Course Number: 28599

Course Name: Intelligent Systems in Modeling and Control, Fundamentals

Course Type: Theory	Type & Max Unit: Constant 3
Prerequisite: Nothing	Corequisite: Nothing.
Level: Graduate	First Presentation: 2003-2
Group: Applied mechanics	Last Edition: 2018-1

Objectives:

The main idea of presenting this course is to introduce to the graduate students of Mechanical Engineering about using intelligent systems and techniques to model and control of complex and nonlinear systems that almost cannot be investigated by the classical methods. They will be trained to use different intelligent systems such as Artificial Neural Networks, Genetic Algorithm and so on.

Topics:

- Introductions to Dynamics Modeling and System Identifications and Control using classical and conventional methods such as Newton-Euler, Single Input Single Output system to Multi Input Multi Output ones and their modeling and control strategies.
- Difficulties in Dynamics Modeling of complex systems having nonlinearies by physics' fundamentals and how to find an alternative methods using different System Identifications, namely Nueral Net.
- How a nerve cell functions and how to model a nerve cell mathematically, Artificial Neuron and Propagation Function including Synaptic Weight and Synaptic Bias and Neuron Activation Function such as Bias, Linear and Nonlinear, Sigmoid, Hyperbolic Tangent, etc. and then extending the results to the networks of multi neurons in multi layers, namely Neural Network. Definition of Feed Forward Neural Networks suitable for statics and time irrelevant system identifications and introducing Feed Back Neural Networks using recurrent from hidden layers or output layer to all previous layers, namely Jordan and Elman network and it combinations suitable for dynamics and time relevant system and control purposes.
- Supervised Learning and Unsupervised Learning in Neural Networks trainings, how to collect rich data from experiments to be needed for Supervised Learning, Errors between data and network output, least square of error and optimizing it by learning procedure using Error Back Propagation to tune up Synaptic Weights and Bias Value for every neurons in the network, learning rate and learning momentum, decomposing a MIMO system to several SISO systems to ease up training and convergence of learning procedure and then composing back to early MIMO one, cutting of external recurrent loops to make a Dynamic System to Static one to speed up convergence in training and then turning on recurrent loops for Dynamics Simulation, other training consequences such as training in state variables, their derivatives, Example By Example Learning and Batch Learning, Simulation of the trained network to accomplish its performances, Unsupervised Learning suitable for training Neural Network for control application, decomposing to Supervised Learning with imitating a very simple

controller data such as On-Off controller and then composing the controller using Unsupervised Learning to optimize Neural Network Controller. Running different examples in Supervised and Unsupervised Learning, Static and Dynamic Networks, Control Networks, SISO and MIMO systems.

- Mission Control in Industrial systems such as robots and Optimized Control tasks, how to program a mission control for an autonomous system using Intelligent Algorithm such as Genetic Algorithm. GA and its mechanisms namely, Reproduction, Crossover and Mutation. Modification in simple GA by using similarities between gens and chromosomes and Schema concept. Schema theorems in speeding up and convergence of GA to the optimum points. Running different examples in simple GA and modified GA.
- Term projects in dynamics modeling and control and GA.

References:

1- Sandhya Samarasinghe, "Neural Networks for Applied Sciences and Engineering", First Edition, Taylor & Francis Group, 2007.
2- David E. Goldberg, "Genetic Algorithm in Search, Optimization and Machine Learning", First Edition, Adison Wesley, 1989.
3- Hassan Sayyaadi, "Personal Notes and Comments", Professor of the School of Mechanical Engineering, Sharif University of Technology, Tehran, Iran, Since 2002.