# Politehnica University of Bucharest

# Faculty of Electronics, Telecommunications and Information Technology

**COURSE DESCRIPTION**

**1. Program identification information**

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| 1.1 Higher education institution | POLITEHNICA University of 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’s degree |
| 1.6 Program of studies/Qualification | Information engineering |

**2. Course identification information**

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| 2.1 Name of the course | | | | Pattern Recognition and Artificial Intelligence | | | |
| 2.2 Lecturer | | | | Prof. Dr. Victor-Emil Neagoe | | | |
| 2.3 Instructor for practical activities | | | | Lect. Dr. Dumitru-Adrian Ciotec | | | |
| 2.4 Year of studies | III | 2.5 Semester | II | 2.6 Evaluation type | Exam | 2.7 Course choice type | Compulsory |

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

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| 3.1 Number of hours per week, out of which | 4 | | 3.2 course | 2 | 3.3 practical activities | | 2 |
| 3.4 Total hours in the curricula, out of which | 56 | | 3.5 course | 28 | 3.6 practical activities | | 28 |
| Distribution of time | | | | | | | hours |
| Study according to the manual, course support, bibliography and hand notes | | | | | | | 32 |
| Supplemental documentation (library, electronic access resources, in the field, etc) | | | | | | | 10 |
| Preparation for practical activities, homeworks, essays, portfolios, etc. | | | | | | | 18 |
| Tutoring | | | | | | | 0 |
| Examinations | | | | | | | 4 |
| Other activities | | | | | | | 0 |
| 3.7 Total hours of individual study | | 64 | | | |  |  |
| 3.9 Total hours per semester | | 120 | | | |  |  |
| 3.10 Number of ECTS credit points | | 4 | | | |  |  |

**4. Prerequisites (if applicable)**

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| 4.1 curricular | 1. Special Mathematics;  2. Signals and Systems; |
| 4.2 competence-based | Programming skills in Matlab environment. |

**5. Requisites (if applicable)**

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| 5.1 for running the course | Not the case. |
| 5.2 for running of the applications | The presence at laboratories is compulsory |

**6. Specific competences**

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| Professional competences | C6. Application in typical cases of basic image acquisition and processing methods as well as those of *artificial intelligence*:  – using of methods and specific tools for image analysis and *pattern recognition.*  – using of (Matlab) simulation environment for analysis and processing of digital images and solving pattern recognition problems. |
| Transversal competences | CT1. Honorable, responsible, ethical and in the spirit of law behavior to ensure the reputation of the profession. |

**7. Course objectives (as implied by the grid of specific competences)**

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| 7.1 General objective of the course | The main purpose of this subject is to develop the student abilities to understand and apply the general knowledge of *pattern recognition and artificial intelligence* for specific projects. The curriculum aims to present both the knowledge of natural inspired intelligent systems (artificial neural networks, fuzzy and neuro-fuzzy systems, genetic algorithms, swarm intelligence) and also to present basics of intelligent systems using statistical and logic-symbolic techniques. A curriculum target is also to train the students for algorithm implementation using dedicated software (Matlab). |
| 7.2 Specific objectives | – *For courses:*  Students will learn basic principles of pattern recognition and artificial intelligence: theory, algorithms, architectures and applications.  – *For applications*:  The students must learn to implement corresponding algorithms using dedicated software (MATLAB) for the following curriculum chapters:   * Feature selection * Supervised classification * Unsupervised classification * Artificial neural networks * Swarm Intelligence * Fuzzy systems |

