Intelligent Control

Academic Year: (2020 / 2021) **Review date: 14-07-2020**

Department assigned to the subject: Systems Engineering and Automation Department

Coordinating teacher: MORENO LORENTE, LUIS ENRIQUE

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

OBJECTIVES

Upon successful completion of this content area, students will be able to:

1. Have a systematic understanding of the key concepts and aspects of its engineering branch of systems identification, optimization of controller parameters, as well as controller design through Fuzzy techniques and Neural networks
2. Have adequate knowledge of its engineering branch that includes some knowledge at the forefront of its field, especially artificial intelligence techniques based on global optimization (GA's, DE, etc.), Fuzzy and Neural Network techniques, including Deep Learning .
3. Apply their knowledge and understanding to identify, formulate and solve engineering problems using established methods, using systems identification methods, optimization of controller parameters, and the design of new neuronal controllers.
4. Apply their knowledge to develop and carry out designs that meet specific requirements of the above controllers.
5. Have an understanding of the different methods and the ability to design control systems through the global optimization of controller parameters, as well as the development of Fuzzy and Neural controllers.
6. Have technical and laboratory skills
7. Select and use appropriate equipment, tools and methods for the analysis of continuous time systems.
8. Combine theory and practice to solve engineering problems
9. Have an understanding of applicable methods and techniques and their limitations

DESCRIPTION OF CONTENTS: PROGRAMME

The program is broken down as follows:
1. Fundamentals of fuzzy or blurred logic.
1.1. Basics of fuzzy logic. Imprecision and uncertainty.
1.2. fuzzy sets.
1.3. Membership functions.
1.4. Operations on fuzzy sets.
1.5. fuzzy relations.
1.6 Operations with fuzzy relations.
1.7. Approximate reasoning. Linguistic variables.
1.8. fuzzy propositions.
1.9. Operations with fuzzy propositions.
1.10. Fuzzy if-then rules.
1.11. Operators involvement. fuzzy inference.
1.12. Controller design based on fuzzy logic rules.
1.13. Models Takagi-Sugeno Mandani and-Kang.

2. Modeling and identification systems using fuzzy techniques.
2.1. Fuzzy function approximation.
2.2. Fuzzy modeling systems.
2.3. Model types.
2.4. Fuzzy model state of a dynamic system.
2.5. Models Takagi-Sugeno Mandani and-Kang.
2.6. Mandani and TSK fuzzy models equivalent of a classic controller.
2.7. Identification of fuzzy models. Methods.
2.8. Identification of the structure.
2.9. Parameter estimation.

3. Design of fuzzy controllers.
3.1. Design of fuzzy controllers without model.
3.2. PID fuzzy controllers.
3.3. Design of fuzzy model based controllers. Adaptive Methods. Direct synthesis methods. Optimization methods online.
3.4. Fuzzy controller design with matlab.

4. Fundamentals of neural networks.
4.1. Concept artificial neuron. Layers of neurons. Concept of neural network.
4.2. Multilayer networks. recurrent networks.
4.3. basic neural networks. Network linear flow: Perceptron and Adaline. Recurrent networks: Hopfield and Hamming. Learning methods.
4.4. feedforward networks. Learning backpropagation.
4.5. Radial basis functions. Probabilistic networks and networks generalized regression.
4.6. Neural networks in matlab.

5. Identification of neural network systems
5.1. Function approximation with neural networks.
5.2. Types of system models.
5.3. Modeling systems with neural networks. NN-FIR. NN-ARX. NN-ARMAX, OE-NN, NN-SSIF. hybrid models.
5.4. Types of networks used in modeling. Networks with delay in inner layers. Backpropagation in dynamic systems.
5.5. Identification of dynamic systems.

6. Control systems with neural networks.
6.1. Direct control schemes. reverse direct control. Internal model control. Feedback linearization. feedforward control.
6.2. Indirect control schemes.

7. Fundamentals of optimization and evolutionary algorithms.
7.1 Methods single point optimization.
7.2 Methods based on the derivative: maximum slope, Newton-Raphson, Quasi-Newton, conjugate gradient.
7.3 Non-derivative methods: brute force, random walk, Hooke-Jeeves, Simulated Annealing-.
7.4 Multipoint optimization methods.
7.5 Derivative Methods: MultiStart and clustering.
7.6 Non-derivative methods: Nelder-Mead, CRS, Genetic Algorithms, Differential Evolution, PSO.

LEARNING ACTIVITIES AND METHODOLOGY

The activities carried out in the teaching of the subject are:

- Theory classes. Presentation of the main concepts. Discussion and clarification of doubts about the concepts. We will work on transparencies that will be given to students to facilitate learning, in addition to a text or basic reference texts required in the course. Problems will arise and solutions will be discussed.
- Laboratories. Students (in teams of 2 or 3) will be offered practical case studies, must study them and then take the simulation data and analyze it. Knowledge of the topics covered in master classes and practical classes in the subject will be used. A preliminary study will be carried out, work will be carried out in the laboratory, and a written report will be delivered with the results and proposed solutions.

Addendum COVID-19:
Due to the situation caused by COVID-19, if it were necessary both the theory classes and practical exercises will be carried out online, the practices will be attempted in the laboratories unless it is impossible in which case they would also be adapted to be carried out online.

ASSESSMENT SYSTEM

The evaluation of the course is based on continuous assessment model. The total grade student will be derived from the evaluation of the different activities proposed in the course.

These activities may include:
Written problem solving and case studies
The performance of individual laboratory practices or group
The realization of self-learning tests,

The participation in online discussion forums, etc.

It may therefore pass the subject through continuous evaluation.

% end-of-term-examination:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

BASIC BIBLIOGRAPHY

- Kriesel, D. Neural Networks, http://www.dkriesel.com/en/science/neural_networks.
- Oliver Nelles Nonlinear System Identification: from classical approaches to Neural Networks and Fuzzy Models, , Springer Verlag, 2001
- Spall, J.C. Introduction to stochastic search and optimization, Ed Wiley-Interscience..
- Zhang, H. and Liu, P. Fuzzy modelling and control., Ed Birkhauser..

ADDITIONAL BIBLIOGRAPHY

- A. Eiben and J. Smith Introduction to evolutionary computing, , Springer, 2003