الجمهوريـــة الجزائريـــة الديمقراطيـــة الشعبيـــة
People's Democratic Republic of Algeria
وزارة التعليـــم العالـــي والبحـــث العلمـــي
Ministry of Higher Education and Scientific Research
جامعــة محمــد البشــير الابراهيمــي – برج بوعريريج
University of Mohamed Elbachir El Ibrahimi – Bordj Bou Arreridj
كلية الرياضيات و الاعلام الالي

POSTGRADUATE TRAINING OFFER FOR THE OBTAINMENT OF A DOCTORATE FOR THE ACADEMIC YEAR 2024/2025

Knowledge Enhancement Training Program

It is evident to everyone that the world today is evolving, and social and technological innovations are progressing rapidly. Therefore, we want this doctoral training to be based on a new approach to knowledge, innovation, and skills. The goal is to foster a sense of community through combing learning, practice, and open sharing. The challenge is to gather several instructors familiar with the current issues and work together to carry out this program successfully. This way, we seek other renowned partners to strengthen our capacities to achieve our objectives.

At the end of this training program, the learner should acquire and consolidate knowledge and implement their research project. However, the continuous enhancement process revolves around scientific, human, and technological capacities. We have carefully selected a set of courses, described in order of priority; to guide this process (the instructor may add or modify certain parts during their intervention). This emphasis on continuous improvement will keep you motivated and striving for excellence.

Knowledge Enhancement Training Program

Specialized Knowledge Enhancement Courses Related to Doctoral Training

Semester 1	Semester 2
Course Title and Hours	**Course Title and Hours**
Mathematical Foundations for Machine Learning (2h/week)	Foundations and Issues of the Internet of Things (2h/week)
Theoretical & Practical Course	**Theoretical & Practical Course**
Machine Learning (ML) and Deep Learning, Python for ML (Development Tools/Libraries: TensorFlow, Keras, etc.) (2h/week)	Foundations of Cryptography & Network Security (2h/week)
Theoretical Course	**Theoretical Course**
Techniques for Writing Scientific Articles (2h/week)	Sensors and Actuators (2h/week)
Theoretical Course	**Theoretical Course**
Image and Signal Processing (2h/week)	Optimization and Metaheuristics (2h/week)
Theoretical & Practical Course	**Theoretical Course**
Natural Language Processing (NLP): Foundations and Tools (2h/week)	Bioinformatics (2h/week)
Seminar	
1. Research Issues and Concerns of Doctoral Students (2h)	2. Ongoing Objectives and Perspectives (2h)

Semester 1:

1. First Course: Mathematical Foundations for Machine Learning

   Mathematics foundations are a prerequisite for advanced topics such as machine learning, deep learning, natural language processing, and reinforcement learning, which all require an understanding of mathematical concepts.

Matrices

- Matrix associated with a linear transformation.
- Operations on matrices: sum, product of two matrices, transpose matrix.
- Vector space of matrices with n rows and m columns.
- Ring of square matrices.
- Determinants of a square matrix and their properties.
- Invertible matrices.
- Rank of a matrix.

Solving Systems of Equations

- System of equations.
- Cramer's Method.

Vectors and Matrices

- Operations on vectors and matrices - Elementary mathematical functions.
- Orthogonal matrices - Diagonalization of matrices.
- Real symmetric matrices.

Reduction of Endomorphisms of Finite-Dimensional Vector Spaces

- Eigenvalues and eigenvectors; characteristic polynomial, Cayley-Hamilton theorem.
- Diagonalization of diagonalizable matrices, tridiagonalization, Jordan forms.
- Change of bases.

Differentiable Functions

- Automatic differentiation.
- Sequential differentiation.
- Right-hand derivative, left-hand derivative, geometric interpretation of the derivative.
- Study of functions.

References

- E. Azoulay et J. Avignant, Mathématiques. Tome1, Analyse. Mc Graw-Hill, 1983.

