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	Masters
1.6 Programme of studies	Advanced Techniques for Digital Imaging

2. Date despre disciplină

2.1 Course name (ro) (en)				Machine Learning pentru aplicatii vizuale			
2.2 Course Lecturer				Prof. Dr. Corneliu Nicolae FLOREA			
2.3 Instructor for practical activities				Prof. Dr. Corneliu Nicolae FLOREA			
2.4 Year of studies	2	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M3.A.15-34		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	4	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	28
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.					56
Tutoring					10
Examinations					3
Other activities (if any):					0

3.7 Total hours of individual study	69.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion of the following disciplines: Decision and estimation in information processing, Techniques for automatic analysis and classification of information

4.2 Results of learning	Elements of algebraic calculation; Elements of mathematical analysis; Knowledge of object oriented programming

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.
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room with specific equipment, which must include high-performance computers with graphics card with NVIDIA processor

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)*

The objective of the **course** is to familiarize students with the specific notions of automatic learning and subsumed mathematical modeling. Given that we have at our disposal increasingly large volumes of data, the problem arises of building intelligent models capable of extracting useful information from these models and using it to explore new situations. The main characteristics and limitations of common data analysis models such as tree assemblies, support vector machines or convolutional networks are discussed. Semi- or unsupervised data mining techniques are studied, as well as ways in which we can use them effectively. Emphasis is placed on the computational cost of the solutions with a detailed presentation of the efficiency options

The objective of the **laboratory** applications is for students to learn how to use a popular library (PyTorch) for using deep convolutional networks in various applications. The aim is to familiarize the student (in the direction of efficient use) with the classic variants of the type of shaft assemblies, respectively machines with support vectors. Later, during several sessions, it is discussed how to use convolutional networks inside a public bookstore. The aim is the practical acquisition of the necessary skills for the development of intelligent solutions for understanding the content at the image level and improving them by implementing new techniques and algorithms, learning the skills to solve concrete research problems, practical implementation and comparative validation of the results. Studying the Python environment with the PyTorch library.

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 of machine learning • Correlates the knowledge related to the MLAV field with those from color image processing and analysis (PAIC), respectively with those from Human-Machine Visual Interface (IVOM) • Apply knowledge in practice It applies standardized methods and tools, specific to the field, to carry out the evaluation and diagnosis process of a situation involving complex functions associated with the problem of automatic learning, depending on the problems identified/reported, and identifies solutions. • It argues and analyzes coherently and correctly the context of applying the basic knowledge of automatic learning in the context of visual applications, using key concepts such as classification, regression, supervised learning, deep neural networks, transfer learning • Oral and written communication in Romanian: uses the scientific vocabulary specific to the field, in order to communicate effectively, in writing and orally
Transversal (General) Competences	• Works in a team and communicates effectively, coordinating efforts with others to solve problem situations of medium complexity. • Autonomy and critical thinking: the ability to think in scientific terms, search and analyze data independently, and draw and present conclusions / identify solutions. Ability to analyze and synthesize: presents the acquired knowledge in a synthetic way, as a result of a process of systematic analysis. • Respects the principles of academic ethics: correctly cite the bibliographic sources used in the documentation activity. • Places elements of emotional intelligence into practice in the appropriate social-emotional management of real-life/academic/professional situations, demonstrating 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.* • Defines domain-specific notions: training/testing data, machine learning, optimization, classification, regression, neural networks, supervised, unsupervised learning. • Describes the process of training (optimization), convergence, overfitting. • Uses principled approaches (based on mathematical concepts and structures) for data analysis. • Highlights relationships between the nature of the data and the performance, between the trainable model and the performance, etc.

