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

2. Date despre disciplină

2.1 Course name (ro) (en)				Introducere în sisteme cu învățare automată			
2.2 Course Lecturer				Prof. Dr. Ruxandra-Georgiana TAPU			
2.3 Instructor for practical activities				Prof. Dr. Ruxandra-Georgiana TAPU			
2.4 Year of studies	4	2.5 Semester	II	2.6. Evaluation type	V	2.7 Course regime	Op
2.8 Course type		S	2.9 Course code	04.S.08.A.513		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	3.5	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	1.5
3.4 Total hours in the curricula	49.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	21
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.					69
Tutoring					4
Examinations					3
Other activities (if any):					0

3.7 Total hours of individual study	76.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completing and/or promoting the following disciplines: - Object oriented programming; - Signal and Systems; - Operating Systems; - Information Transmission Technology.
4.2 Results of learning	General knowledge of one-dimensional / two-dimensional signals, object-oriented programming and working with dedicated programming libraries.

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 a video projector and a computer.
5.2 Seminary/ Laboratory/Project	The laboratory will be held in a room with specific equipment, which must include: high-performance computers equipped with graphics cards (GPUs) necessary for parallel data processing, video projector or TV with a minimum diagonal of 179 cm, graphic tablet.

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 discipline is studied within the field of Electronics, Telecommunications and Information Technology, dedicated to the students enrolled at the specialization Telecommunications Technologies and Systems and aims to familiarize students with the main approaches, models and explanatory theories in the field of artificial intelligence, used to solve practical applications and problems, with relevance in order to stimulate the learning process. The discipline aims at presenting the fundamental notions in the field of neural networks, convolutional neural networks with the purpose of automatically identify the relevant semantic content existing in multimedia documents. The discipline involves studying the methods of selection and exploitation of artificial intelligence systems based on machine learning algorithms, as well as designing novel systems. The emphasis is put on using the theoretical knowledge in practical 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** basic/advanced knowledge in the field of artificial intelligence. **It** correlates and applies in practice the fundamental concepts related to machine learning systems used in designing deep neural network architectures. **Elaborates** software programs in an object-oriented programming language, starting from the specification of requirements to the software execution, debugging and interpretation of results in correlation with the requirements imposed. **Oral and written communication in the Romanian language**: uses scientific vocabulary specific to the field, with a view to effective communication, in writing and orally. **Oral and written communication in a foreign language (English):** demonstrate the understanding of the vocabulary related to the field, in a foreign language.

Transversal (General) Competences	**W**ork in a team and communicate efficiently, coordinating their efforts with the others in order to solve problems of medium complexity. **Autonomy and critical thinking:** the ability to think in scientific terms, to search and analyze data independently, as well as to draw and present conclusions / identify solutions. **Capacity** of analysis and synthesis: summarises the knowledge acquired as a result of a systematic analysis process. **Respects the principles of academic ethics:** in the state of the-art review the student cites correctly the bibliographic sources used. **Puts into practice elements of** emotional intelligence in a proper socio-emotional management of real-life/academic/professional situations, demonstrating self-control and objectivity in decision making in stressful situations. **Methodical analysis** of the problems encountered in the activity, identifying the elements for which there are established solutions, thus ensuring the fulfillment of professional 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.* •List the most important stages that marked the development of machine learning techniques: supervised and unsupervised. •It defines specific notions such as: score functions and loss functions, artificial neural networks, convolutional neural networks, classification/regression systems, deep network architectures used in practical applications. •Describes/classifies the steps required to train a system that uses artificial intelligence. •Highlights relationships between different topologies of systems based on deep learning.
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 for a given context. •It uses specific principles in order to establish the specialized software tools that allow the automatic extraction of the semantic content existing in multimedia documents. •Work productively in a team. •Develop a scientific text. •Experimental evaluation of the selected solutions. •Identifies solutions and develops resolution plans/projects. •Draw conclusions from the experiments carried out. •It justifies the selected solutions/ways of solving problems.

Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* •Selects the right bibliographic sources and analyze them. •Respects the principles of academic ethics, by correctly citing the bibliographic sources used. •Demonstrates responsiveness to new learning contexts. •Collaborates with other colleagues and teachers in carrying out the teaching activities. •Demonstrates autonomy in organizing the learning situation or in the context of a given problem to be solved. •Applies principles of professional ethics/deontology in analyzing the technological impact of the solutions proposed over the environment. •Analyzes and capitalizes the business opportunities/entrepreneurial development in the specialized field. •Demonstrates management skills (collaborative time management vs. conflict) in real-life situations.

