartGrids: **Les Réseaux Electriques Intelligents**. Hermes Science Publ., 2012.
5. Stuart Russell, Peter Norvig. **Intelligence Artificielle**. Edition Pearson France, 2021.
6. Russell, Stuart, and Peter Norvig. **Intelligence Artificielle: Avec plus de 500 exercices**. Pearson Education France, 2010.
7. Borlase, Stuart, ed. **Smart Grids: Infrastructure, Technology, and Solutions**. CRC press, 2017.
8. Momoh, James A. **Smart Grid: Fundamentals of Design and Analysis**. Vol. 63. John Wiley & Sons, 2012.
9. Buchholz, Bernd M., and Zbigniew Styczynski. **Smart Grids-Fundamentals and Technologies in Electricity Networks**. Vol. 396. Heidelberg: Springer, 2014.
10. Pandey, Pavan Kumar, Vineet Kansal, and Abhishek Swaroop. **Vehicular Ad Hoc Networks (VANETs): Architecture, Challenges, and Applications**. Handling priority inversion in time-Constrained distributed databases. IGI Global, 2020. 224-239.
11. Sataraddi, Mamata J., and Mahabaleshwar S. Kakkasageri. **Artificial Intelligence Techniques Based Routing Protocols in VANETs: A Review**. Industry 4.0, AI, and Data Science (2021): 163-188.
12. Laberteaux, Kenneth, and Hannes Hartenstein, eds. **VANET: Vehicular Applications and Inter-Networking Technologies**. John Wiley & Sons, 2009.
13. Lipson, Hod, and Melba Kurman. **Driverless: Intelligent Cars and the Road Ahead**. Mit Press, 2016.
14. Jha, Pooja, and K. Sridhar Patnaik. **Self-Driving Cars: Role of Machine Learning**. Handbook of Research on Emerging Trends and Applications of Machine Learning. IGI Global, 2020. 490-507.
15. Dingli, Alexiei, Foaad Haddod, and Christina Klüver. **Artificial Intelligence in Industry 4.0**. Springer International Publishing, 2021.
16. Adrian A. Hopgood, **Intelligent Systems for Engineers and Scientists: A Practical Guide to Artificial Intelligence**, CRC Press, 2021.

Master's title: Artificial Intelligence

Semester: *1*

Teaching Unit: MTU1

Subject title: Knowledge Representation Techniques

Credit weight: 2

ECTS Credits: 4

Course Objectives

The aim of this teaching is to provide an overview of the techniques of representation of knowledge generally used by researchers and practitioners of Artificial Intelligence.

Recommended Prerequisites

Knowledge acquired during a Bachelor's degree program in Computer Systems (SI), Information System and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1. Introduction to Artificial Intelligence (AI)

1.1. Definitions
1.2. AI Goal
1.3. AI Mechanisms
1.4. History of AI

Chapter 2. Important Concepts

2.1. Information Encoding
2.2. Data, Information, and Knowledge
2.3. Inference and Reasoning
2.4. Characteristics of Knowledge Representation
    2.4.1. A represented world
    2.4.2. - A representative world
    2.4.3. - Representing Rules
    2.4.4. - Processus (Process)

Chapter 3. Knowledge Representation Models

3.1. Concept Maps
3.2. Rules
3.3. Logic
3.4. Semantic Networks
3.5. Structured Objects (Schemas and Scripts)

Chapter 4. Semantic Web

4.1. Introduction to the Semantic Web
4.2. RDF
4.3. SPARQL
4.4. Ontology and Ontology Languages
4.5. Descriptive Logic and OWL
4.6. Inference in Descriptive Logic

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Markman, A. B. (2013). **Knowledge Representation**. Psychology Press.
2. Doherty, P., Lukaszewicz, W., &Szalas, A. (2007). **Knowledge Representation Techniques: a Rough Set Approach**. (Vol. 202). Springer.
3. Van Harmelen, F., Lifschitz, V., & Porter, B. (Eds.). (2008). **Handbook of Knowledge Representation**. Elsevier.
4. Kayser, D. (1997). **La Représentation des Connaissances.** (p. 308). Paris: Hermes.
5. Baader, F., Horrocks, I., Lutz, C., & Sattler, U. (2017). **Introduction to Description Logic**. Cambridge University Press.
6. Berners-Lee, T., Hendler, J., &Lassila, O. (2001). **The Semantic Web**. Scientific american, 284(5), 34-43.
7. Shadbolt, N., Berners-Lee, T., & Hall, W. (2006). **The Semantic Web Revisited**. IEEE Intelligent Systems, 21(3), 96-101.
8. Fung, K. W., &Bodenreider, O. (2019). **Knowledge Representation and Ontologies**. In Clinical research informatics (pp. 313-339). Springer, Cham.
9. Hoekstra, R. (2009). **Ontology Representation: Design Patterns and Ontologies that Make Sense**.

Master's title: Artificial Intelligence

Semester: *1*

Teaching Unit: DTU1

Subject title: Pattern Recognition

Credit weight: 1

ECTS Credits: 1

Course Objectives

The objective of this course is to present the techniques and algorithms used for pattern recognition and to develop the skills required by the student to build pattern recognition models in order to assign data (images) to classes representative of the problem**.**

Recommended Prerequisites

Knowledge acquired during a Bachelor's degree program in Computer Systems (SI), Information System and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: Introduction

1.1. Definition
1.2. Pattern recognition process
1.3. Examples of applications
1.4. Difficulties

Chapter 2: Image processing

2.1. Characteristics of a digital image
2.2. Image acquisition
2.3. Image pre-processing
    2.3.1. Histogram modification
    2.3.2. Noise reduction by filtering
2.4. Edge detection
    2.4.1. Gradient approach
    2.4.2. Laplacian approach
    2.4.3. Optimal filtering approach: Canny approach
2.5. Segmentation
    2.5.1. Region-based segmentation
    2.5.2. Segmentation by thresholding
    2.5.3. Segmentation by frontier approach
    2.5.4. Segmentation by classification

Chapter 3: Feature extraction and classification

3.1. Feature extraction (Calculation of representations)
3.2. Classification
    3.2.1. Learning
        - Supervised learning
        - Unsupervised learning
    3.2.2. Model validation

3.2.3. Test

3.3. Classification algorithms

3.3.1. Linear classifiers

3.3.2. Hidden Markov chains

3.3.3. Artificial neural networks

3.3.4. Support vector machines

3.3.5. Decision trees

3.3.6. Deep Learning

Evaluation Criteria

- Examination (100%).

Recommended Readings

1. Agarwal, S. and Roth, D. (2002). **Learning as Parse Representation for Object Detection**. In Proceedings of 7th European Conference on Computer Vision, Copenhagen (Denmark), 2002.
2. Aitken, C. and Taroni, F. (2004). **Statistics and the Evaluation of Evidence for Forensic Scientists** by, Wiley.
3. Bishop, C. (2006). **Pattern Recognition and Machine Learning**, Springer.
4. Duda, R. O. Hart,P. E. and Stork, D. (2002). **Pattern Classification**, (2nd Edition), Wiley. Jain, A. K., Duin, R. P. W. and Mao, J. (2000) Statistical Pattern Recognition: A Review. IEEE Transactions on PAMI, 22(1): 4{37}.
5. Braga-Neto, Ulisses. **Fundamentals of Pattern Recognition and Machine Learning**. Cham: Springer, 2020.
6. Travieso-Gonzalez, Carlos M. (2021). **Applications of Pattern Recognition**. 2021.
7. Castillo, Oscar, and Patricia Melin, eds. (2020). **Hybrid Intelligent Systems in Control, Pattern Recognition and Medicine**. Springer International Publishing, 2020.
8. Burgos, Diego Alexander Tibaduiza, Maribel Anaya Vejar, and Francesc Pozo, eds. (2019). **Pattern Recognition Applications in Engineering**. IGI Global, 2019.
9. Lund, Nick. (2020). **Attention and Pattern Recognition**. Routledge, 2020.
10. Gibson, William. (2004). **Pattern Recognition**. Vol. 1. Berkley, 2004.

