Universitatea Naţională de Ştiinţă şi Tehnologie Politehnica Bucureşti
Facultatea de Electronică, Telecomunicaţii şi
Tehnologia Informaţiei

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	**Applied Electronics and Information Engineering**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Applied Electronics

2. Date despre disciplină

2.1 Course name (ro) (en)				Inteligenţă artificială Artificial Intelligence			
2.2 Course Lecturer				S.l./Lect. Dr. Liviu-Daniel Ştefan			
2.3 Instructor for practical activities				S.l./Lect. Dr. Liviu-Daniel Ştefan			
2.4 Year of studies	3	2.5 Semester	1	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.05.O.105		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	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	42	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.					29
Tutoring					0
Examinations					4
Other activities (if any):					0

3.7 Total hours of individual study	33.00
3.8 Total hours per semester	75
3.9 Number of ECTS credit points	3

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion and/or promotion of the following subjects: • Object Oriented Programming; • Signals and Systems 1; • Information Transmission Theory.

4.2 Results of learning	General knowledge of one-dimensional and two-dimensional signals, object-oriented programming and working with dedicated libraries.

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

5.1 Course	Video projection system for physical presence and access to the e-learning platform Moodle and Microsoft Teams. Attendance at the course is established according to ETTI regulations.
5.2 Seminary/ Laboratory/Project	Laboratory equipped with computing systems for physical presence and access to the e-learning platform Moodle and Microsoft Teams. Attendance at the laboratory is mandatory, according to ETTI 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)*

Course:
The course aims to develop students' understanding of the mechanisms involved in designing machine learning models, including data preprocessing, selection of algorithms suited to specific problems, and/or construction of model architectures. It also focuses on defining training, optimization, and evaluation strategies. Students will study the fundamental principles underlying algorithm design, with an emphasis on efficient program design criteria, case studies, and methods for evaluating algorithmic performance.

Laboratory:
The laboratory component focuses on the practical application of the concepts presented in the lectures through hands-on software implementation. Students will develop and test practical systems with real-world applications, consolidating their theoretical understanding through experimentation and problem-solving.

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	• Acquisition of both fundamental and advanced knowledge in the field of Artificial Intelligence, including the principles and methodologies of supervised learning, unsupervised learning, and deep learning. • Fluency in standard programming methods and techniques applied to data processing, model training and inference, and performance optimization using domain-specific evaluation metrics. • Ability to design and develop software solutions using object-oriented programming languages, following all stages of the software development life cycle: requirements specification, system design, implementation, testing, debugging, and results analysis. • Awareness of the need for continuous professional development and the capacity to efficiently utilize informational resources and technology-assisted communication and training tools (such as specialized Internet portals, professional software applications, databases, and online courses) in both Romanian and an international language.

Transversal (General) Competences	• Ability to make informed decisions for solving both routine and unforeseen problems that arise during the operation and maintenance of computing systems. • Capacity for continuous learning and self-directed professional development through the study of specialized scientific and technical literature. • Ability to communicate and present technical information effectively in both Romanian and English.

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.* • • Understand and explain the fundamental concepts of machine learning, including basic principles of model design, training, and evaluation. • Demonstrate knowledge of Python programming and the use of specialized modules for data manipulation, such as data frame management, data visualization, advanced indexing, numerical summarization, and descriptive graphics. • Apply machine learning techniques using Scikit-learn and PyTorch frameworks for solving data-driven problems. • Describe and analyze different types of machine learning models, including regression systems, supervised and unsupervised classification algorithms, and deep neural network architectures, in relation to specific application contexts. • Explain the relationships among various topologies of deep learning–based systems, recognizing their structural and functional differences. • Evaluate the impact of parameter and structural modifications on model performance and interpret the practical implications of such changes.
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).* • Analyze, understand, and explain machine learning models implemented in Python code. • Design and implement machine learning algorithms suitable for specific tasks and datasets. • Validate and interpret the results and performance metrics of machine learning models. • Identify and formulate appropriate programming solutions for computational and data-driven problems. • Communicate and justify technical solutions and design choices clearly and coherently, both in written and oral form.

Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • Select, analyze, and utilize appropriate bibliographic and scientific sources relevant to the field of study. • Demonstrate adherence to the principles of academic ethics, including the correct citation and acknowledgment of all bibliographic sources used. • Show openness and adaptability to new learning contexts and emerging technologies. • Collaborate effectively with colleagues and instructors in the planning and execution of academic and project-based activities. • Demonstrate autonomy and responsibility in organizing learning activities and in addressing problem-solving situations within the study or professional context.

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.)*

Based on the analysis of students' learning characteristics and specific needs, the teaching process will employ a combination of expository (lecture-based, presentation) and interactive-conversational methods, grounded in discovery-based learning models that encourage both direct and indirect exploration of real-world phenomena (experimentation, demonstration, and modeling). In addition, action-oriented methods such as exercises, practical activities, and problem-solving sessions will be used to consolidate theoretical knowledge through hands-on experience. Lectures will be supported by PowerPoint presentations, which will be made available to students. Each lecture will begin with a review of previously covered material, emphasizing key concepts from the last session.

All course and laboratory materials will be accessible on the Moodle e-learning platform in digital format. Presentations will integrate images, diagrams, and source code examples, ensuring that the information delivered is clear, engaging, and easily assimilated. Students will be encouraged to actively participate in defining their learning paths, and remedial activities will be implemented when learning gaps are identified, ensuring inclusive and adaptive learning experiences.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction to artificial intelligence, general context presentation. Key concepts: supervised learning vs unsupervised learning, regression vs classification. Practical application examples.	2
2	Description of data content, terminologies and representations associated with multimodal data. Data analysis and processing.	6
3	Unsupervised learning and specific applications. Overview of unsupervised learning, differences from supervised learning. Clustering methods: K-Means clustering, hierarchical clustering. Practical considerations and real-world applications.	4
4	Supervised learning and specific applications. Regression techniques: simple and multiple linear regression. Classification techniques: Logistic regression, K-Nearest Neighbors (KNN), Support Vector Machines (SVM), Decision Trees. Practical considerations and real-world applications.	4

5	Evaluating the performance of classifiers. Similarity metrics between data points and classification metrics for evaluating the performance of a classification model. Bias-diversity trade-off.	2
6	Fundamentals of deep learning. Single-layer, multi-layer neural networks, convolutional neural networks, non-linear activation functions, cost functions, hyperparameters. Convolutional neural networks - case study. Recurrent neural networks - case study. Autoencoders - case study.	4
7	Training neural networks. Forward propagation, back propagation, regularization and SGD. Overfitting and underfitting of networks. Optimizing neural networks: Transfer Learning and Fine Tuning–case study.	2
8	Presentation of various modern neural network architectures: AlexNet, VGG, ResNet, Inception, Xception, R-CNN, SSD, YOLO.	4
	Total:	28

Bibliography:

1. Ionescu, B., & Mironică, I. (2013). The Content-Based Indexing Paradigm in the Context of Multimodal Data. MartrixRom.
2. Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: springer.
3. Kroese, D. P., Botev, Z., & Taimre, T. (2019). Data science and machine learning: mathematical and statistical methods. Chapman and Hall/CRC.
4. Jiang, H. (2021). Machine learning fundamentals: A concise introduction. Cambridge University Press.
5. Tom Bäckström, Okko Räsänen, Abraham Zewoudie, Pablo Pérez Zarazaga, Liisa Koivusalo, Sneha Das, Esteban Gómez Mellado, Mariem Bouafif Mansali, & Daniel Ramos. (2022). Introduction to Speech Processing: 2nd Edition.
6. Chollet, F. (2021). Deep learning with Python. Simon and Schuster.
7. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT press.
8. Zhang, A., Lipton, Z. C., Li, M., & Smola, A. J. (2021). Dive into deep learning. arXiv preprint arXiv:2106.11342.

