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	Applied Electronics

2. Date despre disciplină

2.1 Course name (ro) (en)				Rețele neurale și sisteme Fuzzy Neural Networks and Fuzzy Systems			
2.2 Course Lecturer				Prof. Dr. Georgeta-Mihaela NEAGU			
2.3 Instructor for practical activities				Prof. Dr. Georgeta-Mihaela NEAGU			
2.4 Year of studies	3	2.5 Semester	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.06.O.113		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.					6
Tutoring					0
Examinations					2
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	Attending and/or graduating the following courses: Mathematical Analysis Linear Algebra, Analitic and Differential Geometry Object Oriented Programming Algorithms and Data Structures Fundamentals of Information Science Digital signal processing Decision and Estimation in Information Processing Medical electronics and informatics
4.2 Results of learning	Acquiring the following knowledge: mathematics algorithms object-oriented programming digital signal processing decision and estimation programming (knowledge in Matlab programming)

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

5.1 Course	The lectures will be presented using the videoprojector.
5.2 Seminary/ Laboratory/Project	The lab will be run using the videoprojector and the computers having Matlab installed on. The labs are mandatory, as stipulated by the „Regulamentul studiilor universitare de licenţă” (Romanian version only) and „Regulamentul privind activitatea profesională a studenţilor” (Romanian version only).

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 provides the basic knowledge in neural networks and fuzzy systems. Different types of neural networks and fuzzy systems are analized, revealing especially the learning mechanisms an the implementation strategy using general sofware (C, C++) or dedicated software (Matlab). The neural networks and fuzzy systems aplicability in electronics is also investigated.
Specific objectives (e.g., applying the general knowledge in undestanding and developing of concrete neural networks and fuzzy ystems applications, using Matlab dedicated toolboxes) are considered. Particularly, the following aspects are of interest:
acquiring the basic knowledge about the neural networks and fuzzy systems classification
getting familiar with the AI problem identification and implementing the proper AI systems using Matlab.

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	Demonstrate the ability to operate with basics of neural networks and fuzzy systems and correlates and applies the domain knowledge/methods/toold, identifying proper solutions for the AI problems, with the support of neural networks and fuzzy systems. Provides solid arguments for the proposed AI structure (SW and/or HW) by: - identifying the problems group and their specific solving by using neural networks and fuzzy systems; - using interdisciplinary knowledge, standard solutions/tools, running experiments and evaluating the provided results. Communicate fluently, verbally and in written, in English, using the vocabulary specific to the course domain.
Transversal (General) Competences	Throughly investigates an AI problem, looking for available AI solutions, to offer the best solving strategy. Work within teams and efficiently communicate with the colleagues to solve problems of a medium complexity. Critical and independent evaluation: the students have the scientific ability to look for the necessary information and to present valuable conclusions/solutions. The ability to analyse and synthesize: the students have the ability to present efficiently the acquired knowledge, applying the systematisation. Respect the academic ethics: proper citation. Apply emotional intelligence principles to emotionally and socially solve some situations regarding the real life/academic/professional tasks, showing self control and objectivity when deciding and under stress.

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 information regarding the domain development. **Define**s domain specific concepts. **Descr**ibes/classify domain specific concepts/processes/fenomena/structures. **Reveals** domain specific consequences and relations.

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. **Apply** logically argued the domain specific principles. **Efficently** work within teams. **Generate** scientific documents. **Experimentally** verify the identified solutions. **Solve** practical applications. **Correctly** identify the causal relations. **Anali**se and compare available domain solutions. **Identif**y solutions and propose solving plans/projects. **Formul**ate conclusions regarding the realzed experiments. **Give** arguments when identifying solving solutions/steps.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* **Select** and analyze the appropriate literature. **Respect** the academic ethics, correctly citing the used literature. **Are open** to learn new concepts. **Collaborate** with the colleagues and the academic staff during the didactical activities. **Show** authonomy when organizing some applications, learning activities or when solving specific problems **Show social** responsability by geting involved in the academic social life. **Promo**te and contribute to the domain, offering new solutions, to improve the quality of the social life. **Realistically** identify the contribution of the engineering domain to the social and economic life by offering reliable and sustenable solutions. **Apply** professional ethics/deonthologyn when evaluating the technological impact of the domain specific proposed solutions, considering the environmental impact. **Anali**ze and take business opportunities specific to the domain. **Demonstr**ate management skills in real life situations (time administration, conflict elimination).