Master's title: Artificial Intelligence

Semester: *1*

Teaching Unit: DTU1

Subject title: Speech Recognition

Credit weight: 1

ECTS Credits: 1

Course Objectives

Speech recognition is one of the applications of artificial intelligence. More specifically, it is approached as a pattern recognition problem. It consists of recognizing speech pronounced by a speaker, and acquired in the form of an analogue signal with the aim of producing the equivalent text. This subject introduces this discipline, by presenting the inherent problems, and by explaining the stages of a generic speech recognition process. Given that this subject is taught as part of an AI master's course, at the end of the course we present the methods AI methods, and more specifically machine learning and Deep Learning.

Recommended Prerequisites

Knowledge acquired during a Bachelor's degree program in Computer Systems (SI), Information System and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: Introduction and definition

1.1. Human speech
1.2. Modelling and specific features of the speech signal
1.3. Phonetics: Articulatory, acoustic, auditory.
1.4. Speech signal artefacts

Chapter 2: Speech Preprocessing and Representation

2.1. Acquisition devices and the speech signal
2.2. Sampling and digitisation
2.3. Noise filtering in a speech signal
2.4. Lexical segmentation of the speech signal
2.5. Selecting and extracting features from a speech signal

Chapter 3: Automatic Speech Recognition Systems

3.1. Taxonomies of speech recognition systems
3.2. Generic process of a speech recognition system
3.3. Acoustic analysis
3.4. Construction of acoustic models
3.5. Feature extraction and decision

Chapter 4: Machine Learning-based Approaches to Speech Recognition

4.1. Feature selection and extraction
4.2. Learning in an automatic speech recognition system
4.3. Classification-based recognition methods
4.4. Statistical and Markov methods
4.5. Neural methods

4.6. Deep Learning-based methods

Evaluation Criteria

- Examination (100%).

Recommended Readings

1. Reconnaissance automatique de la parole, Jean-Paul Haton, Christophe Cerisara, Dominique Fohr, Yves Laprie, Kamel Smaïli, Dunod, 2006.
2. Fundamentals Of Speech Recognition, Pearson India, Lawrence Rabiner, 2008.
3. Automatic Speech Recognition - A Deep Learning Approach, Authors: Yu, Dong, Deng, Li, Springer, 2015.
4. Rabiner, Lawrence, and Biing-Hwang Juang. Fundamentals of speech recognition. Prentice-Hall, Inc., 1993.
5. Markowitz, Judith A. Using speech recognition. Prentice-Hall, Inc., 1995.
6. Mary, Leena. Extraction of prosody for automatic speaker, language, emotion and speech recognition. Springer, 2018.
7. Kamath, Uday, John Liu, and James Whitaker. Deep learning for NLP and speech recognition. Vol. 84. Cham, Switzerland: Springer, 2019.
8. Vasilev, Ivan, et al. Python Deep Learning : Exploring deep learning techniques and neural network architectures with Pytorch, Keras, and TensorFlow. Packt Publishing Ltd, 2019.
9. Qin, Tao. Dual Learning. Springer, 2020.
10. Sarkar, Dipanjan. Text Analytics with python. New York, NY, USA : Apress, 2016.
11. Mark Liu. Make Python Talk : Build Apps with Voice Control and Speech Recognition. 2021

Master's title: Artificial Intelligence

Semester: *1*

Teaching Unit: TTU1

Subject title: Ethics of Artificial Intelligence

Credit weight: 1

ECTS Credits: 1

Course Objectives

The aim of this subject is to provide the students on this course with the guidelines for the development and use of Artificial Intelligence.

Recommended Prerequisites

Knowledge acquired during a Bachelor's degree program in Computer Systems (SI), Information System and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: Artificial Intelligence

1.1. Definitions
1.2. Aims
1.3. Tools
1.4. Domains

Chapter 2: Artificial Intelligence and Ethics

2.1. Why ethics in AI?
2.2. Why now?
2.3. AI initiatives and ethics
2.4. Approaches to ethics in AI

Chapter 3: About ethics?

3.1. Domains of ethics: Self, Friend, Stranger, World
3.2. Adequate justification and argumentation in ethics?
3.3. Moral relativism, moral justification and AI

Chapter 4: Guidelines for the Development and Use of AI

4.1. Transparency
4.2. Justice, clarity and fairness
4.3. Non-maleficence
4.4. Responsibility and accountability
4.5. Intimacy
4.6. Beneficence
4.7. Freedom and autonomy
4.8. Trust and confidence
4.9. Sustainability
4.10. Dignity
4.11. Solidarity

Chapter 5: Ethical dilemmas of AI

5.1. Biased AI
5.2. Autonomous cars
5.3. AI creates art
5.4. AI at the Court of Justice

Evaluation Criteria

- Examination (100%).

Recommended Readings

1. Jobin, A., Ienca, M., & Vayena, E. (2019). The global landscape of AI ethics guidelines. Nature Machine Intelligence, 1(9), 389-399.
2. Ryan, M., & Stahl, B. C. (2020). Artificial intelligence ethics guidelines for developers and users: clarifying their content and normative implications. Journal of Information, Communication and Ethics in Society.
3. Smuha, N. A. (2019). The EU approach to ethics guidelines for trustworthy artificial intelligence. Computer Law Review International, 20(4), 97-106.
4. Rothenberger, L., Fabian, B., & Arunov, E. (2019). Relevance of ethical guidelines for artificial intelligence–a survey and evaluation.
5. Rigby, M. J. (2019). Ethical dimensions of using artificial intelligence in health care. AMA Journal of Ethics, 21(2), 121-124.
6. Boddington, P. (2017). Towards a code of ethics for artificial intelligence (pp. 27-37). Cham:Springer.
7. Fjeld, J., Hilligoss, H., Achten, N., Levy Daniel, M., Feldman, J., & Kagay, S. (2020). Principled artificial intelligence. Berkman Klein Center, February, 14.
8. Adam C., Milena P., & Lawrence H. (2019). Everyday Ethics For Artificial Intelligence. IBM
9. Bostrom, N., & Yudkowsky, E. (2014). The ethics of artificial intelligence. The Cambridge handbook of artificial intelligence, 1, 316-334.
10. Russell, S., Hauert, S., Altman, R., & Veloso, M. (2015). Ethics of artificial intelligence. Nature, 521(7553), 415-416.

Master's title: Artificial Intelligence

Semester: *2*

Teaching Unit: CTU1

Subject title: Machine Learning 2

Credit weight: 3

ECTS Credits: 6

Course Objectives

This course is a continuation of "Machine Learning 1," taught in the first semester. The objective is to allow students to deepen their knowledge of machine learning by covering advanced algorithms and more complex methods. Students will develop skills to work with sophisticated models. They will learn to apply these methods to real problems, optimize their models, and critically interpret results. Python will be used to implement these algorithms, reinforcing students' practical skills in a widely adopted machine learning environment.