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).* • Select and group relevant information in the context of training applications. • Reasonably uses specific principles in view of abc. • Work productively in a team. • Elaborates a scientific text, on the occasion of the report associated with the project. • Experimentally verifies applied solutions with performances reported in the literature. • Solves practical applications, one of which is extensive in the project and several shorter ones in association with the laboratory. • Interpret causal relationships appropriately. • Identifies solutions and develops resolution/project plans. • Formulate conclusions to the experiments carried out. • Argue the identified solutions/workarounds
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • Selects appropriate bibliographic sources and analyze them. • Respects the principles of academic ethics, correctly citing the bibliographic sources used. • Demonstrates responsiveness to new learning contexts. • Demonstrates collaboration with other colleagues and teaching staff in carrying out teaching activities • Demonstrates autonomy in organizing the learning situation/context or the problem situation to be solved • Demonstrates social responsibility through active involvement in student social life/involvement in academic community events • Promotes/contributes through new solutions related to the specialized field to improve the quality of social life. • Realizes the value of his contribution in the field of engineering to the identification of viable/sustainable solutions to solve problems in social and economic life (social responsibility). • Apply principles of professional ethics/deontology in the analysis of the technological impact of the solutions proposed in the specialized field on the environment

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 students' learning characteristics and their specific needs, the teaching process will explore both expository (lecture, exposition) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct exploration and indirect of reality (experiment - especially in the case of the laboratory, demonstration, modelling), but also on action-based methods, such as exercise and practical activities.
- In the teaching activity, lectures will be used, based on some Power Point presentations that will be made available to the students.
- The presentations are interrupted by free discussions that appeal to the students' direct experience, respectively to small mathematical demonstrations.

- Each course will start with a recap of the chapters already covered, with an emphasis on the concepts covered in the last course.
- Presentations use images and diagrams so that the information presented is easy to understand and assimilate.
- This discipline covers information and practical activities designed to support students in their learning efforts and the development of optimal collaborative and communicative relationships in a climate conducive to discovery learning.
- The practice of active listening and assertive communication skills, as well as feedback construction mechanisms, will be taken into account, as ways of regulating behavior in various situations and adapting the pedagogical approach to the students' learning needs.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	1. Introduction. 1.1 The problem: generalities, definitions, applicability. 1.2. Linear regression 1.3 Limits of automatic learning	4
2	2. Feature selection: 2.1. Sequential selection 2.2. Principal Component Analysis - PCA 2.3 Independent component analysis – ICA 2.4. Locality Preserving Projection LPP properties	2
3	3. Ensemble learning 3.1. Principles 3.2. Bootstrapping	2
4	4. Boosting 4.1 Problem 4.2 Adaboost 4.3 LogitBoost.	2
5	5. Optimization 5.1 Netwon methods 5.2. Gradient descent 5.3. Constraint optimization	2
6	6. Neural networks 6.1 Perceptron, 6.2 Multi-layer perceptron 6.3 Backpropagation 6.4 Vanishing gradient	2
7	7. Convoluțional neuroal networks 7.1 Convolutional layer 7.2. Other layer. Non-linear activations 7.3 CNN architecture 7.4 Feature extraction with CNN 7.5 Computaționally efficient CNNs	4

8	8. Applications of CNN in computer vision problems 8.1 Localization 8.2 The Yolo model 8.3. Semantic segmentation	2
9	9. Transfer Learning 9.1 Domain adaptation 9.2 Self-taught learning 9.3 Active learning; hard negative mining 8.3. Contrastive learning	2
10	10. Semi-supervised learning 10.1. Low density area principle 10.2 Self-labelling 10.3 Co-training	2
11	11. Unsupervised learning 11.1. AutoEncoder 11.2 Generative adversarial networks	2
12	12. Transformer-type architectures 12.1. The self-attention mechanism 12.2 Visual transformers	2
	Total:	28

Bibliography:

