SYLLABUS

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Electronics, Telecommunications and information Technology
1.3 Department	Bases of Electronics
1.4 Field of study	Electronic Engineering, Telecommunications and Information Technologies
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Applied Electronics / Engineer
1.7 Form of education	Full time
1.8 Subject code	53.20

2. Data about the subject

2.1 Subject name			Fuzzy Systems				
2.2 Subject area			Theoretical area Methodological area Analytic area				
2.3 Course responsible			Prof. Gabriel Oltean, PhD Eng. – Gabriel.Oltean@bel.utcluj.ro				
2.4 Teacher in charge with seminar / laboratory / project			Prof. Gabriel Oltean, PhD Eng. – Gabriel.Oltean@bel.utcluj.ro Assist. Prof. Laura Ivanciu, PhD Eng. Laura.Ivanciu@bel.utcluj.ro				
2.5 Year of study	IV	2.6 Semester	2	2.7 Assessment	V	2.8 Subject category	DS/DOP

3. Estimated total time

3.1 Number of hours per week	4	of which: 3.2 course	2	3.3 seminar / laboratory	1/1
3.4 To Total hours in the curriculum	56	of which: 3.5 course	28	3.6 seminar / laboratory	28

Distribution of time	hours
Manual, lecture material and notes, bibliography	7
Supplementary study in the library, online specialized platforms and in the field	5
Preparation for seminars / laboratories, homework, reports, portfolios and essays	7
Tutoring	0
Exams and tests	3
Other activities:	

3.7 Total hours of individual study	22
3.8 Total hours per semester	78
3.9 Number of credit points	3

4. Pre-requisites (where appropriate)

4.1 curriculum	N.A.
4.2 competence	Mathematics: logic, linear and non-linear functions, discrete mathematics; sets theory; Boolean algebra; Matlab/Simulink use, programming knowledge

5. Requirements (where appropriate)

5.1. for the course	Amphitheatre, Cluj-Napoca
5.2. for the seminars / laboratories / projects	Laboratory, Cluj-Napoca

6. Specific competences

Professional competences	C2. Applying the basic methods for signal acquisition and processing • C2.3 Use of simulation environments for signal analysis and processing • C2.4 Use of the specific method and tools for signal analysis C3. Application of the basic knowledge, concepts and methods regarding the architecture of computer systems, microprocessors, microcontrollers, languages and programming techniques • C3.5 Projects involving hardware (processors) and software (programming) components C4. Design and use of low complexity hardware and software • C4.1 To define the concepts, principles and methods used in the fields of computer programming, high-level and specific languages, CAD techniques for making electronic modules, microcontrollers, computer systems architecture, programmable electronic systems, graphics, reconfigurable hardware architectures • C4.5 Design of dedicated equipment in the fields of applied electronics, which use: microcontrollers, programmable circuits or computing systems with simple architecture, including related programs C6. To solve technological problems, specific to applied electronics • C6.1 Defining the principles and methods underlying the manufacture, adjustment, testing and troubleshooting of the appliances and equipment in the fields of applied electronics
Cross competences	N.A.

7. Discipline objectives (as results from the key competences gained)

7.1 General objective	Developing the competences regarding the design and implementation of applications using fuzzy sets and/or fuzzy logic systems. Other skills: - identification of practical situations in which it is appropriate to describe data and their attributes through fuzzy sets and fuzzy relationships - application of simple procedures (algorithms) for data representation through fuzzy sets - designing, implementation (Matlab / microcontroller), checking, testing and optimizing different type of systems with fuzzy logic: controller; function modeling; expert fuzzy system; fuzzy decision-making system. - modeling by mathematical algorithms the uncertainty of information from real problems and the linguistic reasoning of human experts using fuzzy sets and fuzzy rules

	- design, implementation and deployment (using Matlab / microcontroller development boards) of an application based on fuzzy system
7.2 Specific objectives	1. Recognizing and understanding basic fuzzy logic concepts. 2. Developing skills and abilities necessary for data representation and modeling using fuzzy sets. 3. Developing skills and abilities for the analysis, design, implementation and evaluation of fuzzy logic applications.