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 teaching will include both knowledge presentation and interactive discussions, considering the learning preferences of the students and their learning needs; the direct and inderect exploration will be considered (experiments, demonstrations, modelling), and also active learning will be involved (exercises, problems solving, practical activities).
Power point presentations and specialized videos will be considered. Each course will summarize the information from the previous lectures, stressing especiallly the knowledge from the last course.
The lectures will contain images, plot and diagrams that facilitate information acquiring.
The course provides knowledge and practical activities that support students development by establishing optimal communication and collaboration steps and by discovery.
The active information listening and assertive communication skills will be considered, and the feedback will be implemented to include the needs of the students.
Team working activities will be also implemented.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction: Neural networks and fuzzy systems characteristics; Neural network classification; Fuzzy sets and fuzzy logic operators; Fuzzy principles in neural networks	4
2	Introduction: Neural networks and fuzzy systems characteristics; Neural network classification; Fuzzy sets and fuzzy logic operators; Fuzzy principles in neural networks	4
3	Perceptron	4
4	Perceptron	6
5	ADALINE	5
6	ADALINE	5
7	Feed Forward Multilayer Neural Networks. BKP	0
8	Feed Forward Multilayer Neural Networks	0
9	Self Organising Neural Networks: Generalized Hebbian Learning: Competitive Learning. Competitive neural networks: Self Organizing Maps (SOM)	0
10	Self Organising Neural Networks: Generalized Hebbian Learning: Competitive Learning. Competitive neural networks: Self Organizing Maps (SOM)	0
11	Fuzzy systems: Fuzzyfication rules; Rules base development; Defuzzyfication methods; Mamdani system; Sugeno system; Neuro-fuzzy systems	0
12	Fuzzy systems: Fuzzyfication rules; Rules base development; Defuzzyfication methods; Mamdani system; Sugeno system; Neuro-fuzzy systems	0
	Total:	

Bibliography:

11. M. Neagu - Neural Networks and Fuzzy Systems – Lectures Notes, in preparation. M. Ungureanu, Neural Networks and Fuzzy Systems – Power Point Presentations.
22. Graschew Georgi and Roelofs Theo A. (2011). Advances in telemedicine: applications in various medical disciplines and geographical regions, Chapter G. Mihaela Ungureanu, Ilinca Gussi, Werner Wolf, Dragos Taralunga, Sever Pasca and Rodica Strungaru, Advances in Telemedicine, Ch. Prenatal telemedicine - Advances in fetal monitoring, InTech Publisher, March 2011, pp. 97-120, ISBN 978-953-307-161-9, 24 pages, 1 col.
33. Craus M., Galea D., Valachi Al. – New trends in computer science and engineering, Chapter: Strungaru Rodica and Ungureanu Mihaela - Artificial Inteligence in Myoelectric Signal Processing, Polirom Press, Iasi (appreciated by CNCSIS), 2003, pp. 224-237, ISBN 973-9476-40-6 (264 pages), 14 pages, 1 col.
44. Pandalai S. G. - Recent Research Developments in Biomedical Engineering, Chapter Ungureanu Mihaela, Kroworsch Bauer, Wolf Werner - Diaphragmatic EMG Monitoring: Some Aspects on Specific Signal Processing Requirements, Transworld Research Network, 2002, pp. 49-66, ISBN 81-7895-013-8 (193 pages), 18 pages, 1 col.
55. Nielsen Michael (2019). Neural Networks and Deep Learning, The original online book can be found at http://neuralnetworksanddeeplearning.com
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77. Christian Dawson. Applied Artificial Neural Networks (2016). Publisher: MDPI AG 2016, ISBN-13: 9783038422716, http://www.mdpi.com/books/pdfview/book/236 Toshinori Munakata, Fundamentals of the New Artificial Intelligence. Neural, Evolutionary, Fuzzy and More, Second Edition, Springer-Verlag 2008, ISBN 978-1-84628-838-8.
88. N. K. Kasabov, Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering, The MIT Press, 1998, ISBN 0-262-11212-4.
99. M. Akay, Handbook of neural engineering, John Wiley&Sons, 2007, ISBN 0-978-0-470-05669-1.
10. S. Haykin, Neural Networks, 2nd Edition, Prentice Hall, 1999, ISBN 0-13-273350 -1.
11. Gurney K., An Introduction to Neural Networks, UCL Press, 1997, ISBN 1-85728-503-4
12. R. Fuller, Introduction to Neuro-Fuzzy Systems, Springer Verlag, 2000, ISBN: 978-3-7908-1256-5

