Fuzzy Logic and Neural Networks

1. **Course number and name:** 020LFLES5 – Fuzzy Logic and Neural Networks

2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours per week.

3. **Instructor's or course coordinator's name:** Hadi Kanaan

4. **Instructional materials**

   a. **Textbooks:** Bernadette Bouchon-Meunier, *La Logique Floue et ses Applications*, Addison-Wesley, 1995, and Simon Haykin, *Neural Networks: A Comprehensive Foundation*, 2nd Edition, Prentice-Hall, 1999

   b. **Other supplemental materials:** Notes, exercises, PowerPoint presentations

5. **Specific course information**
   a. **Catalog description:**
   In this course, two intelligent techniques for data processing drawn from complex and imprecise environment are presented and studied. Fuzzy Logic theory is based on the empirical aspect of the human reasoning, and is used in the manipulation of imperfect, imprecise or approximate knowledge. It allows the modeling and processing of very complex systems in which, for example, human factors are present. Theory and applications concerning fuzzy logic exit for more than fifty years. They cover several fields such as artificial intelligence, identification and control of dynamic systems, automatic decision-making in complex systems, and fault diagnosis in industrial processes. On the other hand, Artificial Neural Networks are based on the biological aspect of the human brain. They are currently widely applied in various sectors such as telecommunication systems, automation, robotics, image processing and recognition, artificial intelligence, medicine and economics.

   b. **prerequisites:** None

   c. **Selected Elective** for EE students.

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
   The students will be able to:
   - ✓ Design, develop and implement a fuzzy logic based decision-making system
   - ✓ Design, develop and implement a fuzzy controller for complex systems
   - ✓ Select and train an artificial neural network to be able to perform a certain task or simulate a specific function or system

✓ Design, develop and simulate a neural-net-based control systems for complex dynamic processes
✓ Manipulate the Fuzzy and Neural Networks toolboxes of Matlab/Simulink

b. PI addressed by the course:

PI	1.1	1.2	1.3	2.5	3.1	3.2	4.1	4.2	6.3	7.1
Covered	x	x	x	x			x	x	x	
Assessed			x	x	x	x				x

7. Brief list of topics to be covered:

✓ Introduction of Fuzzy Logic and Neural Networks as intelligent techniques to manipulate imprecise and approximated data and systems. Industrial applications. Intelligent control of complex systems (1.25 hours)
✓ Fuzzy sets theory and concepts, membership functions, operations on fuzzy sets, triangular norms (3.75 hours)
✓ Fuzzy relations and fuzzy quantities, fuzzy intervals, fuzzy numbers, operation on fuzzy quantities (2.5 hours)
✓ Linguistic variables, linguistic modifiers, fuzzy rules, fuzzy quantifiers (1.25 hours)
✓ Fuzzy reasoning, fuzzy implications, generalized modus ponens (2.5 hours)
✓ Fuzzy control, Mamdani and Larsen methods. Applications (2.5 hours)
✓ Exercises on Fuzzy Logic (1.25 hours)
✓ Matlab simulations using the Fuzzy Toolbox (1.25 hours)
✓ Introduction to neural networks, artificial neuron model, activation functions, neural network structures (1.25 hours)
✓ Learning process, error correction learning algorithm, Hebb learning algorithm, competitive learning (1.25 hours)
✓ Single-layer neural networks, associative memory, perceptron, Adaline, LMS algorithm (6.25 hours)
✓ Multi-layer perceptron. Applications. Back-propagation algorithm. Momentum. Adaptive learning rate. Levenberg-Marquardt learning algorithm. Cross validation technique (2.5 hours)
✓ Generalized back-propagation algorithms (1.25 hours)
✓ Radial Basis Functions networks (1.25 hours)
✓ Application of neural networks in the identification and control of complex dynamic systems (2.5 hours)
✓ Exercises on Neural Networks (1.25 hours)
✓ Simulations using the Neural Networks Toolbox of Matlab (1.25 hours)