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	Computers and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Information Engineering

2. Date despre disciplină

2.1 Course name (ro) (en)				Inteligenţă artificială 2 - Recunoaşterea formelor Artificial Intelligence 2 - Pattern Recognition			
2.2 Course Lecturer				Prof. Dr. Anamaria RĂDOI			
2.3 Instructor for practical activities				As. Drd. Ing. George Cioroiu			
2.4 Year of studies	4	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		D	2.9 Course code	04.D.07.O.103		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.					50
Tutoring					0
Examinations					8
Other activities (if any):					0

3.7 Total hours of individual study	58.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion of the following disciplines: • Mathematical Analysis • Linear Algebra, Analytical and Differential Geometry • Probability Theory and Mathematical Statistics • Signals and Systems • Computer Programming and Programming Languages 1, 2 • Information Transmission Theory • Decision and Estimation in Information Processing • Artificial Intelligence 1
4.2 Results of learning	Acquired knowledge: • Multilayer neural networks • Convolutional neural networks • Feature extraction using convolutional network architectures • Encoder-decoder neural structures • Generative adversarial networks • Transformer networks

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

5.1 Course	The course will take place in a room equipped with blackboard, projector and laptop
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room equipped with desktop computers

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 subject is studied within the CTI field / specialization II and aims to familiarize students with the main approaches, models and explanatory theories of the field, used in solving practical applications and problems related to extracting relevant features from data (signals, images) in order to recognize and classify them. The course focuses on neural network architectures and learning paradigms. In this regard, specific concepts and principles are addressed, such as activation functions, cost functions, optimization strategies. All these notions contribute to the formation of an overview of the methodological and procedural benchmarks related to the field.

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	Understanding and using fundamental concepts in the artificial intelligence domain

Transversal (General) Competences	The ability to take decisions in order to solve current, or unpredicted, problems that appear in the process of operating the computer system The ability to ensure the planning and management of information engineering projects The ability to constantly inform and document for personal and professional development by reading specialized literature The ability to communicate and present technical content both in Romanian and in English Flexibility in using new systems and technologies within a team where members together achieve a well-defined goal while assuming different roles or tasks.

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.* Lists the most important stages that have marked the development of Artificial Intelligence. Defines domain-specific notions, such as multilayer neural network, convolutional network, representation learning, transformer architectures. Describes/classifies learning problems. Highlights consequences of using optimization techniques. Knows the training stages of an AI-based recognition system and techniques for improving its performance.
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 relevant information in a concrete recognition / classification context. Uses specific principles in an argumentative manner in order to use certain neural network architectures. Works in a team through discussions related to solving some requirements within the laboratory. Experimentally verifies solutions identified through specific performance measures. Solves applications in the laboratory. Analyzes and compares various AI systems for pattern recognition. Formulates conclusions from the experiments performed.

Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Selects suitable bibliographic sources. Respects the principles of academic ethics. Demonstrates responsiveness of learning in new contexts. Shows collaboration with other colleagues and teaching staff during the teaching activities. Demonstrates autonomy in solving problems. Shows social responsibility through active involvement in the events of the academic community. Realizes the value of his contribution to the field of engineering to identifying solutions to real social and economic problems, demonstrating social responsibility. Applies principles of ethics/professional deontology in identifying optimal solutions. Demonstrates effective time management skills.

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 teaching process will explore both expository (lecture, exposition) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct and indirect exploration of reality, but also on action-based methods, such as exercise, practical activities and solving problems. The oral communication methods used are exposition, problematization and conversation.

Lectures will be used in the teaching activity, based on presentations in .pdf format and notes written on the blackboard. Each course will begin with the recapitulation of the chapters already covered, with an emphasis on the concepts covered in the last course.

The presentations use images / diagrams and connections with current technology so that the information presented is easy to understand, assimilate and apply in various contexts.

Active listening and assertive communication techniques will be applied, as well as bi-directional feedback mechanisms.