- Course lectures are available on the Moodle page https://curs.upb.ro/2024/course/view.php?id=7263. These information are partially available at http://www.master-taid.ro/Cursuri/MLAV_curs.html
- Florea, C., Vertan, C. and Florea, L., 2023. SoftClusterMix: learning soft boundaries for empirical risk minimization. Neural Computing and Applications, pp.1-15.
- Badea, M., Florea, C., Racoviţeanu, A., Florea, L. and Vertan, C., 2023. Timid semi–supervised learning for face expression analysis. Pattern Recognition, 138, p.109417.
- Florea, C., Badea, M., Florea, L., Racoviteanu, A. and Vertan, C., 2020. Margin-mix: Semi-supervised learning for face expression recognition. In *Computer Vision–ECCV 2020: 16th European Conference, Glasgow, UK, August 23–28, 2020, Proceedings, Part XXIII 16* (pp. 1-17). Springer International Publishing.
- Corneliu Florea, Mihai Ciuc "Analiza faciala automata" - editura Politehnica Press, Bucuresti 2016, ISBN 978-606-515-1, 221 pag. Cod CNCSIS 19,
- Corneliu Florea, Laura Florea , Raluca Butnaru , Alessandra Bandrabur , Constantin Vertan "Pain Intensity Estimation by a Self–Taught Selection of Histograms of Topographical Features" , Image and Vision Computing, 10.1016/j.imavis.2016.08.014, Volume 56, Dec. 2016, Pages 13–27,
- C. Florea, F. Gieske, ”Artistic movement recognition by consensus of boosted SVM based experts”, Journal of Visual Communication and Image Representation, Vol 56, pp. 220-233, 2018
- Razvan Condorovici,Corneliu Florea, Constantin Vertan „Author Identification for Digitized Paintings Collections” in Proc. of IEEE International Symposium on Signals, Circuits and Systems ISSCS, Iulie, Iaşi, România, 2013, pp. 1-4;WOS:000337926700031
- Razvan Condorovici,Corneliu Florea, Ruxandra Vrânceanu, Constantin Vertan "Perceptually-Inspired Artistic Genre Identification System in Digitized Painting Collections", in Proc of Scandinavian Conference on Image Analysis 2013, pp 687-696
- Raluca Boia, Alessandra Bandrabur,Corneliu Florea, „Local description using multi-scale complete rank transform for improved logo recognition” 10th International Conference on Communications (COMM), page 1-4, 2014,
- Bishop, C. (2006). Pattern Recognition and Machine Learning. Pattern Recognition and Machine Learning.
- Ian Goodfellow and Yoshua Bengio and Aaron Courville “Deep Learning, MIT Press, 2016 disponibilă online la http://www.deeplearningbook.org

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to Python. The SciKit Learn package. Support Vector machines and tree enssembles	2
2	Pytorch library	2
3	Multi-layer perceptron and MNIST database	2
4	Convolutional neural networks 1	2
5	Convolutional neural networks 2	2
6	Autogenerative networks	2
7	Final evaluation	2
	Total:	

Bibliography:

- Practical works are available on the Moodle page https://curs.upb.ro/2024/course/view.php?id=7263 and partially available at http://www.master-taid.ro/Cursuri/MLAV_curs.html
- Introductory examples from scikit-learn https://scikit-learn.org/stable/tutorial/index.html
- Introductory examples from PyTorch https://pytorch.org/tutorials/
- Bishop, C. (2006). Pattern Recognition and Machine Learning. Pattern Recognition and Machine Learning.
- Ian Goodfellow and Yoshua Bengio and Aaron Courville “Deep Learning, MIT Press, 2016 disponibila online la http://www.deeplearningbook.org

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	knowledge of the fundamental theoretical notions of image processing and analysis in the context of automatic learning;	Written exam in the exam session corresponding to the semester; the subjects cover the entire subject, realizing a synthesis between the comparative theoretical course of the subject and the explanation through exercises and problems of application models.	20%
	knowledge of how to apply the theory to specific problems	Written exam in the exam session corresponding to the semester; the subjects cover the entire subject, realizing a synthesis between the comparative theoretical course of the subject and the explanation through exercises and problems of application models.	20%
11.5 Seminary/laboratory/project	Laboratory: simulation and practical implementation on the computer of the studied methods.	Final laboratory colloquium. Both the ability to implement and test a practical problem and the understanding of the theoretical aspects that underpin the chosen solution are evaluated	30
	Homework: Solving a problem with deep convolutional network	Oral examination in which the operation of the solution is verified, respectively the reasoning of the decisions made	30
11.6 Passing conditions			
Grade >= 50 pts			

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)

Every year the course is updated with recent discoveries that convince the community

Date	Course lecturer	Instructor(s) for practical activities
25.09.2025	Prof. Dr. Corneliu Nicolae FLOREA	Prof. Dr. Corneliu Nicolae FLOREA

Date of department approval	Head of department

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