Universitatea Națională de Știință și Tehnologie Politehnica București
Facultatea de Electronică, Telecomunicații și
Tehnologia Informației

COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Electronic Devices, Circuits and Architectures**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Microelectronics, Optoelectronics and Nanotechnologies

2. Date despre disciplină

2.1 Course name (ro) (en)				Inteligență artificială Artificial Intelligence			
2.2 Course Lecturer				Ș.L. dr. ing. Șerban MIHALACHE			
2.3 Instructor for practical activities				Ș.L. dr. ing. Șerban MIHALACHE			
2.4 Year of studies	3	2.5 Semester	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.06.O.413		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	3	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	42.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	14
Distribution of time:					hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.					4
Tutoring					0
Examinations					4
Other activities (if any):					0

3.7 Total hours of individual study	8.00
3.8 Total hours per semester	50
3.9 Number of ECTS credit points	2

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Finishing the following courses: – Linear Algebra, Calculus, Special Mathematics; – Computer Programming.

4.2 Results of learning	General knowledge of: – fundamental knowledge computer programming; – basic signal processing techniques.

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	– The lectures will take place in a room equipped with a video projector.
5.2 Seminary/ Laboratory/Project	– The laboratory will take place in a room with specific equipment, which must include: computers, video projector, specialized software (Python). – Mandatory attendance of laboratory sessions (in accordance with the NUSTPB undergraduate studies regulations).

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

This course provides a fundamental perspective on the field of machine learning: the K means Model (KMM), the K-nearest Neighbors algorithm (KNN), Gaussian Mixture Models (GMM), Decision Trees (DT), Random Forests (RF), Support Vector Machines (SVM), and fundamental artificial neural networks, particularly Fully connected Neural Networks (FCNN). Additionally, an introduction to the field of deep learning is offered: Convolutional Neural Networks (CNN), Residual Neural Networks (ResNet), and advanced training techniques – regularization, dropout, batch normalization, etc.
– The lectures offer an introduction to the specific problems in the field and addresses the three fundamental paradigms (supervised learning, unsupervised learning, and reinforcement learning), providing a comparative analysis of these and the types of applications that are natively suited to each. The most important machine learning techniques and methods are presented, tailored for clustering, supervised classification, and regression problems (KMM, KNN, GMM, DT, RF, SVM, FCNN, CNN, and ResNet).
– The laboratory begins with a comprehensive introduction to using the Python programming language and the essential packages used in the field of machine learning (numpy, scipy, pandas, matplotlib, etc.). The remaining sessions cover the practical implementation of the main machine learning models studied in the lectures, using the scikit-learn and Keras/TensorFlow Python packages, and their use for various clustering, supervised classification, and regression applications.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	– Demonstrates a basic understanding of theoretical concepts and modern models and techniques of artificial intelligence and machine learning. – Applies theoretical knowledge in practice and uses simulation environments to analyze and process various types of data and signals (especially speech signals). – Applies standardized methods, techniques, and methodologies specific to the field of artificial intelligence and machine learning to solve classification or regression problems, depending on the nature of the application. – Coherently and correctly argues and analyzes the context of application of the basic knowledge of the field of artificial intelligence and machine learning, using key concepts of the course and specific methodology. – Oral and written communication in Romanian: uses the specific scientific vocabulary of the studied field, in order to communicate efficiently and correctly, both in writing and orally. – Oral and written communication in a foreign language (English): demonstrates understanding and correct application of the vocabulary related to the studied field, in a foreign language.
Transversal (General) Competences	– Communicates effectively, especially during practical sessions, coordinating efforts with others to solve medium-complexity problems. – Autonomy and critical thinking: the ability to think scientifically, to independently search for and analyze data, to identify solutions, and to draw and present conclusions. – Analytical and synthetic ability: presents acquired knowledge in a synthetic manner as a result of a systematic analysis process. – Adheres to academic ethics: accurately cites bibliographic sources used in research activities. – Practical application of emotional intelligence: demonstrates appropriate socio-emotional management of academic situations, showing self-control and objectivity in decision-making or stressful situations.