Recommended Prerequisites

- Basic machine learning concepts covered in "Machine Learning 1"
- Basic mathematics: linear algebra, differential calculus, statistics, and probability
- Python programming skills

Course Outline

Chapter 1. Support Vector Machines (SVMs)

1.1. Introduction
1.2. General working principle
1.3. Linear SVMs
1.4. Non-linear SVMs
1.5. Multi-class SVMs
1.6. SVMs for regression
1.7. Advantages and disadvantages

Chapter 2. Artificial Neural Networks

2.1. Introduction
2.2. Concept of Artificial Neurons
    2.2.1. Biological neurons
    2.2.2. Perceptron
2.3. Basic functioning: Inputs, weights, weighted sum, activation functions
2.4. Neural network architecture
    2.4.1. Single-layer Perceptron
    2.4.2. Multi-Layer Perceptron (MLP)
2.5. Training neural networks
    2.5.1. Loss function
    2.5.2. Optimization algorithms (Gradient Descent, SGD, Adam, etc.)
    2.5.3. Backpropagation
2.6. Types of neural networks
2.7. Introduction to Deep Learning

Chapter 3. Ensemble Learning

3.1. Introduction
3.2. Objective and requirements
3.3. Concept of diversity
3.4. Ensemble architectures
3.5. Fusion strategies
3.6. Ensemble methods
    3.6.1. Boosting
    3.6.2. Bagging
    3.6.3. Random Subspace Method (RSM)
    3.6.4. Random Forests

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Burges, C. C. (1998). A Tutorial on Support Vector Machines for Pattern Recognition. Data Mining and Knowledge Discovery, 2(2), 121-167. doi: 10.1023/A:1009715923555
2. Freund, Y., Schapire, R., and Abe, N. (1999). A short introduction to boosting. Journal-Japanese Society For Artificial Intelligence, 14(771-780) :1612.
3. Hastie, T., Rosset, S., Tibshirani, R., and Zhu, J. (2004). The entire regularization path for the support vector machine. Journal of Machine Learning Research, 5(Oct) :1391–1415.
4. Hastie, T., Tibshirani, R., and Friedman, J. (2011). The Elements of Statistical Learning. Springer.
5. James, G., Witten, D., Hastie, T., and Tibshirani, R. (2013). An introduction to statistical learning, volume 112. Springer.
6. Mitchell, T. (1997). Machine Learning. McGraw Hill.
7. Quinlan, J. (1986). Induction of decision trees. Machine Learning, 1(1) :81–106.
8. Quinlan, J. R. (1993). C4.5 : programs for machine learning. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.
9. Rokach, L. (2010). Ensemble-based classifiers. Artificial Intelligence Review, 33(1-2) : 1–39.
10. Amini M. « Apprentissage Machine : de la théorie à la pratique » Edition Eyrolles 2015.
11. Aurélien Géron. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition. O'REILLY. 2019.
12. Kevin P. Murphy. Probabilistic Machine Learning : An Introduction (Adaptive Computation and Machine Learning series). 2022.
13. Raschka, Sebastian, Yuxi Liu, and Vahid Mirjalili. Machine Learning with PyTorch and Scikit-Learn. (2022).
14. Moroney, Laurence. Ai and machine learning for coders. O'Reilly Media, 2020.
15. Müller, Andreas C., and Sarah Guido. Introduction to machine learning with Python: a guide for data scientists. " O'Reilly Media, Inc.", 2016.
16. Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong. Mathematics for machine learning. Cambridge University Press, 2020.
17. Lakshmanan, Valliappa, Sara Robinson, and Michael Munn. Machine learning design patterns. O'Reilly Media, 2020.
18. Raschka, Sebastian, and Vahid Mirjalili. Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2. Packt Publishing Ltd, 2019.

Master's title: Artificial Intelligence

Semester: ***2***

Teaching Unit: CTU1

Subject title: Statistical Artificial Intelligence

Credit weight: 3

ECTS Credits: 6

Course Objectives

The main objective of this course is to provide students with a comprehensive understanding of data mining techniques and statistical methods for model evaluation. The course begins with an introduction to the basic concepts of data mining, including data types, functionalities, and statistical descriptions. It covers essential data preprocessing techniques such as normalization, handling missing values, outlier detection, and feature selection. Students will also explore association rule mining, focusing on market basket analysis and the Apriori algorithm. The course further delves into Bayesian networks, providing a detailed overview of their structure, inference, and learning methods. Lastly, it addresses critical statistical techniques for evaluating machine learning models, including cross-validation, bias-variance tradeoff, model selection, and hyperparameter tuning, equipping students with the tools to build and evaluate robust predictive models.

Recommended Prerequisites

Knowledge of data analysis, probability, and statistics acquired during the Bachelor's program in Computer Systems (SI), Information Systems and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: basic concepts of data mining

1.1. Background and definition of data mining
1.2. Data types
1.3. Data mining functionalities
1.4. Basic statistical descriptions of data
1.5. Graphic displays of basic statistical descriptions of data

Chapter 2: Data Preprocessing

2.1. Normalization
2.2. Missing values
2.3. Outliers
2.4. Feature Selection methods

Chapter 3: Association rules

3.1. Market Basket Analysis
3.2. Association rules
3.3. Apriori Algorithm: finding frequent item sets

Chapter 4: Bayesian Networks

4.1. Overview of Bayesian Networks
4.2. Fundamental Concepts
4.3. Structure of a Bayesian Network
4.4. Inference in Bayesian Networks
4.5. Learning Bayesian Networks

Chapter 5: Statistical Techniques for Model Evaluation

5.1. Cross-Validation and Bootstrap Methods
5.2. Model Selection and Overfitting
5.3. Bias-Variance TradeOff
5.4. Statistical Significance Testing in AI
5.5. Hyperparameter Tuning and Grid Search

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Robert Nisbet, Gary Miner & Ken Yale.Handbook of Statistical Analysis and Data Mining Applications. Elsevier, 2018.
2. David R. Westhead&M. S. Vijayabaskar. Hidden Markov Models: Methods and Protocols. Springer, 2017.
3. Patrick Naïm, Pierre-Henri Wuillemin, Philippe Leray, Olivier Pourret & Anna Becker. Réseaux bayésiens. Eyrolles, 2007.
4. Olivier Pourret, Patrick Naïm&BruceMarcot. Bayesian Networks: A Practical Guide to Applications. Wiley, 2008.
5. Powell, Warren B. Reinforcement Learning and Stochastic Optimization: A unified framework for sequential decisions. John Wiley & Sons, 2022.
6. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. " O'Reilly Media, Inc.", 2019.
7. Joshi, Prateek. Artificial intelligence with python. Packt Publishing Ltd, 2017.
8. Bruce, Peter, Andrew Bruce, and Peter Gedeck. Practical statistics for data scientists: 50+ essential concepts using R and Python. O'Reilly Media, 2020.
9. Raschka, Sebastian, and VahidMirjalili. Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2. PacktPublishing Ltd, 2019.

Master's title: Artificial Intelligence

Semester: ***2***

Teaching Unit: CTU1

Subject title: Collective Artificial Intelligence

Credit weight: 3

ECTS Credits: 6

Course objectives

This subject covers the intelligence of swarms, including mathematical, computational and biological aspects. The subject is organized into six chapters. In the first chapter, students will learn about Agent-Based Modelling of complex systems and the basic concepts of self-Organization, such as positive and negative feedback. The second chapter deals with the social capacity of Agents. The third chapter is Stochastic Diffusion Research with application. The fourth and fifth chapters cover optimization algorithms inspired by the intelligence of swarms, namely particle swarm optimization and ant colony optimization respectively. The sixth chapter deals with the distributed form of swarms. The course considers both theory and practice: students will implement the algorithms discussed in class.

Recommended Prerequisites

Knowledge of data analysis, probability, and statistics acquired during the Bachelor's program in Computer Systems (SI), Information Systems and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: Agent-based Modelling

1.1. Systems theory and Agent-Oriented Modelling.
1.2. Individual Agents.
1.3. Passive particle Agents.
1.4. Producer-Consumer Agents.
1.5. Active Particle Agents.
1.6. Intelligent Agents.