8. Contents

8.1 Lecture (syllabus)	Teaching methods	Notes
1. Course description. Fuzzy logic. Introduction to fuzzy mathematics and its practical applications. Representation of uncertain information using fuzzy sets.	Presentation, heuristic conversation, exemplification, problem presentation, teaching exercise, case study, formative evaluation	Use of .ppt presentation, projector, blackboard
2. Definition and representation of fuzzy sets. Types of fuzzy sets. Properties and parameters of fuzzy sets. Fuzzy sets operations.		
3. Fuzzy relationships: crisp and fuzzy relationships; definition of fuzzy relationships; operations with binary fuzzy relationships. Cartesian product of two fuzzy sets. Composition of fuzzy relationships.		
4. Approximate reasoning. Propositions and fuzzy rules. Modus Ponens and generalized Modus Ponens. Fuzzy compositional inference (Mamdani, Larsen).		
5. SISO fuzzy logic systems: structure, knowledge base and operations. Defuzzification methods. Development aspects for fuzzy logic systems.		
6. MISO Mamdani fuzzy logic systems: structure, rule base, computational process. Case study: Automatic car driver		
7. MISO Takagi-Sugeno (TS) fuzzy logic systems: structure, rule base, computational process. Case study – fuzzy logic washing machine. Mamdani to TS conversion		
8. Fuzzy logic controllers: process, closed loop control systems, fuzzy controller types, rule base. Analysis of Mamdani and Takagi-Sugeno PI type fuzzy controllers. Case study – fuzzy temperature controller. Design and implementation of a fuzzy temperature control system - simulation		
9. Fuzzy data clustering: problem description, crisp and fuzzy clustering. Fuzzy C-Means algorithm. Subtractive clustering.		
10. Fuzzy logic systems for non-linear functions modeling: problem description, appropriateness of using fuzzy logic systems in modeling applications, modeling procedure, generating the initial fuzzy logic system, ANFIS training. Case study - fuzzy modeling of a one variable nonlinear function.		
11. Analogic electronic circuits modeling using fuzzy logic systems. Performance functions modeling: modeling		

procedure, case study – modeling of SOTA circuit. Functional modeling of an analogic circuit: modeling procedure, case study – modeling of FCOTA circuit, Simulink implementation.		
12. Dynamic system identification. Design, implementation, evaluation and performance improvement. Fuzzy model inputs selection: sequential forward selection, exhaustive selection. Case study – modeling a SISO dynamic system.		
13. Fuzzy decision. Case study – decision system for selecting job candidates.		
14. Recapitulation. Preparation for the final exam.		
8.2 Laboratory	Teaching methods	Notes
1. Introduction in Fuzzy Logic Toolbox	Didactic and experimental proof, simulations, testing, implementation, didactic exercise, team work	Use of computers, white/magnetic board
2. Fuzzy Sets. Applications of Fuzzy Sets Operations in Color Images Segmentation		
3. Simulation of Fuzzy Logic Systems using Matlab. Fuzzy logic Washing Machine.		
4. Fuzzy Logic Control Systems. Fuzzy Temperature Controller		
5. FLS Approximation of the I-V Diode Characteristic		
6. Subtractive Clustering. Fuzzy Modeling of a Two-Variable Nonlinear Function		
7. Laboratory test		
8.2 Project	Teaching methods	Notes
The project consists of the design and implementation of an application containing a fuzzy logic system with at least two inputs. *Fuzzy logic systems are implemented, tested and optimized in Matlab. The final application that incorporates the fuzzy system is implemented in another environment as C ++, Python, Java, etc., or on a development boards such as Arduino, Raspberry, etc.* *For the project presentation the student will demonstrate the operation of the implemented application in both versions and will discuss the implementation mode and experimental results.*	Didactic and experimental proof, simulations, testing, implementation, didactic exercise, team work	Use of laboratory instrumentation, experimental boards, computers, smart board
1. General presentation of the project. General and particular requirements.		
2. Case study 1: Temperature control system in a closed loop using a fuzzy logic controller. Arduino board implementation.		
3. Case study 2: Speed control system of a dc motor in a closed loop using a fuzzy logic controller. Arduino board implementation.		
4. Simulation and optimization of the fuzzy control system in Matlab.		
5. Application implementation; testing; debugging.		
6. Application implementation; putting into service; experimental analyses and data collection		
7. Project presentation; assessment/marking		