**8. Contents**

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| 8.1 Lectures | Teaching techniques | Remarks |
| **1. Bayes algorithms and discriminant functions in pattern recognition.** Bayes theory of classification. Discriminant functions for M classes (M≥2). Case of normal multivariate densities. | Most of teaching time (90%) course presentation uses the video projector (corresponding to the communication and demonstrative functions). The oral communications methods are expositive method and questioning method. For explanation or pointing out some details/examples, one has made “zoom” using the old classic method with chalk and sponge on the blackboard (for 10% of time). The lecture notes are given to the students in electronic form | 6 h |
| **2. Clustering**. Classical algorithms. Thorndike algorithm.„Basic Isodata” (Ball-Hall) algorithm. „Fuzzy Isodata” algorithm. Hierarchical clustering. | 4 h |
| **3. Feature selection.** Principal Component Algorithm (PCA). Fisher criterion. Linear Discriminant Analysis (LDA). Independent Component Analysis (ICA). Divergence criterion. Nonlinear transforms and projection in 2D spaces. | 3 h |
| **4. Supervised artificial neural networks.** Multilevel perceptron. Radial basis function neural network. Associative neural networks (Hopfield, memory; bidirectional associative memory). | 6 h |
| **5. Unsupervised artificial neural networks.** Carpenter-Grossberg neural net (ART1). Self-organizing map (Kohonen neural net). Hebbian neural network for principal component analysis. | 6 h |
| **6. “Fuzzy” systems.** Introduction to fuzzy logic. Fuzzy metrics. Fuzzy implications. Approximate reasoning. Classification systems with fuzzy rules. | 6 h |
| **7. Neuro-fuzzy systems.** Integration of fuzzy logic and artificial neural networks. Fuzzy neurons. Neural networks trainable with IF-THEN fuzzy rules. The Kwan-Cai fuzzy neural net. Fuzzy-perceptron. Fuzzy-ART. Fuzzy” self-organizing map. | 3 h |
| **8. Genetic algorithms.** The stages of the genetic algorithm: selection, crossover, mutation. Optimization of multidimensional functions. Neural networks with genetic algorithms. Applications in pattern recognition. | 6 h |
| **9. Symbolic computation and expert systems.** Knowledge representation. Inference machine. Predicate of first order. Controlul Inference control. Models of elementary actions. Hierarchical planning. Planning using metareasoning. Expert systems: structure and applications. |  |  |
| **10. Applications.** Classification of medical signals and images. Recognition of planar images. Automatic analysis of satellite imagery. Biometric technology : face recognition, iris recognition, speaker identification. Applications for security and national defense. Mobile robots with artificial vision. Earthquake prediction. Financial prediction. |  |
| Bibliography  (1) V. Neagoe, O. Stanasila, Teoria recunoasterii formelor, Ed. Academiei Romane, Bucuresti, 1992.  (2) V. Neagoe, O. Stanasila, Recunoasterea formelor și retele neurale, Ed. Matrix ROM, Bucuresti, 1999.  (3) V. Neagoe, Inteligenta computationala, in Enciclopedia Matematica, coordonatori volum Marius Iosifescu and O. Stanasila , Ed. AGIR, Bucuresti, 2010.  (4) Z. Michalewicz, Genetic Algorithms + Data structures = Evolution Programs, Springer, Berlin, 1996.  (5) M. Bishop, Pattern Recognition and Machine Learning, Springer, New York, 2006.  (6) A. Engelbrecht, Computational Intelligence, John Wiley & Sons, West Sussex, England, 2002.  (7) V. Neagoe, “Decorrelation of the Color Space, Feature/Decision Fusion, and Concurrent Neural Classifiers for Color Pattern Recognition”, The 2008 World Congress in Computer Science, Computer Engineering, and Applied Computing (WORLDCOMP'08), International Conference on Image Processing, Computer Vision & Pattern Recognition (ICPV'08), July 14-17, 2008, Las Vegas, Nevada, USA., pp. 28-34.  (8) V. Neagoe and G. Strugaru, "A concurrent neural network model for pattern recognition in multispectral satellite imagery", Proc. of the World Automation Congress, 2008 (WAC 2008), International Symposium on Soft Computing in Industry (ISSCI'08), Sept. 28–Oct. 2, 2008, Hawaii, USA, ISBN :978-1-889335-38-4, IEEE Catalog No. 08EX2476.  (9) V. E. Neagoe, A. Ropot, and A. Mugioiu, “Real Time Face Recognition Using Decision Fusion of Neural Classifiers in the Visible and Thermal Infrared Spectrum”, Proc. of the 2007 IEEE International Conference on Advanced Video and Signal based Surveillance (AVSS 2007), London (United Kingdom), 5-7 September 2007, ISBN :978-1-4244-1696-7  (10) V. Neagoe, R. Stoica, A. Ciurea, "A Modular Neural Model for Change Detection in Earth Observation Imagery," 2013 IEEE International Geoscience & Remote Sensing Symposium Proceedings (IGARSS 2013), Melbourne (Australia), 2013, pp. 3321-3324. | | |
| 8.2 Practical applications | Teaching techniques | Remarks |
| k-Nearest Neighbour (k-NN), Nearest Prototype (NP)  Naive Bayes classifier | All the laboratory works use Matlab environment simulation. The lab platforms are available for the students in their electronic form. Sometimes one complementary uses the classical method with chalk, sponge and blackboard.  Students independently simulate, implement, test and evaluate same problems by using the computer and software environment. | 4 h |
| Principal Component Analysis (PCA) | 4 h |
| Linear Discriminant Analysis (LDA)  Self-organizing map (Kohonen neural network) | 4 h |
| Multilayer Perceptron neural network (MLP)  Radial Basis Functions neural network (RBF) | 4 h |
| Genetic algorithms  Ant Colony Optimization (ACO) | 4 h |
| K-Means Clustering  Fuzzy C-Means  Hopfield neural network | 4 h |
| Final assessment | 4 h |
| Bibliography  <http://www.victorneagoe.com/university/prai/lab.html> | | |