Chapter 2: Sociable Agents

2.1. Flocking Behaviour
2.2. Ant Colonies
2.3. Communication

Chapter 3: Stochastic Diffusion Search SDS

3.1. Mining game
3.2. Mathematical model
3.3. Architecture
3.4. Application

Chapter 4: Particle Swarm Optimisation (PSO)

4.1. Swarm Intelligence in Nature (Bird Flocking)
4.2. Basic principles of swarm intelligence
4.3. PSO Algorithm

4.4. Path Planning
4.5. PSO for Path Planning
4.6. Dynamic Replanning with Obstacles

Chapter 5: Ant Colony Optimisation (ACO)

5.1. ACO algorithm.
5.2. Bee Colony Algorithm.

Chapter 6: System Reorganisation and Self-Organisation

6.1. Re-organisation
6.2. Self-organisation
6.3. Agent-centred point of view (ACPV)
6.4. Organisation Centred Point of View (OCPV)
6.5. Reorganisation and self-organisation mechanisms
6.6. Aspects of Organisational adaptation

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Kennedy, J. (2006). Swarm intelligence. In Handbook of nature-inspired and innovative computing (pp. 187-219). Springer, Boston, MA.
2. Eberhart, R. C., Shi, Y., & Kennedy, J. (2001). Swarm intelligence. Elsevier.
3. Picard, G., Hubner, J. F., Boissier, O., & Gleizes, M. P. (2009). Réorganisation et auto-organisation dans les systèmes multi-agents. Journées Francophones sur les systèmes multiagents—Génie Logiciel Multiagent (JFSMA09), 89-97.
4. Vittikh, V. A., & Skobelev, P. O. (1970). Multi-agent systems for modelling of self-organization and cooperation processes. WIT Transactions on Information and Communication Technologies, 20.
5. Guerin, S., & Kunkle, D. (2004). Emergence of constraint in self-organizing systems. Nonlinear Dynamics, Psychology, and Life Sciences, 8(2), 131-146.
6. Gershenson, C. (2007). Design and control of self-organizing systems. CopIt Arxives.
7. Boes, J., & Migeon, F. (2017). Self-organizing multi-agent systems for the control of complex systems. Journal of Systems and Software, 134, 12-28.
8. Prokopenko, M. (Ed.). (2013). Advances in applied self-organizing systems. Springer.
9. Visser, A., Pavlin, G., Van Gosliga, S. P., & Maris, M. (2004, November). Self-organization of multi-agent systems. In Proc. of the International workshop Military Applications of Agent Technology in ICT and Robotics, The Hague, the Netherlands (November 23-24, 2004).
10. Bonabeau, E., Marco, D. D. R. D. F., Dorigo, M., Théraulaz, G., & Theraulaz, G. (1999). Swarm intelligence: from natural to artificial systems (No. 1). Oxford university press.
11. Beni, G. (2004, July). From swarm intelligence to swarm robotics. In International Workshop on Swarm Robotics (pp. 1-9). Springer, Berlin, Heidelberg.
12. Beni, G., & Wang, J. (1993). Swarm intelligence in cellular robotic systems. In Robots and biological systems: towards new bionics? (pp. 703-712). Springer, Berlin,Heidelberg.

Master's title: Artificial Intelligence

Semester: *2*

Teaching Unit: MTU1

Subject title: Formal Methods in Artificial Intelligence

Credit weight: 3

ECTS Credits: 5

Course Objectives

The concepts and techniques of artificial intelligence involve numerous mathematical and logical concepts. The aim is to introduce students to some important mathematical and logical concepts that play a key role in Artificial Intelligence.

Recommended Prerequisites

The recommended prerequisites are the knowledge acquired during the bachelor's degree in Computer Systems (SI) or Software and Information Systems Engineering (ISIL), or an equivalent Computer Science degree. In addition, knowledge acquired during the first semester.

Course Outline

Chapter 1: General Introduction

1.1. Introduction to Artificial Intelligence
1.2. Introduction to Expert Systems
1.3. Introduction to Logic: Models and Proofs

Chapter 2: Propositional and Predicate Logic

2.1. Introduction
2.2. Definition of Propositional Calculus
2.3. Concept of Interpretation in Propositional Logic
2.4. Definition of Predicate Calculus
2.5. Concept of Interpretation in Predicate Logic

Chapter 3: Modal and Description Logic

3.1. Axioms for Modal Logic
3.2. Theorem Proving Techniques with Modal Logic
3.3. Reasoning about Knowledge
3.4. Description Logic
3.5. Semantic Tableau Method
3.6. Practice of Terminological Reasoning

Chapter 4: Temporal and Non-Monotonic Logic

4.1. Modal Logics of Time
4.2. Reification of Temporal Logic
4.3. Situation Calculus
4.4. Monotonic and Non-Monotonic Inference
4.5. Non-Monotonic Rules
4.6. Non-Monotonic Reasoning

Chapter 5: λ-calculus and Fuzzy Logic

5.1. λ-calculus

5.2. Proof in λ-calculus
5.3. Fuzzy Logic

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Allan M. Ramsay, Formal Methods in Artificial Intelligence. Cambridge Tracts in Theoretical Computer Science, 1991.
2. Delahaye, Jean-Paul. Formal Methods in Artificial Intelligence. Halsted Press, 1987.
3. Clarke, Edmund M., and Jeannette M. Wing. "Formal Methods: State of the Art and Future Directions." ACM Computing Surveys (CSUR) 28.4 (1996): 626–643
4. Fisher, Michael. An Introduction to Practical Formal Methods Using Temporal Logic. John Wiley & Sons, 2011.
5. Schneider, Klaus, Jimmy Shabolt, and John G. Taylor. Verification of Reactive Systems: Formal Methods and Algorithms. Springer, 2004.
6. Wang, Jiacun, and William Tepfenhart. Formal Methods in Computer Science. Chapman and Hall/CRC, 2019.
7. Nanda, Manju, and Yogananda Jeppu. "Formal Methods for Safety and Security." (2018).
8. Marcus, Gary, and Ernest Davis. Rebooting AI: Building Artificial Intelligence We Can Trust. Vintage, 2019.

Master's title: Artificial Intelligence

Semester: ***2***

Teaching Unit: MTU1

Subject title: Agents and Multi-Agents Systems

Credit weight: 2

ECTS Credits: 4

Course Objectives

This module aims to introduce the field of Distributed and Collective Artificial Intelligence through the cognitive/reactive Multi-Agent paradigm. It defines the dimensions, concepts, and architectures of multi-agent systems and demonstrates how these systems can be used to solve problems in a decentralized and collective manner. It emphasizes the modeling and solving of complex problems through the implementation of Collective Intelligence, decentralized control, and self-* solutions (self-control, self-organization, self-adaptation, etc.). The teaching of this module should be accompanied by practical application of the acquired knowledge through a development project of a multi-agent system using multi-agent frameworks or platforms (such as JADE or NetLogo).

Recommended Prerequisites

- Basic knowledge in Artificial Intelligence and Knowledge Representation.

