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

# COURSE DESCRIPTION

## 1. Program identification information

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|---|---|
| 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

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|---|---|---|---|---|---|---|---|
| 2.1 Course name (ro)<br>(en) | | | | Tehnici de analiză şi clasificare automată a informaţiei<br>Information analysis and automatic classification techniques | | | |
| 2.2 Course Lecturer | | | | Prof. Dr. Bogdan Emanuel IONESCU | | | |
| 2.3 Instructor for practical activities | | | | S.l./Lect. Dr. Serban CARATĂ | | | |
| 2.4 Year of studies | 1 | 2.5 Semester | II | 2.6. Evaluation type | E | 2.7 Course regime | Ob |
| 2.8 Course type | | S | 2.9 Course code | 2 | | 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<br>Supplemental documentation (library, electronic access resources, in the field, etc)<br>Preparation for practical activities, homework, essays, portfolios, etc. | | | | | 53 |
| Tutoring | | | | | 0 |
| Examinations | | | | | 5 |
| Other activities (if any): | | | | | 0 |

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| 3.7 Total hours of individual study | 83.00 |
| 3.8 Total hours per semester | 125 |
| 3.9 Number of ECTS credit points | 5 |

## 4. Prerequisites (if applicable) (where applicable)

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| 4.1 Curriculum | General knowledge of digital signal processing and computer programming. |

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| 4.2 Results of learning | Not applicable. |

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

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|---|---|
| 5.1 Course | The course will take place in a room equipped with a video projector and computer. |
| 5.2 Seminary/ Laboratory/Project | The laboratory will be held in a room with specific equipment, which must include: individual computer, specific software such as Matlab, Python and C++ compiler. |

**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 course aims to provide students with basic knowledge of multimedia data processing and analysis techniques and algorithms with the objective of being able to design, implement and evaluate practical automatic information classification systems. The course starts from a general introduction to the field of data science, continues with familiarization with the concepts of multimedia data processing and representation (image-video-audio-text), unsupervised classification techniques (clustering), supervised classification techniques (classification) where the system learns to achieve certain objectives based on examples and ends with the presentation of the methods for evaluating the performance of such systems. The laboratory applications aim to provide practical mastery of the main concepts taught in the course, using various programming environments, through the development of concrete, practical software applications, such as the classification by genre of video sequences for media platforms such as YouTube, the automatic classification of objects in images for information search platforms such as Google Image Search, the automatic identification of faces for biometric security systems, and so on.

**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.)*

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| **Specific Competences** | Demonstrates basic/advanced knowledge in the field of data analysis techniques, supervised and unsupervised classification techniques, as well as performance evaluation of prediction systems.<br>Correlates knowledge of computer system programming with that of implementing algorithms specific to machine learning.<br>Applies knowledge in practice to design, develop and implement systems that solve concrete problems in fields such as security, medicine, finance, etc.<br>Analyzes and interprets the results of automatic information classification systems.<br>Uses scientific vocabulary specific to the field, in order to communicate effectively, in writing and orally.<br>Demonstrates understanding of the vocabulary related to the field in English. |
| **Transversal (General) Competences** | They work in a team and communicate effectively, coordinating their efforts with others to solve problems of medium complexity.<br>They have the ability to think in scientific terms, to search for and analyze data independently, as well as to capture and present conclusions/identify solutions.<br>They have the ability to analyze and synthesize knowledge and information for a specific topic.<br>They respect the principles of academic ethics by respecting intellectual property. |

**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.)*

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| **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.*<br>Defines the main concepts of the field.<br>Knows the basic notions of multimedia data pre-processing specific to machine learning systems.<br>Knows the basic notions of operation of unsupervised and supervised classification systems.<br>Knows the principles of evaluating the performance of information classification systems. |
| **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).*<br>Uses programming languages to implement multimedia data processing and information classification systems.<br>Identifies solutions, designs, develops and implements machine learning systems that solve concrete multi-modal information processing problems.<br>Uses specific concepts to evaluate the performance of a classification system.<br>Develops a scientific text presenting methods and results.<br>Interprets appropriately the results obtained from the analysis of information classification systems. |
| **Responsability and autonomy** | *The student's capacity to autonomously and responsably apply their knowledge and skills.*<br>Selects appropriate bibliographic sources and analyzes them.<br>Respects the principles of academic ethics by respecting intellectual property.<br>Demonstrates collaboration with other colleagues and teachers in carrying out teaching activities.<br>Recognizes the value of his contribution in the field of engineering to identifying viable/sustainable solutions to solve problems in social and economic life (social responsibility). |

**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 courses are taught in an interactive manner, encouraging active student participation and teamwork. Multimedia tools and techniques (video projector) are used. Course materials are available in electronic format on the Internet and in the classroom. In the laboratory, teaching is based on oral communication and detailed explanation of the methods used and the results obtained; students design and experiment with a series of data processing and information classification systems. Laboratory materials are available to students in printed and electronic form on the Internet and in the laboratory.

