GUJARAT TECHNOLOGICAL UNIVERSITY

INSTRUMENTATION AND CONTROL (APPLIED INSTRUMENTATION) (03)
INTELLIGENT SYSTEMS AND CONTROL
SUBJECT CODE: 3710312
SEMESTER: I

Type of course: Core II

Prerequisite: CONTROL ENGINEERING

Rationale: This course provides an overview and fundamentals of intelligent systems (Neural Networks and Fuzzy logic)), which includes a wide range of real time engineering applications. Also covers intelligent auto tuning of controller with evolutionary techniques, Fuzzy-PID controls, hybrid systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	PA (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**INTRODUCTION:** Motivation, Neural Networks, Rationale for Using NN in Engineering, Fuzzy Logic Control, Rationale for Using FL in Engineering, Evolutionary Computation, Hybrid Systems	04	2%
2	**FUNDAMENTALS OF NEURAL NETWORKS:** Introduction, Basic Structure of a Neuron, Model of Biological Neurons, Elements of Neural Networks, Weighting Factors, Threshold, Activation Function, ADALINE, Linear Separable Patterns, Single Layer Perceptron, General Architecture, Linear Classification. Perceptron Algorithm, Multi-Layer Perceptron, General Architecture, Input-Output Mapping, XOR Realization	05	8%
3	**NEURAL NETWORK ARCHITECTURES:** Introduction , NN Classifications, Feedforward and feedback networks, Supervised and Unsupervised Learning Networks, Back Propagation Algorithm, Delta Training Rule, Radial Basis Function Network (RBFN), Training of the Kohonen Network, Examples of Self-Organization, Hopfield Network	06	15%
4	**INTRODUCTION TO FUZZY SETS: BASIC DEFINITIONS AND RELATIONS** Introduction, Classical Sets, Classical Set Operations, Properties of Classical Sets, Fuzzy Sets, Fuzzy Membership Functions, Fuzzy Set Operations, Properties of Fuzzy Sets, Alpha-Cut Fuzzy Sets, Extension Principle, Classical Relations vs. Fuzzy Relations	05	10%
5	**INTRODUCTION TO FUZZY LOGIC:** Introduction, Predicate Logic, Tautologies, Contradictions, Deductive Inferences, Fuzzy Logic, Approximate Reasoning	02	10%
6	**FUZZY CONTROL AND STABILITY:** Introduction, Basic Definitions, Inference Engine, Defuzzification, Fuzzy Control Design,	06	15%

	Analysis of Fuzzy Control Systems, Stability of Fuzzy Control Systems, Lyapunov Stability, Stability via Interval Matrix Method		
7	**INTELLIGENT AUTO TUNING OF PID CONTROLLLER:** Process Reaction Curve and Relay Methods Identification and PID Tuning, Introduction, Developing Simple Models from the Process Reaction , Identification Algorithm for Oscillatory Step Responses, Identification Algorithm for Non-Oscillatory Responses Without Overshoot , Developing Simple Models from a Relay Feedback Experiment, On-line Identification of FOPDT Models , On-line Identification of SOPDT Models , Examples for the On-line Relay Feedback Procedure , Off-line Identification , An Inverse Process Model-Based Design Procedure for PID Control , Inverse Process Model-Based Controller Principles , PI/PID Controller Synthesis , Auto tuning of PID Controllers, Assessment of PI/PID Control Performance, Achievable Minimal IAE Cost and Rise Time, Assessment of PI/PID Controllers	06	25%
8	**FUZZY LOGIC AND GENETIC ALGORITHM METHODS IN PID TUNING**: Introduction, Fuzzy PID Controller Design , Fuzzy PI Controller Design, Fuzzy D Controller Design , Fuzzy PID Controller Design, Fuzzification, Fuzzy Control Rules, Defuzzification, A Control Example, Multi-Objective Optimised Genetic Algorithm Fuzzy PID Control , Genetic Algorithm Methods Explained , Case study A: Multi-Objective Genetic Algorithm Fuzzy PID Control of a Nonlinear Plant, Case study B: Control of Solar Plant	06	15%

Reference Books:

1. **Intelligent Control Systems Using Soft Computing Methodologies** by Ali Zilouchian and Mo Jamshidi, CRC Press.
2. **Principles of Soft Computing** by S.N.Sivanandam, S.N.Deepa , 2e, Wiley India Pvt.Ltd.
3. **PID Control New Identification and Design Methods** by Michael A. Johnson and Mohammad H. Moradi, Springer
4. **Artificial Intelligence and Intelligent Systems** by N.P.Padhi, Oxford University Press.
5. **PID controllers: theory, design, and tuning** *by* Karl J. Astrom and Tore Hagglund Instrument Society of America (ISA)
6. NEURAL NETWORKS, FUZZY LOGIC AND GENETIC ALGORITHM: SYNTHESIS AND APPLICATIONS by S. RAJASEKARAN, G. A. VIJAYALAKSHMI PAI, PHI Learning Pvt. Ltd

Course Outcome:

After learning the course the students should be able to

1. Understand the structure of Neural Networks and learning algorithms.
2. Implement ANN based Intelligent system for real time engineering application.
3. Understand and implement the structure of a fuzzy PID controller and its components.
4. Understand how the concepts of Fuzzification and Defuzzification are used in a fuzzy PID controller.
5. Understand how to create a PID controller using genetic algorithms concepts.
6. Appreciate the potential performance benefits of these intelligent systems and controllers by looking at the results from several industrial applications

List of Experiments:

Student has to prepare computer programs and simulations for various intelligent soft computing techniques covered in this course with any computing tools (C, C++, Java, MatLab, Scilab, etc...).

Prepare research paper and submit report by using intelligent soft computing techniques covered in this course for any engineering problems

1. Design and implementation of intelligent system for industrial process control and Industrial drives control application.
2. Design and implementation of intelligent system for Research Activity in Medicine and Biological Sciences.
3. Design and implementation of intelligent system in Cancer Research
4. Design and implementation of intelligent system for Biosignal Detection, processing Correction.
5. Design and implementation of intelligent system for Decision-making in Medical Treatment Strategies.
6. Design and implementation of intelligent system for image processing in vision control.
7. Design and implementation of intelligent system for data communication and networking

Major Equipment:

Computer Laboratory

List of Open Source Software/learning website:

- Scilab, C, C++, Java
- NTPEL