Course Outline

Chapter 1: Introduction to Distributed/Collective Artificial Intelligence

1.1. Artificial Intelligence vs. Distributed Artificial Intelligence
1.2. Collective Intelligence
1.3. Cooperative Problem Solving
1.4. Emergence

Chapter 2: Agent, Models, and Architectures

2.1. Types and Architectures of Agents
2.2. Agent and Its Environment
2.3. Control and Autonomy in Agents

Chapter 3: Multi-Agent Systems and Forms of Interaction

3.1. From Agent to Multi-Agent System
3.2. Communication and Interaction
3.3. Cooperation, Coordination, and Planning

Chapter 4: Modeling and Design Methodology for Multi-Agent Systems

4.1. Problem Solving by Multi-Agent Systems
4.2. Modeling in Multi-Agent Systems
4.3. Agent-Based Design Methodology
4.4. Testing and Verification

Chapter 5: Multi-Agent Frameworks/Platforms

5.1. Frameworks
5.2. Platforms
5.3. Libraries

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

13. J. Ferber. Les systèmes multiagents, 1995
14. S. Russel, P. Norvig. ArtificialIntelligence: A Modern Approach, 2003
15. J. Vidal. Fundamentals of Multiagent Systems, 2009
16. G. Weiss. Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence, 1999
17. M. Wooldridge. An Introduction to Multiagent Systems, 2002
18. Kevin Leyton-Brown and Yoav Shoham. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, 2008

Master's title: Artificial Intelligence

Semester: ***2***

Teaching Unit: DTU1

Subject title: Autonomic Computing

Credit weight: 1

ECTS Credits: 1

Course Objectives

The aim of this course is to present Autonomic Computing from the perspective of its operation, architecture, and the frameworks supporting the construction of autonomic systems.

Recommended Prerequisites

Students must have knowledge of algorithms, programming, and mathematics acquired during a Bachelor's degree in Computer Systems (SI), Information Systems and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: The Autonomic Computing Paradigm
- 1.1. Definition of an Autonomic System
- 1.2. Autonomic Properties
  - 1.2.1. Self-Adaptation
  - 1.2.2. Self-Healing
  - 1.2.3. Self-Protection
  - 1.2.4. Self-Reconfiguration
  - 1.2.5. Self-Optimization

Chapter 2: Reflexivity
- 2.1. Definitions
- 2.2. Properties of a Reflexive System
  - 2.2.1. Introspection
  - 2.2.2. Intercession
- 2.3. Architecture of a Reflexive System
  - 2.3.1. Metadata Level
  - 2.3.2. Base Level
- 2.4. Types of Reflexivity
  - 2.4.1. Structural Reflexivity
  - 2.4.2. Behavioral Reflexivity

Chapter 3: Elements of an Autonomic System
- 3.1. Architecture of an Autonomic System
- 3.2. Managed Subsystem
- 3.3. Manager Subsystem

Chapter 4: The MAPE-K Autonomic Loop
- 4.1. MAPE-K Architecture
- 4.2. Elements of the MAPE-K Loop
  - 4.2.1. Monitoring
  - 4.2.2. Analysis
  - 4.2.3. Planning
  - 4.2.4. Execution

4.2.5. Knowledge

Chapter 5: Examples of Autonomic Systems

5.1. Self-Organized Planning

5.2. Multi-Strategy Learning Systems

Evaluation Criteria

- Examination (100%).

Recommended Readings

1. Parashar, M., Harir, S. (2007). Autonomic Computing Concepts, Infrastructure and Application. Taylor and Francis.
2. Kephart, J. O., & Chess, D. M. (2003). The Vision of Autonomic Computing. Computer, 36(1), 41-50.
3. Computing, A. (2006). An Architectural Blueprint for Autonomic Computing. IBM White Paper, 31(2006), 1-6.
4. Sterritt, R. (2005). Autonomic Computing. Innovations in Systems and Software Engineering, 1(1), 79-88.
5. Huebscher, M. C., & McCann, J. A. (2008). A Survey of Autonomic Computing—Degrees, Models, and Applications. ACM Computing Surveys (CSUR), 40(3), 1-28.
6. Parashar, M., & Hariri, S. (2004, September). Autonomic Computing: An Overview. In International workshop on unconventional programming paradigms (pp. 257-269). Springer, Berlin, Heidelberg.

Master's title: Artificial Intelligence

Semester: *2*

Teaching Unit: DTU1

Subject title: Intelligent Homes and Cities

Credit weight: 1

ECTS Credits: 1

Course Objectives

The aim is to learn about the latest and most advanced trends in smart homes and smart cities: background, components and applications.

Recommended Prerequisites

The recommended prerequisites are the knowledge acquired during the bachelor's degree in Computer Systems (SI) or Software and Information Systems Engineering (ISIL), or an equivalent Computer Science degree. In addition, knowledge acquired during the first semester.

Course Outline

Chapter 1: Introduction to key technologies

1.1. The Internet of Things
1.2. Wireless sensor networks, optical networks and vehicular ad hoc networks
1.3. LTE and 5G systems
1.4. Social networks
1.5. Biometric systems
1.6. GPS and GIS systems
1.7. Cloud computing systems

Chapter 2: Smart Homes

2.1. Introduction
2.2. Smart Home Systems
2.3. Smart Home system components
2.4. Smart Home System Comparisons
2.5. Review of methodologies for ADL recognition in SHMS
2.6. Users of Smart Home technologies
2.7. Benefits and limitations of smart home technologies
2.8. Impact of smart home technologies on societies

Chapter 3: Smart Cities

3.1. Introduction
3.2. Intelligent transport systems
3.3. Intelligent Grids
3.4. Electronic systems: e-learning, e-Commerce, e-Government, e-Business and e-Service Systems
3.5. Combating pollution in smart cities
3.6. Privacy and security in smart cities

Evaluation Criteria

- Examination (100%).

Recommended Readings

7. Mohammad S., Nicopolitidis, Petros, Smart Cities and Homes: Key Enabling Technologies. Morgan Kaufmann eds. 2016.
8. Nagender Kumar Suryadevara, Subhas Chandra Mukhopadhyay, Smart Homes: Design, Implementation and Issues. Springer International Publishing, 2015.
9. Miller, Michael. My smart home for seniors. Que Publishing, 2017.
10. Lahby, Mohamed, Utku Kose, and Akash Kumar Bhoi, eds. Explainable Artificial Intelligence for Smart Cities. CRC Press, 2021.
11. Saravanan, Krishnan, and G. Sakthinathan, eds. Handbook of Green Engineering Technologies for Sustainable Smart Cities. CRC Press, 2021.
12. Sharma, Lavanya, ed. Towards smart world: homes to cities using internet of things.CRC Press, 2020.
13. Kirwan, Christopher Grant, and Fu Zhiyong. Smart Cities and Artificial Intelligence: Convergent Systems for Planning, Design, and Operations. Elsevier, 2020.
14. Luti, Malik. Smart Citizens in Smart Cities: The Fourth Industrial Revolution (Industry 4.0). Lutiya LLC, 2021.

Master's title: Artificial Intelligence

Semester: ***2***

Teaching Unit: DTU1

Subject title: Scientific and Technical Communication

Credit weight: 1

ECTS Credits: 1

Course Objectives

This subject is designed to teach students how to express themselves and use knowledge acquired in English.

Recommended Prerequisites

Knowledge acquired during a Bachelor's degree program in Computer Systems (SI), Information System and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1: Scientific mindset
Chapter 2: Critical Thinking
Chapter 3: Careful Listening
Chapter 4: Argumentation

Evaluation Criteria

- Examination (100%)

Recommended Readings

1. Gaston Bachelard, La Formation de l'Esprit Scientifique, 1938, éditions Vrin.
2. Gaston Bachelard, Le Nouvel Esprit Scientifique, 1934
3. Gérard De Vecchi, Former l'Esprit Critique : Pour une pensée libre, 2016
4. Marie-Claude Nivoix et Philippe Lebreton, L'Art de Convaincre : Du Bon Usage des Techniques d'Influence, 2007.

Master's title: Artificial Intelligence

Semester: *3*

Teaching Unit: CTU1

Subject title: Deep Learning

Credit weight: 3

ECTS Credits: 6

Course Objectives

The aim of this subject is to present Deep Learning and its different variants, namely single perceptron, multi-layer perceptron, recurrent neural networks and convolutional neural networks, with applications in R and Python.

Recommended Prerequisites

Knowledge of algorithms, programming and mathematics acquired during the degree course: Information Systems (IS) or Information Systems and Software Engineering (ISIL) or an equivalent Computer Science degree and knowledge of Artificial Intelligence acquired during the first semester.