**10. Contents**

| **COURSE** | | |
|---|---|---|
| **Chapter** | **Content** | **No. hours** |

| | | |
|---|---|---|
| 1 | Introduction<br>1.1 Introduction Current context<br>1.2 Concrete applications<br>1.3 The concept of learning<br>1.4 Domain terminology<br>1.5 Existing techniques<br>1.6 Software utilities | 4 |
| 2 | Processing and Representing Input Data<br>2.1 Data Representation<br>2.2 Content Description<br>2.3 Data Normalization<br>2.4 Data Decorrelation | 6 |
| 3 | Unsupervised Classification Techniques<br>3.1 General<br>3.2 Data Similarity Analysis<br>3.3 Hierarchical Classification<br>3.4 Classification using k-means<br>3.5 Classification using Gaussian Mixture Models | 6 |
| 4 | Supervised Classification Techniques<br>4.1 General<br>4.2 Classification using k-NN<br>4.3 Classification using Support Vector Machines<br>4.4 Classification using decision trees | 6 |
| 5 | Evaluating the performance of classifiers<br>5.1 General<br>5.2 Performance measures and metrics<br>5.3 Evaluating performance by partitioning the dataset<br>5.4 Examples of classification systems | 6 |
| | **Total:** | 28 |

**Bibliography:**

1. Bogdan Ionescu, Şerban Carata, TACAI, suport de curs electronic, https://curs.upb.ro/2021/course/view.php?id=9558
2. B. Ionescu, I. Mironică, Conceptul de Indexare Automată după Conţinut în Contextul Datelor Multimedia, Editura MartrixRom, ISBN: 978-973-755-941-8, 2013 (112 pagini, PDF: http://campus.pub.ro/lab7/bionescu/index_files/pub/Conceptul%20de%20Indexare.pdf; Premiul “Constantin Dinculescu” al Academiei Oamenilor de Ştiinţă).
3. Mark A. Hall, Eibe Frank, Ian H. Witten, Christopher J. Pal, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann Publishers, 2016.

**LABORATORY**

| Crt. no. | Content | No. hours |
|---|---|---|
| 1 | Development environments for information classification systems. Creating an image database for classification. | 2 |
| 2 | Manipulation and processing of input data for a classification system: multimedia content descriptors, normalization and decorrelation. | 2 |

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|---|---|---|
| 3 | Unsupervised classification systems (hierarchical classification, k-means) and applications. | 3 |
| 4 | Supervised classification systems (k-NN, Support Vector Machines) and applications. | 3 |
| 5 | Evaluation of classification system performance (precision, recall, F-measure). | 2 |
| 6 | Final colloquim | 2 |
| | **Total:** | 14 |

**Bibliography:**

1. Bogdan Ionescu, Şerban Carata, TACAI, suport de curs electronic, https://curs.upb.ro/2021/course/view.php?id=9558
2. Libraria OpenCV https://docs.opencv.org/4.x/
3. Librăria ScikitLearn https://devdocs.io/scikit_learn/

**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 related to multimedia data processing, classification and performance evaluation of decision systems. | Written exam in the exam session corresponding to the semester. The subjects cover the entire subject, achieving a synthesis between the comparative theoretical examination of the discipline and the explanation of the application models through exercises and examples. | 20 |
| | - Knowing how to apply theory to specific implementation problems. | Written exam in the exam session corresponding to the semester. The subjects cover the entire subject, achieving a synthesis between the comparative theoretical examination of the discipline and the explanation of the application models through exercises and examples. | 20 |
| | - Differential analysis of theoretical principles and methods. | Written exam in the exam session corresponding to the semester. The subjects cover the entire subject, achieving a synthesis between the comparative theoretical examination of the discipline and the explanation of the application models through exercises and examples. | 10 |

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|---|---|---|---|
| 11.5 Seminary/laboratory/project | - Understanding the principles of multimedia data processing and content descriptors. | Final laboratory colloquium consisting of the evaluation of an individual project - the full development of a content classification system for a specific concrete requirement. Both the understanding of the theoretical aspects and the ability to implement and test a practical problem are assessed. | 20 |
| | - Knowledge and practical implementation of the studied unsupervised and supervised classification techniques. | Final laboratory colloquium consisting of the evaluation of an individual project - the full development of a content classification system for a specific concrete requirement. Both the understanding of the theoretical aspects and the ability to implement and test a practical problem are assessed. | 20 |
| | - The possibility of evaluating the performance of a classification system through tests. | Final laboratory colloquium consisting of the evaluation of an individual project - the full development of a content classification system for a specific concrete requirement. Both the understanding of the theoretical aspects and the ability to implement and test a practical problem are assessed. | 10 |
| 11.6 Passing conditions | | | |
| Obtaining 50% of the total mark. | | | |

**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 curriculum provides graduates with the mathematical and programming tools necessary for the practical implementation, on computing systems, of multimedia data analysis and processing techniques as well as various decision-making systems that involve the classification of information by content. The discipline specifically responds to the current requirements for the development and evolution of the European economy of ICT services. In the context of the current progress of information technology and electronic devices, the areas of activity targeted are extremely numerous, from "consumer" applications (speech technologies for incorporation into various household appliances or mobile terminals of the "smart-phone" type), the medical field (products and technologies for signal analysis and processing, control of medical robots, medical prescription dictation systems, indexing of medical databases), the security field (biometric systems based on speaker recognition), the field of audio indexing for multimedia applications, robotics (intelligent interfaces based on speech recognition and voice response) and others. This ensures that

graduates have skills appropriate to the needs of current qualifications and a modern, quality and competitive scientific and technical training, which will allow them to be employed quickly after graduation, the discipline being perfectly aligned with the policy of the POLITEHNICA University of Bucharest, both in terms of content and structure, as well as in terms of the skills and international openness offered to students. Potential employers target both the academic environment (teaching and research profile) and the research and development environment in state and private institutions that use decision-making, machine learning and artificial intelligence information systems.

| Date | Course lecturer | Instructor(s) for practical activities |
|---|---|---|
| 25.09.2025 | Prof. Dr. Bogdan Ionescu | S.l./Lect. Dr. Serban CARATĂ |

| Date of department approval | Head of department |
|---|---|
| | Conf. Bogdan Florea |

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