COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	Politehnica University of Bucharest
1.2 Faculty	Faculty of Electronics, Telecommunications and Information Technology
1.3 Department	Dept. of Applied Electronics and Information Engineering
1.4 Domain of studies	Electronic Engineering, Telecommunications and Informational Technologies
1.5 Cycle of studies	Licence (engineering)
1.6 Program of studies/Qualification	Applied Electronics

2. Course identification information

2.1 Name of the course				Neural networks and fuzzy systems			
2.2 Lecturer				Prof. Dr. Ing. Georgeta-Mihaela UNGUREANU			
2.3 Instructor for practical activities				Ş.L. Dr. Ing. Cristina-Elena STOICA			
2.4 Year of studies	IV	2.5 Semester	8	2.6 Evaluation type	Verification	2.7 Course choice type	Compulsory

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

3.1 Number of hours per week, out of which	3	3.2 course	2	3.3 practical activities	1
3.4 Total hours in the curricula, out of which	42	3.5 course	28	3.6 practical activities	14

Distribution of time	hours
Study according to the manual, course support, bibliography and hand notes	25
Supplemental documentation (library, electronic access resources, in the field, etc)	3
Preparation for practical activities, homeworks, essays, portfolios, etc.	5
Tutoring	0
Examinations	3
Other activities	0

3.7 Total hours of individual study	36
3.9 Total hours per semester	78
3. 10 Number of ECTS credit points	3

4. Prerequisites (if applicable)

4.1 curricular	Calculus, Algebra and geometry, Data structures and algorithms, Digital signal processing, Medical electronics and informatics
4.2 competence-based	Basic knowledge of mathematics, digital signal processing, decision and estimation, and programming (proficiency in Matlab)

5. Requisites (if applicable)

5.1 for running the course	Not applicable, according to current PUB regulations.
5.2 for running of the applications	Compulsory presence at laboratory classes, according to current PUB regulations.

6. Specific competences

Professional competences	C4. Solving neural networks and fuzzy systems problems by using the architecture characteristics and running principles of hardware/software structures: - identification of classes of problems and solving methods specific to neural networks and fuzzy systems;

	- using interdisciplinary knowledge, solution patterns and tools, performing experiments and interpreting the results.
Transversal competences	CT1. The methodical analysis of the daily issues, identifying the problems for which well-known solutions are already available, thus accomplishing the professional tasks

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

7.1 General objective of the course	The course introduces the students into the basic theory on neural networks and fuzzy systems. Different neural networks and fuzzy systems are analyzed discussing their training strategy, and implemented using different general (C, C++) and dedicated (Matlab) SWs. The course addresses also the application of neural networks and fuzzy systems in medicine.
4.2 Specific objectives	The specific objectives of the course are related to the acquisition of knowledge and abilities related to develop some applications based on neural networks and fuzzy systems using a dedicated programming environment (Matlab). The following aspects are mostly considered: - the students familiarize themselves with the basic neural networks and fuzzy systems; - the students can identify an artificial intelligence problem and propose solutions based on neural networks and fuzzy systems.

8. Content

8.1 Lectures	Teaching techniques	Remarks
Introduction: Neural networks and fuzzy systems characteristics; Neural network classification; Fuzzy sets and fuzzy logic operators; Fuzzy principles in neural networks	Teaching is based on the usage of video projection (for communication and demonstration); the oral communication is based on face-to-face presentations and problematizations. The course materials are the course notes and handouts and proposed exercises (both theoretically and computer-aided solved). All materials are available in electronic form via the course site (Moodle).	1 hour
Neural networks learning methods: Unsupervised learning (Hebbian, competitive, Boltzmann); Supervised learning (BKP); Reinforcement learning.		3 hours
Feed forward neural networks: Perceptron; Multilayer perceptron; BKP learning algorithm; RBF neural network; Fuzzy multilayer perceptron.		6 hours
Recurrent neural networks: Basic elements; Associative memories; Hopfield neural network		3 hours
Competitive neural networks: Hamming network; LVQ network; Kohonen network (SOM); Adaptive resonance theory (ART); Fuzzy ART algorithm.		6 hours
Fuzzy systems: Fuzzyfication rules; Rules base development; Defuzzyfication methods; Mamdani system; Sugeno system; Neuro-fuzzy systems		3 hours
Recurrent Neural Network: Main concepts, Associative Memories, Hopfield Neural Network		2 hours
Competitive Neural Network: Hamming		4 hours

Network; LVQ Network; Kohonen Network (SOM); Adaptive Resonance Theory (ART); Fuzzy Algorithm ART.		