Course Outline

Chapter 1: Introduction to Deep Learning

1.1. Overview of Artificial Intelligence, Machine Learning, and Deep Learning
1.2. History and evolution of Deep Learning
1.3. Importance and applications in various fields

Chapter 2: Fundamentals of Neural Networks

2.1. Perceptrons and Multilayer Neural Network
2.2. Structure of a neural network Activation functions
2.3. Forward and backward propagation
2.4. Gradient Descent
2.5. Loss functions
2.6. Regularization techniques

Chapter 3: Deep Learning Architectures

3.1. Convolutional Neural Networks
3.2. Recurrent Neural Networks
3.3. Transformer Architecture
3.4. Autoencoders
3.5. Generative Adversarial Networks

Chapter 4: Advanced Topics in Deep Learning

4.1. Transfer Learning
4.2. Model Compression and Distillation

Chapter 5: Deep Learning Tools and Frameworks

5.1. Popular libraries
5.2. Model deployment tools
5.3. Cloud platforms for deep learning

Chapter 6: Applications of Deep Learning

6.1. Natural Language Processing (NLP)
6.2. Computer Vision
6.3. Speech and Audio Processing
6.4. Autonomous systems
6.5. Finance and Healthcare

Chapter 7: Ethics and Challenges in Deep Learning

7.1. Ethical considerations and responsible AI
7.2. Bias and fairness in deep learning models
7.3. Data privacy and security
7.4. Interpretability and Explainability

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Chollet, Francois. Deep Learning with Python. Simon and Schuster, 2021.
2. Vasilev, Ivan, et al. Python Deep Learning: Exploring deep learning techniques and Neural Network Architectures with Pytorch, Keras, and TensorFlow. Packt Publishing Ltd, 2019.
3. Buduma, Nithin, Nikhil Buduma, and Joe Papa. Fundamentals of deep learning. " O'Reilly Media, Inc.", 2022.
4. Sarkar, Dipanjan. Text analytics with Python: a practitioner's guide to natural language processing. Bangalore: Apress, 2019.
5. Ravichandiran, Sudharsan. Deep Reinforcement Learning with Python. Packt Publishing, 2020.
6. Raschka, Sebastian, and Vahid Mirjalili. Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2. Packt Publishing Ltd, 2019.
7. Weidman, Seth. Deep Learning from Scratch: Building with Python from First Principles. O'Reilly Media, 2019.
8. Ravichandiran, Sudharsan. Hands-on deep learning algorithms with python: master deeplearningalgorithmswithextensivemathbyimplementingthemusingtensorflow. Packt Publishing Ltd, 2019.
9. FrançoisChollet,"L'apprentissageprofondavecPython",2017
10. Blayo F., VerleysenM, « Lesréseaux deneurones artificiels », Collection QSJ, PUF, 1996.
11. Heudin J. C., « Comprendre le Deep Learning –Une introduction aux réseaux de neurones », Science eBook, 2016.
12. Zhao, Z. Q., Zheng, P., Xu, S. T., & Wu, X. (2019). Object detection with deep learning: A review. IEEE transactions on neural networks and learning systems, 30(11), 3212-3232.

Master's title: Artificial Intelligence

Semester: *3*

Teaching Unit: CTU1

Subject title: Metaheuristics

Credit weight: 3

ECTS Credits: 6

Course Objectives

In optimization, the search for solutions to a given problem may encounter the situation where the solution space is not convex, and consequently the methods classical optimization methods, such as those based on gradient descent, prove to be inefficient, and only produce locally optimal solutions. Metaheuristics a set of optimization methods designed for solution search globally optimal, even in a non-convex space. This subject introduces the student the main Metaheuristics, with the principle and characteristics of each of them.

Recommended Prerequisites

Knowledge of algorithms, programming and mathematics acquired during the degree course: Information Systems (IS) or Information Systems and Software Engineering (ISIL) or an equivalent Computer Science degree and knowledge of Artificial Intelligence acquired during the first and second semester.

Course Outline

Chapter 1: Introduction and Definitions

1.1. Reminder of optimization problems
1.2. Classical Optimization Methods
1.3. Definition of Metaheuristics
1.4. Classification of Metaheuristics

Chapter 2: Path-based Metaheuristics

2.1. The Taboo Research
2.2. Simulated Annealing
2.3. The method GRASP

Chapter 3: Metaheuristics with Populations of Solutions

3.1. Genetic Algorithms
3.2. Optimization by Particle Swarm
3.3. Artificial Immune Systems
3.4. The research Hi there

Chapter 4: Open Topics in Metaheuristics

4.1. Metaheuristics for Multi-Objective Optimization
4.2. Adaptive Metaheuristics Based on Machine Learning

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Patrick Siarry. Metaheuristics, (Edt), Springer, 2016.
2. Laurent Deroussi. Métaheuristiques pour la logistique, Collection Informatique, ed. iSTE, 2013.
3. Rothman, Denis. Transformers for Natural Language Processing: Build innovativedeep neural network architectures for NLP with Python, PyTorch, TensorFlow, BERT, RoBERTa, and more. Packt Publishing Ltd, 2021.
4. Bhattacharyya, Siddhartha. Hybrid Metaheuristics: Research and Applications. Vol. 84. World Scientific, 2018.
5. Talbi, El-Ghazali. Metaheuristics: from design to implementation. Vol. 74. John Wiley & Sons, 2009.
6. Gonzalez, Teofilo F. Handbook of approximation algorithms and metaheuristics. Chapman and Hall/CRC, 2007.
7. Ramadas, Meera, and Ajith Abraham. Metaheuristics for data clustering and image segmentation. Berlin: Springer, 2019.
8. Keller, André A. Multi-objective optimization in theory and practice II: metaheuristic algorithms. Bentham Science Publishers, 2019.
9. Preuss, Mike, et al.,eds. Metaheuristics for Finding Multiple Solutions. Springer, 2021.
10. Ramadas, Meera, and Ajith Abraham. Metaheuristics for data clustering and image segmentation. Berlin: Springer, 2019.

Master's title: Artificial Intelligence

Semester: *3*

Teaching Unit: CTU1

Subject title: Big Data-oriented techniques

Credit weight: 3

ECTS Credits: 6

Course Objectives

This course addresses distributed techniques and technologies used to explore, analyze, and visualize massive data (Big Data). The main goal of this course is to learn how to use tools such as Hadoop MapReduce and Spark dedicated to distributed processing of big data.
Machine Learning algorithms used to exploit Big Data are also introduced in Chapter 4, and Big Data visualization techniques are discussed in Chapter 5.

Recommended Prerequisites

Knowledge of algorithms, programming, and mathematics acquired during the undergraduate program in: Computer Systems (SI), Information Systems and Software Engineering (ISIL) or an equivalent Computer Science degree, as well as knowledge gained during the first and second semesters.