LABORATORY

Crt. no.	Content	No. hours
1	Introduction and familiarization with the Python programming language. Use of Python 3 in the Jupyter Notebook environment, covering concepts such as data manipulation with NumPy, data frame management with Pandas, data visualization with Matplotlib, advanced indexing techniques, numerical summarization, and descriptive graphics, as well as file and directory organization.	2
2	Introduction to image, audio, and text data processing using specialized tools; extraction of relevant feature representations. Visualization of large datasets using exploratory data analysis and preprocessing of datasets.	2
3	Exploration of unsupervised learning methods through understanding clustering concepts, training clustering models, and optimizing their performance.	2
4	Exploration of regression and supervised learning methods, including model design, training, and evaluation.	4

5	Introduction and familiarization with the PyTorch framework. Use of CPU and GPU tensors, management, scaling, and normalization of datasets using torchvision. Construction of a neural network architecture, model training, and performance improvement using transfer learning and fine-tuning techniques.	2
6	Laboratory colloquium.	2
	Total:	14

Bibliography:

1. Ionescu, B., & Mironică, I. (2013). The Content-Based Indexing Paradigm in the Context of Multimodal Data. MartrixRom.
2. Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: springer.
3. Kroese, D. P., Botev, Z., & Taimre, T. (2019). Data science and machine learning: mathematical and statistical methods. Chapman and Hall/CRC.
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5. Tom Bäckström, Okko Räsänen, Abraham Zewoudie, Pablo Pérez Zarazaga, Liisa Koivusalo, Sneha Das, Esteban Gómez Mellado, Mariem Bouafif Mansali, & Daniel Ramos. (2022). Introduction to Speech Processing: 2nd Edition.
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7. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT press.
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11. Evaluation

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

11.4 Course	- knowledge of fundamental theoretical notions of machine learning, - differentiated analysis of theoretical techniques and methods, - solving common machine learning problems.	Midterm evaluation (scheduled at a date established at the beginning of the course): the topics will cover Chapters 1–4, providing a synthesis between the theoretical comparative study of the material and the application of concepts through exercises and problem-solving activities.	25
	- knowledge of fundamental theoretical notions of machine learning, - differentiated analysis of theoretical techniques and methods, - solving common machine learning problems.	Final examination: the topics cover Chapters 5–8, providing a synthesis between the theoretical comparative study of the material and the application of concepts through exercises and problem-solving activities.	25

11.5 Seminary/laboratory/project	- knowledge of how to use the Python programming language and libraries, numpy, matplotlib, pandas, opencv, scikit-learn, pytorch, - knowledge of data processing methods, - knowledge of regression methods, classification and clustering, - knowledge of the process of training and validating machine learning methods, - solving common artificial intelligence problems in the Colab/Jupyter Notebook environment and the Python language.	Final laboratory colloquium: includes both a theoretical and a practical component. The theoretical component is assessed through a written test, while the practical component is evaluated based on the student's ability to solve a practical problem, including its implementation, testing, and functional performance.	50
11.6 Passing conditions			
• **Participation in all laboratory activities** is mandatory. • **A minimum of 50% of the total laboratory score** must be obtained. • **A minimum of 50% of the total course score** (overall discipline score) is required to pass the course.			

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)

The course provides students with a solid foundation in the field of Artificial Intelligence (AI), with an emphasis on designing and training machine learning models in Python. Students acquire essential competencies for correctly formulating AI problems, properly preprocessing data, selecting suitable model architectures or training techniques, evaluating model performance, and using modern libraries such as NumPy, Pandas, Matplotlib, scikit-learn, PyTorch, and HuggingFace Transformers, among others.
Given that current technological progress is strongly influenced by the AI revolution, this discipline plays a fundamental role in shaping the new generation of engineers and researchers.

The curriculum thus ensures that graduates obtain competencies aligned with current qualification requirements, as well as modern, high-quality, and competitive scientific and technical training, enabling them to integrate quickly into the labor market upon graduation.
This course is fully consistent with the educational policy of the National University of Science and Technology Politehnica Bucharest, both in terms of its content and structure, and through the international perspective and openness it provides to students.

Potential employment opportunities for graduates include both the academic sector (teaching and research) and the industrial research and development environment, encompassing organizations and companies of all sizes — from student-founded start-ups and spin-offs to large multinational corporations.

Date	Course lecturer	Instructor(s) for practical activities
25.09.2025	S.l./Lect. Dr. Liviu-Daniel Ştefan	S.l./Lect. Dr. Liviu-Daniel Ştefan

Date of department approval	Head of department
26.09.2025	Conf. Dr. Bogdan Cristian Florea

Date of approval in the Faculty Council	Dean
26.09.2025	Prof. Dr. Mihnea Udrea