Bibliography

1. Oltean, G., Şipoş, E., Tehnici fuzzy în proiectarea şi modelarea circuitelor analogice, U.T.Pres, Cluj-Napoca, Romania, ISBN: 978-973-662-302-8, 2007;
2. Gordan, Mihaela, Miron, C., Oltean, G., *Sisteme Fuzzy. Îndrumător de laborator* , Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca, 1999, ISBN 973-686-003-5;
3. Feng, G., Analysis and Synthesis of Fuzzy Control Systems. A Model-Based Approach, CRC Press, Taylor & Francis Group, 2010, ISBN: 978-1-4200-9264-6;
4. Behera, L., Kar, I., Intelligent Systems and Control. Principles and Applications, Oxford Universuty Press, 2009, ISBN: 978-0-19-806315-5;
5. Eberhart, R., Shi, Y., Computational Intelligence. Concepts to Implementations, Elsevier, Morgan Kaufman Publisher, ISBN 978-1-55860-759-0, 2007;
6. Padhy, N.P., Artificial Intelligence and Intelligent Systems, Oxford University Press, Fourth impression, ISBN-10: 0-19-567154-6, 2005.
7. Constantin von Altrock, *Fuzzy logic and Neuro Fuzzy Logic Applications Explained* – Prentice Hall Englewood Cliffs, 1995

On-line references

1. Oltean, G. Fuzzy logic systems (course slides, laboratories, problem examples, exam subjects), http://www.bel.utcluj.ro/dce/didactic/sln/sln.htm
2. https://www.mathworks.com/help/fuzzy/

Arduino, https://www.arduino.cc/

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The discipline content and the acquired skills are in agreement with the expectations of the professional organizations and the employers in the field, where the students carry out the internship stages and/or occupy a job (in the field of fuzzy systems), and the expectations of the national organization for quality assurance (ARACIS).

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	The level of acquired theoretical knowledge and practical skills	- Summative evaluation written verification	V 50%
10.5.1 Laboratory	The level of acquired knowledge and abilities	- Continuous evaluation - Laboratory test	L 10%
10.5.2 Project	The level of acquired knowledge and abilities	Continuous evaluation - Project presentation	P 40%
10.6 Minimum standard of performance			
Qualitative level: Minimum knowledge: ✓ Knowledge of SISO fuzzy logic systems ✓ Knowledge of Fuzzy logic controllers ✓ Knowledge of data clustering, Fuzzy logic systems for non-linear functions modeling Minimum competences: ✓ To recognizing and understand basic fuzzy logic concepts. ✓ To developing skills and abilities necessary for data representation and modeling using fuzzy sets.			

- ✓ To developing skills and abilities for the analysis, design, implementation and evaluation of fuzzy logic applications.

Quantitative level:

- ✓ The grade on each assessment should be a minimum of 5

Date of filling in:	Responsible	Title Surname NAME	Signature
29.09.2019	Course	Prof. Gabriel Oltean, PhD Eng.	
	Applications	Prof. Gabriel Oltean, PhD Eng.	
		Assist. Prof. Laura Ivanciu, PhD Eng.	

Date of approval in the Department of Bases of Electronics

_____

Head of Department
Prof. Sorin HINTEA, PhD Eng.

Date of approval in the Council of Faculty of Electronics, Telecommunications and Information Technology

_____

Dean
Prof. Gabriel OLTEAN, PhD Eng.