Teamwork skills will be practiced to solve different learning tasks in seminars and laboratories.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction to Artificial Intelligence. 1.1. Defining the field 1.2. Supervised learning. Unsupervised learning. 1.3. Deep learning. 1.4. Current applications of Artificial Intelligence.	2
2	Preliminary concepts 2.1. Concepts from information theory and statistics (probability, random variable, entropy, statistical moments, Kullback-Liebler divergence). 2.2. Decision theory (Bayes criterion) and classification. 2.3. Estimation of model parameters.	2

3	Standard Data Processing and Analysis Techniques 3.1. Principal Component Analysis. 3.2. Data Normalization. 3.3. Data Rescaling.	2
4	Neural Networks 4.1. Perceptron - linear/nonlinear activation functions, forward propagation, cost functions, backpropagation. 4.2. Multilayer architectures. 4.3. RBM architecture. 4.3. Deep linear networks. 4.4. Simple pattern recognition applications.	4
5	Cost function optimization techniques 5.1. SGD optimization method 5.2. ADAM optimization method	2
6	Techniques for reducing overfitting 6.1. L1/L2 norm regularization. 6.2. Reducing the number of neurons.	2
7	Convolutional Networks 7.1. Dimensionality Reduction in Feature Extraction. 7.2. Standard Architectures of Convolutional Networks. 7.3. Encoder-Decoder Networks.	6
8	Sequential Learning 8.1. Recurrent Networks. 8.2. Long-Term Memory Networks.	4
9	Generative Adversarial Networks 9.1. Generator 9.2. Discriminator	2
10	Transformer architectures	2
	Total:	28

Bibliography:

1. Rădoi Anamaria, suport curs Moodle
2. C. Bishop, and H. Bishop, Deep Learning: Foundations and Concepts, Springer, 2024
3. Thomas M. Cover, Joy A. Thomas, Elements of Information Theory 2nd Edition, Wiley-Interscience, 2006
4. Bishop, C. M. ,Pattern Recognition and Machine Learning. Springer, 2006
5. I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2016

LABORATORY

Crt. no.	Content	No. hours
1	Python review. Standard data processing and analysis techniques.	2
2	Neural networks. Optimization techniques.	2
3	Convolutional Neural Networks. Classical architectures.	2
4	Image classification. Image semantic segmentation.	2
5	Sequential learning.	2
6	Generative adversarial networks.	2

7	Transformers. Laboratory exam.	2
	Total:	14

Bibliography:
1. Rădoi Anamaria, suport curs Moodle
2. C. Bishop, and H. Bishop, Deep Learning: Foundations and Concepts, Springer, 2024
3. Thomas M. Cover, Joy A. Thomas, Elements of Information Theory 2nd Edition, Wiley-Interscience, 2006
4. Bishop, C. M. ,Pattern Recognition and Machine Learning. Springer, 2006
5. I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2016

11. Evaluation

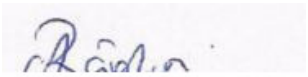
Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Problem solving	Evaluation test	20%
	Problem solving	Final exam	40%
11.5 Seminary/laboratory/project	Correct interpretation of experimental results considering the theoretical information gained during the course	Laboratory final verification	20%
	Problem solving	Tests during exercise sessions	20%
11.6 Passing conditions			
Obtaining 50% of the total score. Obtaining 50% of the laboratory score.			

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)

Through the activities carried out, students develop skills to offer solutions to problems and to propose ideas for improving the existing situation in the CTI field, including in the field of Artificial Intelligence by expanding some notions and concepts.

The course has similar content to the courses held at Stanford, ETHZ, Massachusetts Institute of Technology in Cambridge (Massachusetts).

Date	Course lecturer	Instructor(s) for practical activities
18.09.2025	Prof. Dr. Ing. Anamaria RĂDOI	As. Drd. Ing. George Cioroiu



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Date of department approval	Head of department Conf. dr. ing. Bogdan Cristian FLOREA
Date of approval in the Faculty Council	Dean Prof. Dr. Ing. Mihnea Udrea