**9. Bridging the course content with the expectations of the epistemic community representatives, professional associations and employers representatives for the domain of the program**

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| The curriculum of *Pattern Recognition and Artificial Intelligence* course corresponds to the present requirements for development and evolution characterizing UE economy and services belonging to the field of Computers and Information Technology. Within the present technological progress the fields connected with the knowledge and techniques included in the curriculum of the course has wide practical applications for various fields: security (surveillance and biometry chapters based on facial image recognition, iris recognition, speaker recognition), consumer applications (digital video camera or smartphone with technology of *face detection*), medicine (medical diagnosis), analysis of Earth Observation image data for civil and military applications (technologies of remote sensing for pattern recognition in satellite imagery), industrial control (quality control), robotics (human-machine interaction), finance (financial prediction), seismology (Earthquake prediction) and so on.  The curriculum provides to the graduates competences adequate to the present necessities as well as a modern high quality scientific and technical training; this can aid the graduates to find a job faster. The curriculum is in accordance to the policy of the Politehnica University of Bucharest, both from the point of view of their contents and structure and also from the point of view of training and international opening offered to the students. |

**10. Evaluation**

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| Type of activity | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Weight in the final mark |
| 10.4 Lectures | - knowledge of basic theoretical concepts;  - knowledge of the theory applications to specific problems;  - differential analysis of the theoretical methods and techniques. | Written work for partial examination (1.5 hours in 9th week corresponding to 50% of course contents) | 35% |
| Final written examination (1.5 hours corresponding to the rest 50% of course contents non-included in the first verification) | 35% |
| 10.5 Practical applications | – learning algorithm designing to solve a specific problem;  – learning to write the corresponding Matlab code for a given algorithm  – demonstration of operation for an implemented algorithm  – ability to solve and implement in Matlab an elementary problem  – ability to comparatively analyze the studied techniques and algorithms | Laboratory assessment (last week) | 30% |
| 10.6 Minimal performance standard | | | |
| Simultaneously satisfying the following conditions:   * scoring 50 % out of the total score * scoring 50 % out of the score of the written work for partial examination * scoring 50 % out of the total lab score | | | |

Date Lecturer Instructor for practical activities

Prof. Dr. Victor-Emil Neagoe Lect. Dr. Adrian Ciotec

15.11.2013 ............................................. .............................................

Date of department approval Director of Department,

Prof. Dr. Sever Paşca