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	Masters
1.6 Programme of studies	Advanced Computing in Embedded Systems

2. Date despre disciplină

2.1 Course name (ro) (en)				Introducere în vedere artificială și sisteme de învățare automată Fundamentals of Computer Vision and Machine Learning			
2.2 Course Lecturer				S.l./Lect. Dr. Andrei Mircea RACOVIȚEANU			
2.3 Instructor for practical activities				S.l./Lect. Dr. Andrei Mircea RACOVIȚEANU			
2.4 Year of studies	1	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DS	2.9 Course code	UPB.04.M1.O.22-09		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.					20
Tutoring					8
Examinations					5
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 of the following disciplines: Decision and estimation in information processing, Object Oriented Programming
4.2 Results of learning	Elements of algebraic calculus; 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 project will take place in a room equipped with a video projector

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** curricula is to familiarize students with the specific notions of computer vision and machine 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, especially in the field of computer-aided vision. The main characteristics and limitations of image processing and data analysis models such as filtering, feature extraction (LBP, HoG), tree assemblies, support vector machines or convolutional networks are discussed.

The objective of the **project** is the students' accommodation of solutions based on deep convolutional networks. The aim is to familiarize the student (in the direction of efficient use) with the public codes offered in this direction. Later, the specific aspects of a solution to recognize girls are discussed. The aim is the practical acquisition of the skills necessary for the development of intelligent solutions for understanding the content at the application level and their improvement by implementing new techniques and algorithms, learning the skills to solve concrete research problems, practical implementation and comparative validation of the results. The aim is to run a face recognition application on a device with limited resources

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 computer vision and machine learning • Correlates the knowledge related to the FCVML field with those of signal processing, respectively with those of programming • Applies 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 computer-aided vision, depending on the identified/reported problems, and identifies solutions. • Argues and analyze coherently and correctly the context of applying the basic knowledge of computer-aided vision, using key concepts such as digital camera, image descriptors, classification, regression, supervised learning, deep neural networks, • Oral and written communication in English: 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: digital image, pixel, filtering, image descriptor, training/testing data, artificial learning, optimization, classification, regression, neural networks, Describes the process of improving images or training (optimization), convergence, overfitting. • Uses principled approaches (based on mathematical concepts and structures) for image 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 computer vision applications. • Uses specific principles in order to solve automatic learning problems. • Works 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 course lectures. • Interprets 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). • Applies 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.
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- To support the theoretical concepts, web platforms that can simulate certain concepts of computer vision and machine learning will also be used. In this way, more abstract mathematical notions can be explained by hands-on visual examples. Students can also get involved in these more practical activities.
- 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	Introduction to the problem of computer vision	2
2	Introduction to the digital camera. Types of cameras	2
3	Low-level image processing	2
4	Filtering and feature extraction	2
5	Image registration. SIFT. Harris. RANSAC	4
6	Image descriptors: local and global	2
7	Introduction in machine learning	3
8	Nearest neighbor	1
9	Classification and regression tree. Ensembles	2
10	MultiLayer Perceptron. Support Vector Machine	2
11	Convolutional Neural Networks	2
12	Computer vision application of CNNs	2
13	Face recognition	2
	Total:	28

Bibliography:

- Course handsout on Moodle page https://curs.upb.ro/2023/course/view.php?id=9596
- Constantin Vertan, Mihai Ciuc, Marta Zamfir, Corneliu Florea, Laura Florea, Alina Sultana, Tiberiu Radulescu: "Prelucrarea si analiza imaginilor digitale - elemente fundamentale si aplicatii avansate", Editura MatrixRom, Bucuresti, Romania, 2013. 270 pag., ISBN 978-973-755-943-2
- Corneliu Florea, Bogdan Ionescu, Constantin Vertan: "Computer Vision - Tehnici de calibrare a camerei digitale si analizei informatiei vizuale", Editura MatrixRom, Bucuresti, Romania, 2013. ISBN 978-973-755-942-5, 180 pag.
- C. Vertan: Prelucrarea şi analiza imaginilor, Ed. Printech, Bucureşti, 1999, ISBN 973-9475-71-X
- C. Vertan, M. Ciuc : Căutarea imaginilor prin similaritatea conţinutului: o introducere, Ed. Printech, Bucureşti, 2002, ISBN 973-652-529-5.
- Corneliu Florea, Mihai Ciuc "Analiza faciala automata" - editura Politehnica Press, Bucuresti 2016,ISBN 978-606-515-1, 221 pag.
- Michael S. Brown: Understanding Color and the In-Camera Image Processing Pipeline for Computer Vision, ICCV2019 tutorial https://www.eecs.yorku.ca/~mbrown/ICCV19_Tutorial_MSBrown.pdf
- Bishop, C. (2006). Pattern Recognition and Machine Learning. Pattern Recognition and MachineLearning.
- Ian Goodfellow and Yoshua Bengio and Aaron Courville “Deep Learning, MIT Press, 2016 available at http://www.deeplearningbook.org

PROJECT

Crt. no.	Content	No. hours
1	The project refers to the application of a face recognition solution on a device with limited resources. It is individualized, each student receiving a unique set of recognizable images and people. The bibliography for each topic is specific and must be expanded by the student. The project is completed by presenting a functional solution and demonstrating it on the images provided individually.	14
	Total:	14

Bibliography:

- Jiahao Zhao "Face Recognition based on Convolutional Neural Network" Atlantis Press available online at: www.atlantis-press.com
- Adrian Rosebrock "Face detection with dlib (HOG and CNN)" available online at: https://pyimagesearch.com/2021/04/19/face-detection-with-dlib-hog-and-cnn/

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 computer vision	Written exam, midterm	30%
	Knowledge of the fundamental theoretical notions of machine learning	Written exam	30%

11.5 Seminary/laboratory/project	Solving a face recognition problem with deep convolutional networks running on an embedded device	oral presentation	40%
11.6 Passing conditions			
Total points >= 50			

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)

Periodically the course is updated with recent findings that convince the community

Date	Course lecturer	Instructor(s) for practical activities
09.09.2022	S.l./Lect. Dr. Andrei Mircea RACOVIȚEANU	S.l./Lect. Dr. Andrei Mircea RACOVIȚEANU

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