Course Outline

Chapter 1: Data Mining

1.1. Definition of Data Mining
1.2. The Data Mining Process
1.3. What Type of Data to Mine?
1.4. Data Mining Tasks

Chapter 2: Definitions and Basic Concepts of Big Data

2.1. History
2.2. Definition of Big Data
2.3. Disciplines Involved in Big Data
2.4. Big Data Applications

Chapter 3: Big Data Tools and Technologies

3.1. Distributed File Systems
    3.1.1. Hadoop Distributed File System (HDFS)
    3.1.2. S3
    3.1.3. CEPH
3.2. Distributed Algorithms
    3.2.1. MapReduce
    3.2.2. Spark.
3.3. Distributed Database Systems
    3.3.1. NoSQL

Chapter 4: Machine Learning for Big Data

4.1. Objectives of Machine Learning
4.2. Data Exploration and Preparation

4.3. Clustering Algorithms
    4.3.1. Hierarchical Clustering
    4.3.2. Partitioning Clustering
    4.3.3. Large-Scale Partitioning Clustering
    4.3.4. Large-Scale Non-Spherical Hierarchical Clustering
    4.3.5. Density-Based Clustering (DBSCAN)
4.4. Classification Algorithms
    4.4.1. Decision Trees
    4.4.2. Random Forests

Chapter 5: Big Data Visualization

5.1. Introduction
5.2. General Data Categorization
    5.2.1. Structured Data
    5.2.2. Semi-Structured Data
    5.2.3. Unstructured Data
5.3. Types of Visualization
    5.3.1. Traditional Visualization
    5.3.2. Modern Visualization

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Andrejevic, Mark (2014). Big data, big questions: The big data divide. International Journal of Communication, 8: 1673–1689.
2. Azarmi, B. (2016). Scalable Big Data Architecture. Apress, 2016.
3. Bruchez, R. (2016). NoSQL Databases and Big Data. Eyrolles, 2nd edition, 2016.
4. Deitel, Paul, and Harvey Deitel. Intro to Python for Computer Science and Data Science. Pearson Education, 2020.
5. Mayer-Schönberger, Viktor, and Kenneth Cukier. Big Data: A Revolution That Will Transform How We Live, Work, and Think. Houghton Mifflin Harcourt,2013.
6. Gorelik, Alex. The Enterprise Big Data Lake: Delivering the Promise of Big Data and Data Science. O'Reilly Media, 2019.
7. Erl, Thomas, Wajid Khattak, and Paul Buhler. Big Data Fundamentals: Concepts, Drivers & Techniques. Prentice Hall Press, 2016.

Master's title: Artificial Intelligence

Semester: *3*

Teaching Unit: MTU1

Subject title: Embedded Systems and IoT

Credit weight: 3

ECTS Credits: 5

Course Objectives

This subject introduces the concept of the Internet of Things and deals with the main aspects of integration and use of embedded systems in the development of projects related to the Internet of Things (IoT). It identifies the problems and the technical solutions by defining the software and hardware aspects of the IT used in the design and implementation of IoT projects.

Recommended Prerequisites

Knowledge of algorithms, programming, and mathematics acquired during the undergraduate program in: Computer Systems (SI), Information Systems and Software Engineering (ISIL) or an equivalent Computer Science degree, as well as knowledge gained during the first and second semesters.

Course Outline

Chapter 1: Introduction to the Internet of Things and Connected Objects: Basic Concepts

1.1. Towards a strong coupling between the digital and physical worlds
1.2. Internet of Things (IoT): Definition and characterisation
1.3. Connected objects
1.4. IoT architectures
1.5. Design and implementation of IoT devices: guidelines

Chapter 2: Embedded Systems

2.1. Definitions, Architecture, Basic Components and Characteristics
2.2. IoT objects and Embedded Systems
2.3. Interaction of Embedded Systems with the physical world :Sensor/Actuator
2.4. Microcontrollers (Arduino, Raspberry, etc.)
2.5. Software, languages (C, C++, Python, etc.) and programming tools

Chapter 3: Embedded Operating Systems

3.1. Programming tools
3.2. Embedded Operating Systems

Chapter 4: Interface with IoT / embedded devices (systems)

4.1. Communication interface (SPI/I2C/UART...)
4.2. Communication between embedded systems (M2M)
4.3. Cloud interface
4.4. Cloud architectures and tools for IoT / embedded devices
4.5. Framework and IoT platforms and services (Google IoT, etc.)

Chapter 5: Designing and Prototyping of Embedded Systems

5.1. Design tools and methodology
5.2. Prototyping

5.3. Testing and evaluation

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Dominique MEURISSE. Python, Raspberry Pi et Flask. ENI ; 1re édition, 2018
2. Xiao, Perry. Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed. John Wiley & Sons, Incorporated, 2018.
3. Pierre Ficheux. Linux embarqué : Mise en place et développement. Eyrolles - 1re édition, 2017
4. Blaess, Christophe. Solutions temps réel sous Linux. Eyrolles, 2019.
5. L'Internet des Objets : Pierre-Jean Benghozi, Sylvain Bureau, Françoise Massit-Folléa
6. Designing the Internet of Things Adrian McEwen, Hakim Cassimally ISBN : 978-1-118-43062-0 ; 336 pages ; November 2013
7. L'Internet des objets : Les principaux protocoles M2M et leur évolution vers IP Olivier Hersent ; Collection : Technique et Ingénierie, Dunod ; 2014
8. The Internet of Things (The MIT Press Essential Knowledge series) Paperback –March 20, 2015 samuel Greengard.
9. Introduction aux systèmes embarqués temps réel - Fondamentaux et études de cas: Conception et mise en œuvre, Emmanuel Grolleau, Jérôme Hugues, et al. ;, Edition DUNOD, 2018.
10. Le Temps Réel en Milieu Industriel, ALain Darseoil, Pascal Pillot ; Edition DUNOD, 1991
11. Wolf, Marilyn. Embedded System Interfacing: Design for the Internet-of-Things (IoT) and Cyber-Physical Systems (CPS). Morgan Kaufmann, 2019.
12. Stroustrup, Bjarne. Programming: principles and practice using C++. Pearson Education, 2014.
13. Hillar, Gaston C. Internet of Things with Python. Packt Publishing Ltd, 2016.
14. Kapoor, Amita. Hands-On Artificial Intelligence for IoT: Expert machine learning and deep learning techniques for developing smarter IoT systems. Packt Publishing Ltd,2019.
15. Cox, Tim, et al. Getting Started with Python for the Internet of Things: Leverage the full potential of Python to prototype and build IoT projects using the Raspberry Pi. Packt Publishing Ltd, 2019.
16. Ketkar, Nikhil, and Jojo Moolayil. Deep learning with Python: learn best practices of deep learning models with PyTorch. Apress, 2021.

Master's title: Artificial Intelligence

Semester: *3*

Teaching Unit: MTU1

Subject title: Facial Recognition Systems

Credit weight: *2*

ECTS Credits: 4

Course Objectives

The aim of this course is to introduce students to the techniques of facial detection and recognition techniques, with a focus on Deep Face Recognition

Recommended Prerequisites

Knowledge of algorithms, programming, and mathematics acquired during the undergraduate program in: Computer Systems (SI), Information Systems and Software Engineering (ISIL) or an equivalent Computer Science degree, as well as knowledge gained during the first and second semesters.

Course Outline

Chapter 1: Face recognition system

1.1. Definition
1.2. The process
1.3. Applications
1.4. Challenges

Chapter 2: Face detection

2.1. Feature-based approaches
    2.1.1. Low-level analysis
    2.1.2. Feature analysis
2.2. Image-based approaches
    2.2.1. Linear subspace methods
    2.2.2. Neural networks
    2.2.3. Statistical approaches

Chapter 3: Facial recognition approaches

3.1. Global (holistic) approaches
    3.1.1. Principal component analysis (PCA)
    3.1.2. Linear Discriminant Analysis (LDA)
3.2. Local approaches
    3.2.1. Methods based on local characteristics
    3.2.2. Methods based on local appearance
3.3. Hybrid approaches

Chapter 4: Deep Face Recognition

4.1. Face recognition components
    4.1.1. Face processing
    4.1.2. Deep feature extraction
    4.1.3. Deep feature matching
4.2 Network architecture and training loss

4.2.1. Evolution of training loss
4.2.2. Evolution of network architectures
4.2.3. Deep feature mapping

4.3 Face processing for training and recognition

Evaluation Criteria

- Examination (60%),
- Continuous Assessment (40%).