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.)*

Starting from the analysis of the learning characteristics of students and from their specific needs, the teaching process will explore both expository (lecture, exposition) and conversational-interactive teaching methods, based on various types of learning models: learning through discovery - facilitated by the direct and indirect exploration of reality (experiment, demonstration, modelling) and action-based learning - such as exercise, practical activities and problem solving. Within the teaching activity the lectures will be based on Power Point presentations or different videos that will be made available to students. Each course will start with the recapitulation of the chapters already completed, with a focus on the notions presented in the last course. The presentations use various images and schematics so that the information presented is easy to understand and to assimilate. This discipline covers information and practical activities are designed to support the students during the learning efforts in order to develop optimal relationships of collaboration and communication in a climate conducive to learning through discovery.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	1. Image fundamentals: 1.1. The concept of pixels. 1.2. The building blocks of images. 1.3. Color spaces. 1.4. Scaling and aspect ratios.	2
2	2. Machine learning: 2.1 Supervised Learning: 2.1.1. Linear and logistic regression. 2.1.2. Support Vector Machines (SVMs). 2.1.3. Random Forests. 2.1.4. Artificial Neural Networks. 2.2 Unsupervised Learning: 2.1. K-means clustering. 2.2. Hierarchical clustering.	4

3	3. Fundamentals of deep learning: 3.1. Notations and terminology. 3.2. Network topologies. 3.3. Training of Artificial Neural Networks.	2
4	4. Neural Networks: 4.1 Single Neuron as Linear Classifier. 4.2 Multi-layer Perceptrons. 4.3 Forward Propagation. 4.4. Loss Functions and Optimization. 4.5. Sofmax Classifier. 4.6. Back Propagation.	4
5	5. Convolutional Neural Networks (CNN): 5.1 Layers in CNN: 5.1.1. Convolutional Layers. 5.1.2. Activation Functions. 5.1.3. Pooling Layers. 5.1.4. Fully Connected Layers. 5.1.5. Normalization Layers. 5.1.6. Dropout. 5.2. Visualizing Convolutional Neural Networks. 5.3. Transfer Learning and Fine Tuning.	6
6	6. Deep Learning in Practice: 6.1. Development Environments: 6.1.1. Libraries Dedicated to Deep Learning Applications. 6.1.2. CPU vs GPU. 6.2. Deep Learning for Data Classification: 6.2.1. Dataset Development. 6.2.2. Training and Testing Datasets. 6.2.3. Training a simple CNN. 6.2.4. Saving and Loading Models. 6.2.5. Underfitting and Overfitting in CNN.	6
7	7. State of the art CNN for practical applications: 7.1. AlexNet 7.2. VGG 7.3. ResNet 7.4. Inception 7.5. Xception	4
	Total:	28
Bibliography:		

LABORATORY		
Crt. no.	**Content**	**No. hours**
1	Introduction to neural networks. An XOR gate implementation using a neural network in Python.	3
2	Design of a dense neural network in Keras. Training the network on the MNIST database	3

3	Designing a convolutional neural network. Analysis of the fundamental elements of deep learning systems: convolutional layers, activation functions, pooling layers, fully connected layers, normalization layers and dropout state.	3
4	Training a classifier for object recognition.	3
5	Monitoring a CNN model using Keras Callback and TensorBoard. Understating the various metrics used to evaluate the performance of neural networks. Underfitting and Overfitting a CNN.	3
6	Network architectures used in practical applications. Comparative evaluation.	3
7	Laboratory colloquium	3
	Total:	21
Bibliography:		

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 concepts.	One written test set on a date set at the beginning of the course. - Topics cover the entire field, providing a synthesis between the theoretical materials and the exercises.	50%
	Knowledge of how to apply the theory to specific problems.	Idem	
	Differential analysis of the techniques and theoretical methods.	Idem	

11.5 Seminary/laboratory/project	Knowledge of the Python programming language and dedicated libraries as: Keras, TensorFlow and OpenCV.	- The final laboratory colloquium is divided in two parts: one theoretical and the other one experimental. - The theoretical part is verified based on a multiple choice test. - The practical component is verified by evaluating the solution (implementation, testing, operation) proposed by the student to a real life problem.	50%
	Knowledge about the common neural networks architectures.	Idem	
	Knowledge of how to design an automatic object recognition system.	Idem	
11.6 Passing conditions			
•Getting 50% of the total score. •Basic knowledge of the fundamental elements of deep learning systems: convolutional layers, activation functions, pooling layers, fully connected layers, normalization layers and dropout states. •Knowledge of the main neural network architectures used in practical applications as: VGG, ResNet, Inception, Xception. •Solving a real simple problem of detecting and recognizing objects in multimedia signals.			

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, the students will develop skills necessary to provide solutions to real-life problems and introduce novel ideas to improve the field of information technology with direct and immediate applications in robotics, IoT or autonomous systems.
•The discipline content is based on knowledge/aspects/phenomena described by the specialized literature published by the lecturer or presented by various international researchers.
•The course content is similar with the courses conducted by Stanford University in the USA.
•Through the activities carried out during the lecture/laboratory work, we take into account the development of the graduate's abilities to manage practical situations that he/she may face in real life in order to increase his/her contribution to the improvement of the socio-economic environment.

Date	Course lecturer	Instructor(s) for practical activities
	Prof. Dr. Ruxandra-Georgiana TAPU	Prof. Dr. Ruxandra-Georgiana TAPU

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Date of department approval	Head of department
	Conf. Dr. Ing. Serban Obreja
Date of approval in the Faculty Council	Dean
25.10.2024	Prof. Dr. Mihnea Udrea