- M.Mignotte et J. Nervi, Algèbre : licences sciences 1ère année, Ellipses, Paris, 2004.
- J. Franchini et J. C. Jacquens, Algèbre : cours, exercices corrigés, travaux dirigés, Ellipses, Paris, 199
- Calcul scientifique avec Matlab, Jonas-Koko, Ellipses.
- Mathématiques, tome 4, Algèbre, E. Azoulay et J. Avignant

Second Course: Machine Learning (ML) and Deep Learning, Python for ML (Development Tools/Libraries: TensorFlow, Keras, etc.)

This course will use Python and its popular libraries, such as TensorFlow and Keras, to provide a theoretical understanding and practical implementation of machine learning and deep learning techniques.

Python & Libraries for Machine Learning

1. Python:
    - NumPy and Matplotlib with one or more variables.
    - Elemental operations and vector definition.
    - Plotting functions point by point.
    - Multiple plots (e.g., sigmoid example).
    - Functions of multiple variables.
    - Quadratic surfaces.
    - Linear regression.
    - Conversion between arrays and vectors.

Machine Learning & Neural Networks

1. Linear Perceptron
2. Bias – Affine Perceptron
3. Neural Network Layers
4. Neural Network Theory
5. Gradient
    - Tangents to level curves.
    - Classical gradient descent.
    - Optimization.
    - Stochastic gradient descent.
6. Backpropagation Principle

7. Overfitting and other issues.
8. Convolution:
    - Motivation.
    - Mathematical definition.
    - Matrix.
    - Pooling.
9. Convolution: Two Dimensions.
10. Image Processing.
11. Recurrent Neural Networks (RNN).
12. Bidirectional RNN.
13. Autoencoders.

Python: TensorFlow with Keras

1. Keras Module in TensorFlow.
2. Neural Network Layers.
3. Weights.
4. Visualization.
5. Activation functions.
6. Error functions.
7. Model Setup.
8. Validation and prediction.
9. Text recognition.
10. Image recognition.
11. Convolution with Python.

References

- Bonaccorso, G. (2017). Machine learning algorithms. Packt Publishing Ltd.
- Janiesch, C., Zschech, P., & Heinrich, K. (2021). Machine learning and deep learning. Electronic Markets, 31(3), 685-695.
- https://keras.io/
- https://www.python.org/
- https://tutoriels-data-science.blogspot.com/p/tutoriels-en-francais.html
- https://www.tensorflow.org/tutorials/keras/classification?hl=fr

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Third Course: Scientific Article Writing Techniques

This course will guide students through the process of effectively writing and submitting a scientific article, addressing common challenges like handling negative feedback and dealing with rejection.

1. Defining the Steps in Writing a Scientific Article
2. Survey Article vs. Research Article
3. What Should I Avoid?
4. Submission of a Publication
5. How to Respond to Negative Comments?
6. What to Do if My Paper Is Rejected?

References

- Beaud Michel (1988), L'art de la thèse - Comment préparer et rédiger une thèse de doctorat, un mémoire de DEA ou de maîtrise ou tout autre travail universitaire, Paris : La Découverte (1ère édition : 1985).
- Devillard Joëlle, Marco, Luc (1993), Ecrire et publier dans une revue scientifique, Paris : Les éditions d'organisation.
- DAY, R. A. 1988. How to write and publish a scientific paper. 3rd ed. Phoenix, AZ: The Oryx Press.
- Buttler, A. Comment rédiger un rapport ou une publication scientifique ? septembre 2002, vers. 1.4 Université de Franche-Comté - Laboratoire de chrono-écologie -CNRS/UMR 6565
- Roemer, R. C. (2015). Meaningful metrics: a 21st century librarian's guide to bibliometrics, altmetrics, and research impact;

Fourth Course: Image and Signal Processing

The course will cover the techniques and tools needed to process images and signals, with applications in medicine and beyond. Topics will include filtering methods, image registration, and optimization strategies.