Recommended Readings

1. Jain, A. K., & Li, S. Z. (2011). Handbook of face recognition (Vol. 1). New York : springer.
2. Jain, A. K., Flynn, P., & Ross, A. A. (Eds.). (2007). Handbook of biometrics. Springer Science & Business Media.
3. Masi, I., Wu, Y., Hassner, T., & Natarajan, P. (2018, October). Deep face recognition: A survey. In 2018 31st SIBGRAPI conference on graphics, patterns and images (SIBGRAPI) (pp. 471-478). IEEE.
4. Parkhi, O. M., Vedaldi, A., & Zisserman, A. (2015). Deep face recognition.
5. Brownlee, Jason. Deep learning for computer vision: image classification, object detection, and face recognition in python. Machine Learning Mastery, 2019.
6. Joshi, Prateek. Artificial intelligence with python. Packt Publishing Ltd, 2017.
7. Singh, Himanshu. Practical Machine Learning and Image Processing. New York, NY, USA: Apress, 2019.
8. Elgendy, Mohamed. Deep learning for vision systems. Simon and Schuster, 2020.

Master's title: Artificial Intelligence

Semester: *3*

Teaching Unit: DTU1

Subject title: Artificial Intelligence in Medicine

Credit weight: 2

ECTS Credits: 2

Course objectives

The aim of this course is to present the applications and technologies of artificial intelligence in Medicine. Artificial intelligence algorithms have been applied to a number of medical fields of medicine such as radiology, psychiatry, oncology, telehealth, etc. These algorithms are used to perform different types of tasks, such as computer-aided interpretation of medical images, clinical decision support for medical diagnosis, assistance with drug design, etc.

Recommended Prerequisites

Knowledge of algorithms, programming, and mathematics acquired during the undergraduate program in: Computer Systems (SI), Information Systems and Software Engineering (ISIL) or an equivalent Computer Science degree, as well as knowledge gained during the first and second semesters.

Course Outline

Chapter 1: Medical Decision Support Systems (MDSS)

1.1. Introduction to MDSS
1.2. Objectives of MDSS
1.3. Applications of MDSS
1.4. MDSS design approaches
    1.4.1. Symbolic approaches: expert systems
        - What is an expert system?
        - The components of an expert system
        - Some examples of expert systems
    1.4.2. Numerical approaches: Machine learning
        - Supervised learning
        - Unsupervised learning
        - Advantages and disadvantages of machine learning systems
        - Some examples of machine learning systems

Chapter 2: Bioinformatics

2.1. Introduction to bioinformatics
2.2. Sequence analysis
2.3. Gene prediction
2.4. Genomic editing
2.5. Modelling biomedical data

Chapter 3: Other applications of artificial intelligence in medicine

3.1. Medical imaging
3.2. Drug development
3.3. Preventive medicine
3.4. Personalised medicine

3.5. Psychiatry
3.6. Robotic surgery
3.7. Medical data analysis

Evaluation Criteria

- Examination (100%)

Recommended Readings

1. Bonnet C, Hoc JM, Tiberghien G. Psychologie, intelligence artificielle et automatique. Bruxelles (Belgique): Mardaga;1986.
2. Cai, R., Liu, M., Hu, Y., Melton, B. L., Matheny, M. E., Xu, H., ... &Waitman, L. R. (2017). Identification of adverse drug-drug interactions through causal association rule discovery from spontaneous adverse event reports. Artificial intelligence in medicine, 76, 7-15.
3. Coppersmith, G., Leary, R., Crutchley, P., & Fine, A. (2018). Natural language processing of social media as screening for suicide risk. Biomedical informatics insights, 10, 1178222618792860.
4. Dougherty, G. (2009). Digital image processing for medical applications. Cambridge University Press.
5. Johnson, K. W., Torres Soto, J., Glicksberg, B. S., Shameer, K., Miotto, R., Ali, M., ...& Dudley, J. T. (2018). Artificial intelligence in cardiology. Journal of the American College of Cardiology, 71(23), 2668-2679.
6. Hosny, A., Parmar, C., Quackenbush, J., Schwartz, L. H., &Aerts, H. J. (2018). Artificial intelligence in radiology. Nature Reviews Cancer, 18(8), 500-510.
7. McKinney, S. M., Sieniek, M., Godbole, V., Godwin, J., Antropova, N., Ashrafian, H.,...& Shetty, S. (2020). International evaluation of an AI system for breast cancer screening. Nature, 577(7788), 89-94.
8. Nordlinger B, Villani C. Santé et intelligence artificielle. Paris: CNRS; 2018.
9. Tisseron S, Tordo F. Robots, de nouveaux partenaires de soins psychiques. Toulouse:Érès; 2018.
10. Vallancien G. La médecine sans médecin ? Paris: Gallimard; 2015

Master's title: Artificial Intelligence

Semester: ***3***

Teaching Unit: TTU1

Subject title: Scientific Writing Tools

Credit weight: 1

ECTS Credits: 1

Course Objectives

The goal of this course is to teach students how to develop a research work plan and how to write the different sections of a scientific article, dissertation, or report. It also allows students to master computer tools (Latex, MS Word, etc.) to produce high-quality scientific documents.

Recommended Prerequisites

Knowledge acquired during the Bachelor's degree program: Computer Systems (IS), Information Systems and Software Engineering (ISIL), or an equivalent Computer Science degree.

Course Outline

Chapter 1. The Topic

1.1. Defining the Research Topic
1.2. Isolating the Concepts
1.3. Translating the Concepts into Keywords

Chapter 2. Components of a Research Paper

2.1. Title and Abstract
2.2. Introduction
    2.2.1. Background of the Problem, State of the Art
    2.2.2. Literature Review
    2.2.3. Main Objective of the Article
    2.2.4. Structure of the Paper
2.3. Core of the Paper
    2.3.1. Methods of Approach
    2.3.2. Results
    2.3.3. Discussion
    2.3.4. Conclusion
    2.3.5. Bibliography

Chapter 3. Writing

3.1. Before Starting to Write
3.2. Topic Sentences
3.3. Connecting Ideas
    2.3.6. Linking Sentences
    2.3.7. Linking Paragraphs
3.4. Coherence and Cohesion in Academic Writing
    2.3.8. Coherence
    2.3.9. Cohesion
3.5. Useful Sentences

Chapter 4. Referencing and Plagiarism

4.1. Referencing and Adding References
4.2. Plagiarism and Plagiarism Detection Software

Chapter 5. Latex

5.1. Introduction to Latex
    5.1.1. Installation
    5.1.2. Source Principle and Compilation
    5.1.3. Compiling a Simple Example Document
5.2. Document Structure
5.3. Mathematics
5.4. Figures
5.5. Tables
5.6. Notes, References, and Citations
5.7. Graphs in Latex
5.8. Mathematics and Graphs in Latex
5.9. Presentations in Latex: Beamer

Evaluation Criteria

- Examination (100%).

Recommended Readings

1. Lindsay, D., & Poindron, P. (2011). Guide de rédaction scientifique. Éditions Quæ.
2. Englander, K. (2013). Writing and publishing science research papers in English : A global perspective.
3. Lichtfouse, E. (2009). Rédiger pour être publié!: conseils pratiques pour lesscientifiques. Springer.
4. Mongeau, P. (2008). Réaliser son mémoire ou sa thèse. PUQ.
5. Beaud, M. (2020). L'art de la thèse. La Découverte.
6. Wallwork, A. (2012). English for research: usage, style, and grammar. Springer Science & Business Media.
7. Kleemann-Rochas, C., Farina, G., Fernandez, M., & Michel, M. (2003). Comment rédiger un rapport, un mémoire, un projet de recherche, une activité de recherche encours. Manuel de rédaction avec modules d'apprentissage des techniques d'écriture en français. Firenze : Centre de langues de l'Institut universitaire européen.