Savitribai Phule Pune University

B.E. Civil (2012 Course)

401 010 Elective IV: Open Elective: 5(g)

Artificial Neural Networks in Civil Engineering

Teaching Scheme	Examination Scheme
Lecture: 3 hours / week	Theory Examination:
Practicals: 2 hours / week	In-Sem: 30 Marks
	End-Sem: 70 Marks
	Term work: 50 marks

COURSE OBJECTIVES:

CO-1: discuss ANN as AI, soft computing and data driven model and describe its types

CO-2: compute the Net information given components of neuron

CO-3: Describe various network training algorithms

C0-4: Determine various design related aspects of ANN namely architecture, stopping criteria, performance function, overfitting

CO-5: describe working of Recurrent networks, Radial basis function networks, Generalized regression neural networks, Self-organizing maps using case studies

C0-6: Design, train and test 2 or 3 layered Feed forward back propagation neural network for time series and cause effect models

Unit 1: Introduction to Artificial Neural Networks (3 hr)

Biological Neural Network, Introduction to Artificial Intelligence, Machine learning, soft computing techniques, Data driven modeling, ANN as AI, Soft computing and data driven technique, Artificial Neuron, ANN- history and general properties, ANN types according to architecture and Neuro-Dynamics, ANN Vs empirical, statistical, physical, physics based models

Unit 2: Artificial Neuron (6 hr)

Components of artificial neuron, methods of computing net information, Activation functions (linear, sigmoidal, hyperbolic tangent, hardlim, soft-lin), perceptron, Multi-layered perceptron (MLP),

Unit 3: Network training (8 hr)

Pre-training procedures- data normalization, network initialization, Types of training-Supervised and un-supervised, Network training using supervised training algorithms – Standard back propagation algorithm or gradient descent algorithm (mathematical aspects), introduction to Network training using conjugate gradient, resilient back propagation, Broydan-Fletcher-Goldfarb-Shanno algorithm, One step secant algorithm, Levernberg-Marquardt algorithm

Unit 4: Important Aspects of ANN design (6 hr)

Network architecture- inputs, outputs, number of hidden layers, number of hidden neurons, stopping criteria, overfitting, validation, testing, De-normalization, Evaluating model performance, data division, performance function

Unit 5: Types of ANN (6 hr)

Recurrent networks, Radial basis function networks, Generalized regression neural networks, Self-organizing maps (discuss using case studies of each referring to published papers and literature)

Unit 6: Applications of Feed Forward Back Propagation Neural Networks (7 hr)

Time series (univariate and multivariate) models, cause-effect models, Applications in various fields of civil Engineering including structural engineering, construction management, geo-technical engineering, environmental engineering, transporting engineering, water resources engineering , design, train and test simple 2 or 3 layered feed forward back propagation ANN in any one of the Civil Engineering fields for time series and cause effect models

Practical

1. Calculation of network output for any given ANN with sigmoidal, hyperbolic tangent and linear activation functions
2. Implementing standard backpropagation algorithm manually using WEKA or any other software
3. Designing, training and testing 2-3 layered FFBP ANN using standard backpropagation algorithm for any time series problem (univariate) in Civil Engineering
4. Evaluating the performance of ANN developed in Experiment 3 by varying number of hidden neurons, activation functions, normalization ranges
5. Designing, training and testing 2-3 layered FFBP ANN using standard backpropagation algorithm for any time series problem (multi-variate) in Civil Engineering
6. Evaluating the performance of ANN developed in Experiment 5 by varying number of hidden neurons, activation functions, normalization ranges

7. Designing, training and testing 2-3 layered FFBP ANN using standard backpropagation algorithm for any cause effect problem in Civil Engineering
8. Evaluating the performance of ANN developed in Experiment 7 by varying number of hidden neurons, activation functions, normalization ranges

BOOKS

Artificial Neural Networks by Yegnanarayana (2015)

Neural Networks - A Classroom Approach by Satish Kumar (2017)

Introduction to Neural Networks Using Matlab 6.0 by S Sivanandam , S Sumathi (2017)

Soft computing in Water Resources Engineering, Tayfur,. G., WIT Press 2012

Neural Networks for hydrological modeling, Abrahart, R., Kneale, P, See, L., Balkena Publishers, The Netherlands, 2004

References

Dawson, C. W., Wilby, R. L., (2001), "Hydrological Modeling using Artificial Neural Networks", *Progress in physical Geography*, 25(1), 2001, pp. 80-108

Flood, I. And Kartam, N., (1994a), “Neural Networks in civil engineering 1: Principles and Understanding”, *ASCE Journal of Computing in Civil Engineering*, Vol. 8, No.2 Apr. 1994, pp. 131 –148

Flood, I. And Kartam, N., (1994b), “Neural Networks in civil engineering II: Systems and Applications”, *ASCE Journal of Computing in Civil Engineering*, Vol. 8, No.2 Apr. 1994, pp. 149 –162

Maier, H.R., Dandy, G.C., (2000), “Neural networks for Prediction and Forecasting of Water resources variables: a review of modeling issues and applications”, *Elsevier Environmental Modeling and Software*, Vol. 15, 2000, pp. 101-124

The ASCE Task Committee., (2000), "Artificial Neural Networks in Hydrology I: Preliminary Concepts**”,** *ASCE Journal of Hydrologic Engineering*, Vol.5, No.2, Apr.2000, pp. 115-123

The ASCE Task Committee, (2000), "Artificial Neural Networks in Hydrology II: Hydrologic Applications**”,** *ASCE Journal of Hydrologic Engineering*, Vol.5, No.2, Apr.2000, pp.124-137