Bibliography

1) M. Ungureanu, Analiza şi prelucrarea semnalelor – aplicaţii în ingineria biomedicală, MATRIXROM, 2013, ISBN 9789737559463.
2) M. Ungureanu, R. Strungaru, Reţele neurale şi sisteme fuzzy - Note de curs, în curs de editare.
3) Toshinori Munakata, Fundamentals of the New Artificial Intelligence. Neural, Evolutionary, Fuzzy and More, Second Edition, Springer-Verlag 2008, ISBN 978-1-84628-838-8.
4) N. K. Kasabov, Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering, The MIT Press, 1998, ISBN 0-262-11212-4.
5) M. Akay, Handbook of neural engineering, John Wiley&Sons, 2007, ISBN 0-978-0-470-05669-1.
6) S. Haykin, Neural Networks, 2nd Edition, Prentice Hall, 1999, ISBN 0-13-273350 -1.
7) Gurney K., An Introduction to Neural Networks, UCL Press, 1997, ISBN 1-85728-503-4
8) R. Fuller, Introduction to Neuro-Fuzzy Systems, Springer Verlag, 2000,
ISBN: 978-3-7908-1256-5

8.2 Practical applications	Teaching techniques	Remarks
Matlab: Multilayer perceptron in medical applications	Teaching is based on the video projection usage (for communication and demonstrations); the oral communication is based on face-to-face presentations and problematizations. Students perform simulations, implementations, tests and evaluate independently the same problems by the continuous use of the computer and Matlab environment. The didactical materials are the theoretical and practical instructions from the lab guide.	2 hours
Matlab: Fuzzy perceptron in medical applications		2 hours
Matlab: RBF neural network application		2 hours
Matlab: Vector quantization using competitive networks		2 hours
Matlab: ART application with medical examples		2 hours
Matlab: Fuzzy systems application		2 hours
Final lab examination		2 hours

Bibliography:

1) M. Ungureanu, Analiza şi prelucrarea semnalelor – aplicaţii în ingineria biomedicală, MATRIXROM, 2013, ISBN 9789737559463.
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5) M. Akay, Handbook of neural engineering, John Wiley&Sons, 2007, ISBN 0-978-0-470-05669-1.
6) S. Haykin, Neural Networks, 2nd Edition, Prentice Hall, 1999, ISBN 0-13-273350 -1.
7) Gurney K., An Introduction to Neural Networks, UCL Press, 1997, ISBN 1-85728-503-4
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9. Bridging the course content with the expectations of the epistemic community representatives, professional associations and employers representatives for the domain of the program

Artificial intelligence, and especially neural networks and fuzzy systems, are more and more applied in electronics, the industry following closely this trend. The industry has a strong demand for qualified engineers, specialized in neural networks and fuzzy systems, with a solid background in electronics and information technology systems, so that it can be able to follow new hardware and software development.

The course curriculum answers these trends regarding the developments and evolution requirements, demanded by the general framework of the European economy of services in the IC&T domain. The current technological advances in electronic devices enable countless applications, ranging from consumer usage (smartphone and digital camera technology), medical applications (products and services for biomedical processing), military applications (remote sensing applications), security purposes (biometry and surveillance), industrial automation (quality inspection and control), robotics (man-machine interfaces) and many others.

This provides graduates with the appropriate skills and training requirements according to current qualifications, and a modern, high quality and competitive scientific and technical training, enabling them acquiring a working place after the graduation. The course fits therefore perfectly to the Bucharest Polytechnic University policy, considering both its content and structure, and the skills and international openness it offers to students.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Weight in the final mark
10.4 Lectures	- knowledge of the fundamental theoretical knowledge; - knowledge of the solving specific problems; - comparative analysis of the theoretical methods/techniques.	Two written tests, of equal weight, during the semester, at pre-defined dates; the subjects cover the entire course material, being a synthesis between the comparative theoretical knowledge and the application of the theory when solving problems and exercises.	80%
10.5 Practical applications	- knowledge of the general design of an neural network/fuzzy system for a simple, given problem; - knowledge of the coding [Matlab] of an neural network/fuzzy system; - proof of correct functioning of an neural network/fuzzy system.	The final lab exam consists of a practical examination, during which the student must solve (implement, test, proof of functioning) a practical problem.	20%
10.6 Minimal performance standard			
- modelling a simple real problem using a neural network/fuzzy system; - design, implementation, and testing of a simple artificial intelligence based solution of a problem, involving a neural network/fuzzy system.			

Date	Lecturer	Instructor for practical activities
01.10.2013	Prof. Dr. Ing. G.-M. Ungureanu	Ş.L. Dr. Ing. C.-E. Stoica
Date of department approval		Director of Department,
07.10.2013		Prof. Dr. Ing. S. Paşca