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* – Correctly defines the fundamental concepts of artificial intelligence and machine learning: supervised learning, unsupervised learning, reinforcement learning, experimental methodologies, cross-validation, classification and regression models, signal features and parameters, etc. – Appropriately describes the concepts and particular aspects related to machine learning models (K-means Model, K-nearest Neighbor algorithm, Gaussian Mixture Models, Decision Trees and Random Forests, Support Vector Machines, Fully-connected Neural Networks, Convolutional Neural Networks, Residual Neural Networks), as well as their individual advantages and limitations. – Highlights the methodologies and techniques for training and testing machine learning models. – Understands the principles of dividing datasets and evaluating the generalization capability of machine learning models. – Defines and uses the basic elements related to speech signal analysis and processing (time and frequency domain representations). – Is able to correctly use the main methods of extracting features from speech signals (in the time, spectral, and cepstral domains).
Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* – Selects and groups relevant information in a given context, thus being able to adequately describe various theoretical or practical aspects of the field of artificial intelligence and machine learning. – Uses artificial intelligence and machine learning related concepts justifiably to address problems correctly. – Experimentally verifies the identified solutions for the practical approach of data and signal processing. – Formulates correct conclusions about the results of the experiments performed. – Justifies the methods and the solutions used to solve problems.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* – Selects appropriate bibliographic sources and analyzes them. – Respects academic ethics by correctly citing the bibliographic sources used. – Demonstrates receptiveness to new learning contexts. – Collaborates with peers and faculty in conducting educational activities. – Demonstrates autonomy in organizing the learning context and problems to be solved. – Recognizes the value of their contribution to the engineering field in identifying viable solutions to address social and economic problems. – Analyzes business opportunities or entrepreneurial development based on the knowledge acquired in the field of artificial intelligence and machine learning. – Demonstrates time management skills and other real-life situation management abilities.

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

– The coursework is approached in an interactive manner, encouraging active student participation. Both classical teaching methods are used (lecture and exposition), using PowerPoint presentations through multimedia means, as well as interactive ones, based on question-and-answer sessions and student feedback, constantly adapting the pedagogical approach to the students' assimilation and learning possibilities (through additional review of certain notions and concepts, if this proves necessary).
Each meeting begins with a brief recap of the previous chapters, with an emphasis on the concepts covered in the last meeting. The presentations use numerous images and diagrams, so that the information presented is as easy to understand and assimilate as possible. A number of exercises or problems are worked with the students and the homework related to the lectures is discussed with them.
Complete lecture materials are available in electronic form on the faculty's Moodle platform.
– Teaching in laboratory sessions is based on oral communication and detailed explanation of the methods used and the results obtained, in a constantly interactive manner. Students independently implement and evaluate the same problems using the computer and software environment. The developed applications help students in developing optimal communication relationships in a climate conducive to learning through discovery.
All laboratory materials are available in electronic form on the faculty's Moodle platform.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	"Introduction" – Brief history. State of the art. Remarkable results. Ethical aspects and concerns	2
2	"Fundamental concepts. Paradigms" – Definitions. Machine learning paradigms (supervised, unsupervised, reinforcement) and their comparative analysis. Experimental methodologies and training and testing techniques. Dataset curation principles	4
3	"The K-means Model (KMM). The K-nearest Neighbors algorithm (KNN)" – Theory. Principles of operation. Advantages and limitations. Examples	2
4	"Gaussian Mixture Models (GMM)" – Theory. Principles of operation. Advantages and limitations. Examples	2
5	"Decision Trees (DT). Random Forests (RF)" – Theory. Principles of operation. Advantages and limitations. Examples	2
6	"Support Vector Machines (SVM)" – Theory. Principles of operation. Advantages and limitations. Examples	4
7	"Fully-connected Neural Networks (FCNN)" – Theory. Fundamental principles and principles of operation. Advantages and limitations. Examples	6
8	„Introduction to Deep Learning" – Convolutional Neural Networks (CNN), Residual Neural Networks (ResNet). Advanced training techniques	6
	Total:	28

Bibliography:
1. Ș. Mihalache, *Inteligență artificială*, lecture notes available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. C.M. Bishop, *Pattern Recognition and Machine Learning*, Springer International Publishing, 2006, ISBN: 978-0387-31073-2.
3. M. Kubat, *An Introduction to Machine Learning*, 2nd Ed., Springer International Publishing, 2017, ISBN: 978-3-319-63912-3.
4. I. Goodfellow,Y. Bengio, A. Courville, *Deep Learning*, MIT Press, 2016, ISBN: 978-0-262-03561-3.