1. Objectives of Image Processing
2. Image Representation
3. Formalisms
4. Image Degradation
5. Steps in Image Processing
6. Tools for Image Processing
7. Medical Imaging

8. Image Filtering
9. Linear vs. Non-linear Filtering
10. Multimodal Image Registration
11. Similarity Measures
12. Optimization Procedures

References

- Beutel, J., Kundel, H. L., Kim, Y., Van Metter, R. L., & Horii, S. C. (2000). Handbook of medical imaging (Vol. 3). Spie Press.
- Suetens, P. (2017). Fundamentals of medical imaging. Cambridge university press.
- Shung, K. K., Smith, M. B., & Tsui, B. M. (2012). Principles of medical imaging. Academic Press.
- Patil, D. D., & Deore, S. G. (2013). Medical image segmentation: a review. International Journal of Computer Science and Mobile Computing, 2(1), 22-27.

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5) Fifth Course: Natural Language Processing (NLP): Foundations and Tools

This course emphasizes the foundational concepts of Natural Language Processing, which include key tasks, techniques like word embeddings, and the use of neural networks for applications like speech recognition and NLP. In addition, students will receive practical experience using Python tools for NLP programming.

1. What is Natural Language Processing (NLP)?
2. What tasks can be performed by NLP?
3. Application of Neural Networks for:
    - Speech recognition.
    - Natural Language Processing.
4. Word Embedding
5. CBOW Method (Continuous Bag of Words)
6. Word2Vec
7. Skip-gram
8. Challenges in Natural Language Processing
9. Getting Started with Python Tools for NLP Programming

References

- Speech and Language Processing » Auteurs : Daniel Jurafsky et James H. Martin, https://web.stanford.edu/~jurafsky/slp3/
- Natural Language Understanding » Auteur : James Allen, 0805303340, 9780805303346

- The Handbook of Computational Linguistics and Natural Language Processing. Auteurs : Alexander Clark, Chris Fox et Shalom Lappin. Print ISBN:9781405155816 |Online ISBN:9781444324044
- Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit. Auteurs : Steven Bird, Ewan Klein et Edward Loper https://www.nltk.org/book/
- https://tjzhifei.github.io/resources/NLTK.pdf

Semester 2

Semester 2:

First Course: Foundations and Issues of the Internet of Things (IoT)

This course will cover the Internet of Things (IoT), with a comprehensive introduction that covers the key protocols, tools, technologies, and platforms used to build IoT systems. It will also explore the different types of sensors and detection mechanisms essential for IoT applications.

1. Basic Protocols for the Internet of Things (IoT)
2. Tools for Implementing IoT
3. Defining an IoT Architecture
4. Defining Types of Sensors and Detection Methods
5. Available Technologies
6. Software Communication Platforms

References

- https://www.inria.fr/fr/inria-livre-blanc-internet-des-objets-iot
- The Internet of Things », Samuel Greengard Auteur : Samuel Greengard
- Precision: Principles, Practices and Solutions for the Internet of Things », Timothy Chou Auteur : Timothy Chou

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Second Course: Foundations of Cryptography & Network Security

This course explores the fundamental principles of cryptography and network security, covering topics such as cryptographic techniques, security protocol analysis, and vulnerability identification in security protocols. It also provides an understanding of how to specify and analyze the security properties of these protocols.

1. Motivations and Basic Elements
2. Cryptography
3. Cryptanalysis
4. Security Protocols and Security Properties
5. Vulnerabilities in Security Protocols
6. Specification of Security Protocols
7. Specification of Security Properties
8. Analysis of Security Protocols

References :

- Cybersécurité et PowerShell De l'attaque à la défense du système d'information de Étienne Ladent, ISBN10 : 2409034144 - ISBN13 : 9782409034145
- Sécurité informatique et réseaux Cours avec plus de 100 exercices corrigés de Solange Ghernaouti ISBN10 : 2100599127 - ISBN13 : 9782100599127
- https://ethereum.org/fr/

