Intelligent Control

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

Department assigned to the subject: Department of Systems Engineering and Automation

Coordinating teacher: MORENO LORENTE, LUIS ENRIQUE

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

STUDENTS ARE EXPECTED TO HAVE COMPLETED

It is advisable to have passed "Control Engineering I" and "Control Engineering II" subjects.

COMPETENCES AND SKILLS THAT WILL BE ACQUIRED AND LEARNING RESULTS.

The objective of this course is to introduce students to the basic concepts necessary to use intelligent control techniques for both modeling and identification of systems and controlling systems. The concepts of fuzzy set and fuzzy operations will be introduced to define the concepts then fuzzy relations and fuzzy rules. From these concepts a basic fuzzy controller will be studied and will be showed how to identify and control these systems from these fuzzy regulators.

Then the neural networks will be addressed, starting with the notion of artificial neuron, layers of neurons, neural networks and learning strategies in neural networks. The most common neural networks will be introduced and showed their use to identify and control systems.

Subsequently different system optimization techniques will be showed, both derivative and non-derivative type and single point or multipoint. Genetic algorithms, differential evolution techniques and PSO methods will be introduced.

To achieve these objectives, the student must acquire a series of skills and abilities.

With respect to knowledge, at the end of the course the student will be able to:

1. Designing basic fuzzy controllers for dynamic systems

2. Approximate a nonlinear system with a fuzzy system.

3. Using fuzzy systems for adaptive control schemes.

4. Approximate a nonlinear system with a neural network.

5. Approximate a nonlinear dynamic system by a neural network.

6. Design a neural network based control system for dynamic systems.

7. Use optimization methods based on genetic algorithms.

8. Use optimization methods based on differential evolution algorithmns.

9. Use optimization methods based on PSO algorithmns.

The following are the skills that will be trained during the course:

Overall perspective regarding the identification problem and control of a nonlinerar dynamic system with the above cited techniques.

Ability to design controllers for nonlinear dynamic systems and to analyse and interpret the results. Students will insist on this ability on lab practices and in discussion and solution case studies.

Ability to work cooperatively in teams, in a critical and respectful way to solutions proposed by others. Teams should work in a creative and responsible way sharing work load in a balanced way to solve complex problems and proposed designs. This ability will be trained both in lab practices (performed in teams) and in solving exercises, debates and group tutorials.

Recognition of the need for continuous learning and the ability to obtain and apply the required information accessing related technical literature of the subject field both in Spanish and English. Ability to access the information required to know the details of a particular configuration.

Ability to communicate effectively both orally, written or graphic in both Spanish and English throughout the development of the activities proposed in the subject (exercises, debates, practices, etc..).

DESCRIPTION OF CONTENTS: PROGRAMME

The program has the following sections:

1. Fundamentals of fuzzy logic.
1.a. Basic concepts of fuzzy logic. Imprecision and uncertainty. Fuzzy sets. Membership functions. Operations about fuzzy sets. Fuzzy relations. Operations with fuzzy relations.
1.b. Approximate reasoning. Linguistic variables. Operations with fuzzy propositions. Fuzzy if-then rules. Implicator operators. Fuzzy interference. Design of operators based in fuzzy logic rules. Mandani and Tagaki-Sugeno-Kang models.

2. Modeling and system identification using fuzzy techniques.
2.a. Fuzzy approximation of functions. Fuzzy modelling of systems. Model types.Fuzzy state model for a dynamic system. Mandani and Tagaki-Sugeno-Kang models. Mandani fuzzy models and TSK equivalents of a classic controller
2.b. Identification of fuzzy models. Methods. Structure identification. Parameters estimation.

3. Design of fuzzy controllers.
3.a. Design of fuzzy controllers without a model. Type PID fuzzy controllers.
3.b. Design of fuzzy controllers based in a model. Adaptative methods. Direct synthesis methods. Online optimization methods.
3.c. Design of fuzzy controllers with matlab.

4. Fundamentals of neural networks.
4.a. Concept of artificial neuron. Neuron layers. Concept of neural network. Multilayer networks. Recurrent networks.
4.b. Basic neural networks. Lineal flow networks. Perceptron and Adaline. Recurrent networks. Learning methods.
4.c. Feedforward networks. Backpropagation learning.
4.d. Radial basis functions. Probabilistic and General Regression Networks.
4.e. Neural networks with matlab.

5. System identification with neural networks.
5.a. Function approximation with neural networks. Types of system models. System modelling with neural networks. NN-FIR. NN-ARX. NN-ARMAX, NN-OE, NN-SSIF. Hybrid models.
5.b. Types of networks used in modelling. Retarded internal layer networks. Backpropagation at dynamic systems. Identification of dynamic systems.

6. Control of systems with neural networks.
6.a. Direct control schemes. Reverse direct control. Internal model control. Feedback linearization. Feedforward control.
6.b. Indirect control schemes.

7. Fundamentals of optimization and evolutionary algorithmns.
7.a. Single point optimization methods.
7.a.i. Derivative based methods: derivative steepest, Newton-Raphson, Quasi-Newton. Conjugate gradient.
7.a.ii. Non derivative methods: brute force, random walk, Hooke-Jeeves, Simulated-Annealing.
7.b. Multi point optimization methods.
7.b.i. Derivative methods: multistart and clustering
7.b.ii. Non derivative methods. Nelder-Mead, CRS, Genetic Algorithmns, Differential Evolution, PSO.

LEARNING ACTIVITIES AND METHODOLOGY

Activities performed in the subject are:

Master 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 reference texts required in the subject.

Practical exercises classes. Sessions where suggested problems are solved by teams.

Laboratories. Students (in teams of 2 or 3) will get a practical case study and will analyse and obtain simulation and analysis data. They'll work with the topics covered in master and practical classes in the subject. There will be a previous study, work in the laboratory and then provide a written report with the results and proposed solutions.

Addendum COVID-19:
Due to the situation caused by the COVID-19, if it were necessary both the theory classes and the practical exercises classes 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 do them. on line.

ASSESSMENT SYSTEM

Assessment in this subject is continuous. Marks will be calculated from assessment of several activities. Within these activities can be included the following:

- Solving problems and case studies.

- Fulfillment of individual or group lab practices.

- Performing self tests.

- Participation in online forums.

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