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to the Python programming language and additional packages (numpy, scipy, pandas, matplotlib, etc.)	4
2	Clustering applications: the K-means Model (KMM), Gaussian Mixture Models (GMM). Classification applications: the K-nearest Neighbors algorithm (KNN)	2
3	Classification applications: Decision Trees (DT), Random Forests (RF)	2
4	Classification applications: Support Vector Machines (SVM)	2
5	Classification and regression applications: Fully-connected Neural Networks (FCNN)	2
6	Final colloquium	2
	Total:	14

Bibliography:
1. Ș. Mihalache, *Inteligență artificială – Platforme de laborator*, lab tutorials available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. ***, *scikit-learn – Machine Learning in Python*, documentation and user guide, available in electronic form: https://scikit-learn.org/stable/
3. ***, *Keras API documentation*, documentation and user guide, available in electronic form: https://keras.io/2.17/api/
4. ***, *NumPy documentation*, documentation and user guide, available in electronic form: https://numpy.org/doc/
5. ***, *pandas documentation*, documentation and user guide, available in electronic form: https://pandas.pydata.org/docs/

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade

11.4 Course	Knowledge of fundamental theory and concepts relating to artificial intelligence and machine learning. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Exam during the exam session (written evaluation)	50%
	Knowledge of fundamental theory and concepts relating to artificial intelligence and machine learning. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Test during the semester (written evaluation)	10%
11.5 Seminary/laboratory/project	Understanding artificial intelligence and machine learning models and techniques. Understanding how to simulate and implement (software) the studied methods and techniques using an advanced development environment.	Continuous evaluation (practical and oral evaluation) Final laboratory colloquium (practical and written evaluation)	40%
11.6 Passing conditions			
– Obtaining a grade of at least 50%. – Meeting the general laboratory activity requirements (attending the lab sessions and attempting the final colloquium).			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

In recent decades, the field of artificial intelligence (AI) has experienced spectacular growth, becoming a driving force in global technological progress. Higher education institutions worldwide are revising their curricula to incorporate the knowledge and skills necessary to address this emerging trend. The profound utility of the AI field is reflected in its multiple practical applications, from recommendation systems in e-commerce to healthcare, autonomous vehicles, and many others. Studying AI at the university level not only allows students to gain a deep understanding of technical concepts but also prepares them to be competitive in the job market, in a constantly changing professional landscape. The ability to understand and develop artificial intelligence technologies is becoming an essential skill in the digital age, opening doors to a wide range of career opportunities in technology companies, research and development, innovative startups, and more. In addition, integrating the study of AI in higher education institutions stimulates research and innovation. Research in this field can lead to remarkable discoveries, significantly improving the quality of life and solving complex challenges. Through collaboration with industry, universities can create strong bridges between theory and practical applications, thus preparing students to meet the technological challenges of the future.
Graduates are thus provided with skills that are adequate to the needs of current qualifications and a modern, high-quality, and competitive scientific and technical training, which allows them to be quickly employed after graduation. The discipline is perfectly integrated into the policy of the National University of Science and Technology POLITEHNICA Bucharest, both from the point of view of content and structure, as well as from the point of view of the skills and international openness offered to students. Potential employers target

both the academic environment (teaching and research profile) and the research and development environment in state and private institutions that use (or intend to use) artificial intelligence-based systems.

Date	Course lecturer	Instructor(s) for practical activities
	Ș.L. dr. ing. Șerban MIHALACHE	Ș.L. dr. ing. Șerban MIHALACHE

Date of department approval	Head of department
31.10.2024	Prof. Dr. Claudius DAN

Date of approval in the Faculty Council	Dean
01.11.2024	Prof. Dr. Mihnea Udrea