Third Course: Sensors and Actuators

General Principles

1. Definitions and General Characteristics
2. Active Sensors
3. Passive Sensors
4. Test Bodies
5. Composite Sensors and Influence Quantities
6. Measurement Chain
7. Integrated Sensors
8. Smart Sensors

Proximity Sensors

1. Introduction
2. Mechanical Position Detectors
3. Inductive Proximity Detectors
4. Capacitive Proximity Detectors
5. Photoelectric Proximity Detectors

Pressure Sensors

1. Introduction
2. Pascal's Principle
3. Uniform Cross-section Manometer
4. Reservoir Manometers
5. Bourdon Tube
6. Aneroid Capsule
7. Membrane Manometer

Actuators

1. Definitions
2. Different Types of Actuators
3. Different Types of Cylinders
    - Pneumatic Cylinder
    - Characteristics of a Cylinder

Smart Sensors

1. Definitions
2. Internal Structure of a Smart Sensor
    - Conditioning Circuits
    - Data Processing Unit
    - Communication Interface

3. Sensor Networks

References

- Jacques Lonchamp, Introduction aux systèmes informatiques Architectures, composants, prise en main, 2017 collection infosup, Dunod.
- Georges Asch et collaborateurs : Les capteurs en instrumentation industrielle. " Ed. Dunod.
- Michel GROUT : "Instrumentation industrielle - Spécification et installation des capteurs et des vannes de régulation" Ed. Dunod (2002)
- Georges Asch et al : " Acquisition de données : Du capteur à l'ordinateur " Ed. Dunod.
- J. G. Webster, Measurement, Instrumentation and Sensors Handbook, Taylor & Francis Ltd
- J. G. Webster et al: " The measurement, instrumentation and sensors ".
- Fraden J., Handbook of modern sensors: physics, designs and applications, Springer.
- G. Lacroix, Les actionneurs électriques pour la robotique et les asservissements, Lavoisier.

Fourth Course: Optimization and Metaheuristics

The course will examine the theory and practical aspects of sensors and actuators, particularly emphasizing the types, principles, and technologies of sensors (like proximity, pressure, and smart sensors) and actuators used in various applications.

1. Introduction to Optimization
2. Classification of Solution Methods
3. Concept of Complexity
4. Mathematical Formulation of Optimization Problems
5. Paradigms of Approximate Methods
6. Exact Methods
7. Fundamentals of Heuristics
8. Metaheuristic Methods
9. Evolutionary Algorithms
10. Genetic Algorithms
11. Constructive Metaheuristics
12. Applications in Artificial Intelligence

References

- Talbi, E. G. (2009). Metaheuristics: from design to implementation. John Wiley & Sons.
- Hussain, K., Mohd Salleh, M. N., Cheng, S., & Shi, Y. (2019). Metaheuristic research: a comprehensive survey. Artificial intelligence review, 52(4), 2191-2233.
- Yang, X. S. (2010). Nature-inspired metaheuristic algorithms. Luniver press.
- Fister Jr, I., Yang, X. S., Fister, I., Brest, J., & Fister, D. (2013). A brief review of nature-inspired algorithms for optimization. arXiv preprint arXiv:1307.4186.

Fifth Course: Bioinformatics

The purpose of this course is to introduce students to bioinformatics, which will cover essential techniques, algorithms, and tools for analyzing biological data. It will also explore the role of programming and simulation in solving bioinformatics problems, particularly in protein structure modeling and sequence alignment.

1. Foundations
2. Understanding Biological and Bioinformatics Vocabulary
3. Overview of Bioinformatics Techniques
4. How to Choose Between Algorithms
5. Biological Sequence Alignment vs. Multiple Sequence Alignment
6. Protein Structure Modeling from Sequence Data
7. Introduction to Programming Languages Useful in Bioinformatics
8. Simulation of Biomolecules
9. Identifying Suitable Bioinformatics Solutions