SOFT COMPUTING
MODULE 0

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Pune University Syllabus

- **Subject code -404190**
- **Teaching Scheme**
  - **Lectures/Week:** 3Hrs
  - **Practical/Week:** 2Hrs
- **Examination Scheme**
  - **In- Semester Assessment:** 30 Marks
  - **End Semester Assessment:** 70 Marks

UNIT-I : ARTIFICIAL NEURAL NETWORKS-I

- Biological neuron
- Artificial neuron model, concept of bias and threshold, Mc Culloch-Pits Neuron Model , implementation of logical AND, OR, XOR functions
- Topologies of neural networks, learning paradigms: supervised, unsupervised, reinforcement
- Linear neuron model : concept of error energy , gradient descent algorithm and application of linear neuron for linear regression
- Activation functions : binary , bipolar (linear, signum, log sigmoid, tan-sigmoid)
- Learning mechanisms: Hebbian, Delta Rule
- Perceptron and its limitations

UNIT-II: ARTIFICIAL NEURAL NETWORKS-II

- Multilayer perceptron (MLP) and backpropagation algorithm
- Application of MLP for classification and regression
- Self-organizing Feature Maps, k-means clustering
- Learning vector quantization
- Radial Basis Function networks: Cover's theorem, mapping functions(Gaussian, Multi-quadrics, Inverse multi-quadrics
- Application of RBFN for classification and regression
- Hopfield network, associative memories

UNIT-III : FUZZY LOGIC   -I

- Concept of Fuzzy number, fuzzy set theory(continuous, discrete)
- Operations on fuzzy sets
- Fuzzy member-ship functions (core ,boundary ,support) , primary and composite linguistic terms
- Concept of fuzzy relation, composition operation (T-norm,T-conorm)
- Fuzzy if-then rules

UNIT-IV:FUZZY LOGIC   -II

- Fuzzification , Membership Value Assignment techniques
- De-fuzzification (Max-membership principle, Centroid method, Weighted average method)
- Concept of fuzzy inference
- Implication rules - Dienes-Rescher Implication, Mamdani Implication, Zadeh Implication
- Fuzzy Inference systems -Mamdani fuzzy model , Sugeno fuzzy model , Tsukamoto fuzzy model
- Implementation of a simple two-input single output FIS employing Mamdani model

UNIT-V:FUZZY CONTROL   SYSTEMS

- CONTROL SYSTEM DESIGN PROBLEM
- Control (Decision) Surface
- Assumptions in a Fuzzy Control System Design
- Fuzzy Logic Controllers
- Comparison with traditional PID control, advantages of FLC
- Architecture of a FLC: Mamdani Type
- Example Aircraft landing control problem

UNIT-VI: ADAPTIVE NEURO-FUZZY INFERENCE SYSTEMS   (ANFIS)

- ANFIS architecture
- Hybrid Learning Algorithm
- Advantages and Limitations of ANFIS
- Application of ANFIS/CANFIS for regression

Text Books

1. Fundamentals of Neural Networks: Architectures, Algorithms And Applications, Laurene Fausett, Pearson Education, Inc, 2008

2. Fuzzy Logic With Engineering Applications, Third Edition, Timothy Ross, John Wiley & Sons,2010

3. Neuro-Fuzzy and Soft Computing ,J.S. Jang, C.T. Sun, E. Mizutani, PHI Learning Private Limited

4. Principles of Soft Computing ,S. N. Sivanandam, S. N. Deepa, John Wiley & Sons, 2007

Reference Books

1. Introduction to the theory of neural computation, John Hertz, Anders Krogh, Richard Palmer, Addison –Wesley Publishing Company, 1991
2. Neural Networks-A comprehensive foundation, Simon Haykin,Prentice Hall International Inc.,1999
3. Neural and Adaptive Systems: Fundamentals through Simulations, José C. Principe , Neil R. Euliano , W. Curt Lefebvre ,John-Wiley & Sons, 2000
4. Pattern Classification, Peter E. Hart, David G. Stork Richard O. Duda,Second Edition , 2000
5. Pattern Recognition, Sergios Theodoridis , Konstantinos Koutroumbas,Fourth Edition, Academic Press, 2008
6. A First Course in Fuzzy Logic, Third Edition, Hung T. Nguyen, Elbert A. Walker, Taylor & Francis Group, LLC, 2008
7. Introduction to Fuzzy Logic using MATLAB, S. N. Sivanandam, S.Sumathi, S. N. Deepa, Springer Verlag, 2007

Lab work

1. Implement simple logic network using MP neuron model
2. Implement a simple linear regressor with a single neuron model
3. Implement perceptron netwotk
4. Implement and test MLP trained with backpropagation algorithm
5. Implement and test RBF network
6. Implement SOFM for character recognition
7. Implement fuzzy membership functions (triangular, trapezoidal, gbell, PI, Gamma, Gaussian)
8. Implement defuzzyfication (Max-membership principle, Centroid method, Weighted average method)
9. Implement FIS with Mamdani inferencing mechanism
10. A small project: may include classification or regression problem , using any soft computing technique studied earlier

Extensive use of MATLAB®!!!

Course objectives (Theory)

- Introduce a relatively new computing paradigm for creating intelligent machines useful for solving complex real world problems.
- Insight into the tools that make up the soft computing technique: fuzzy logic, artificial neural networks and hybrid systems.
- To create awareness of the application areas of soft computing technique
- Provide alternative solutions to the conventional problem solving techniques in image/ signal processing, pattern recognition/classification, control systems.

Course outcomes

Having successfully completed this course, the student will be able to:

- use a new tool /tools to solve a wide variety of real world problems
- find an alternate solution , which may offer more adaptability, resilience and optimization
- gain knowledge of soft computing domain which opens up a whole new career option
- tackle real world research problems

Course objectives (Lab)

- *Use MATLAB$^®$ for creating artificial neural networks for solving basic problems*
- *Understand the concept of decision boundary, threshold and activation functions*
- *Implement Fuzzy Logic functions and apply them for simple problems*
- *Implement hybrid systems for basic control applications*

Pre-requisites for the course

- Basic matrix algebra
- Preliminary calculus
- Familiarity with *MATLAB$^®$*
- Preliminary knowledge of control theory, digital signal processing and digital image processing
- *Patience*
- *Resilience*

What would you gain after (successfully)completing the course?

- A completely new tool at your disposal to solve a wide variety of real world problems
- No matter what your main subject of interest is, you would have an alternate solution , which may offer more adaptability, resilience and optimization
- Soft computing domain makes a better choice for students who like software and programming!
- Research area also opens up!
- Hopefully a lot of marks!