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to MATLAB. Basic properties of neural networks. Perceptron. ADALINE	4
2	Introduction to MATLAB. Basic properties of neural networks. Perceptron. ADALINE	4
3	Feedforward Neural Networks. MLP. RBF	4
4	Feedforward Neural Networks. MLP. RBF	2
5	SOM	0
6	SOM	0
7	Final lab examination	0
8	Final lab examination	0
	Total:	

Bibliography:

11. M. Neagu - Neural Networks and Fuzzy Systems – Lectures Notes, in preparation. M. Ungureanu, Neural Networks and Fuzzy Systems – Power Point Presentations.
22. Graschew Georgi and Roelofs Theo A. (2011). Advances in telemedicine: applications in various medical disciplines and geographical regions, Chapter G. Mihaela Ungureanu, Ilinca Gussi, Werner Wolf, Dragos Taralunga, Sever Pasca and Rodica Strungaru, Advances in Telemedicine, Ch. Prenatal telemedicine - Advances in fetal monitoring, InTech Publisher, March 2011, pp. 97-120, ISBN 978-953-307-161-9, 24 pages, 1 col.
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77. Christian Dawson. Applied Artificial Neural Networks (2016). Publisher: MDPI AG 2016, ISBN-13: 9783038422716, http://www.mdpi.com/books/pdfview/book/236 Toshinori Munakata, Fundamentals of the New Artificial Intelligence. Neural, Evolutionary, Fuzzy and More, Second Edition, Springer-Verlag 2008, ISBN 978-1-84628-838-8.
88. N. K. Kasabov, Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering, The MIT Press, 1998, ISBN 0-262-11212-4.
99. M. Akay, Handbook of neural engineering, John Wiley&Sons, 2007, ISBN 0-978-0-470-05669-1.
10. S. Haykin, Neural Networks, 2nd Edition, Prentice Hall, 1999, ISBN 0-13-273350 -1.
11. Gurney K., An Introduction to Neural Networks, UCL Press, 1997, ISBN 1-85728-503-4
12. R. Fuller, Introduction to Neuro-Fuzzy Systems, Springer Verlag, 2000, ISBN: 978-3-7908-1256-5

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Proving the undestanding of the fundamental knowledge. Differential analysis of the theoretical methods/techniques.	written	30%
	Proving the undestanding of the fundamental knowledge. Differential analysis of the theoretical methods/techniques.	written/project	20%
	Proving the ability to apply the theory when solving specific problems.		

11.5 Seminary/laboratory/project	Proving the ability to design neural networks and fuzzy systems for solving specific problems.	written	15%
	Proving the ability to design neural networks and fuzzy systems for solving specific problems.	written/project	15%
	Proving the ability to implement neural networks and fuzzy systems in Matlab.	written/project	20%
	Proving the ability to succesfully apply neural networks and fuzzy systems.		
11.6 Passing conditions			
Exemplu: Graduation rules valid for the students enrolled at ETTI/UPB. Obtaining 50% of the evaluation mark. Obtaining 50% of the evaluation mark during the semester.			

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)

Artificial intelligence, and particularly neural networks and fuzzy systems, are currently used in all applied electronics domains, the industry monitoring the progress. The industry demands engineers specialized in neural networks and fuzzy systems and with strong knowledge in electronics, systems, information technology, to propose new hardware and software applications.
The course curriculum reflect the current development directions, agreed by the European prospects in electronics and telecommunications. Considering the current technological progress in electronical devices, the applicability areas are in fact limitless, including among others common use applications (photo cameras, smart-phones), medical applications (analysis/diagnosis, etc), military applications remote sensing based on satellite images), security (surveilance systems, biometric systems), automatic control (product verification), robotics, man machine interfaces, etc.
The students will therefore acquire competences required by the current scientific and technical development, that allow their fast employment, the course being perfectly integrated in the educational strategy of the Politehnica University of Bucharest, that considers also the international opportunities for the student.

Date	Course lecturer	Instructor(s) for practical activities
9.10.2024	Prof. Dr. Georgeta-Mihaela NEAGU	Prof. Dr. Georgeta-Mihaela NEAGU

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Date of department approval	Head of department Conf. Dr. Bogdan Cristian FLOREA
Date of approval in the Faculty Council	Dean Prof. Dr. Mihnea Udrea