

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRONICS & COMMUNICATION (WIRELESS COMMUNICATION SYSTEMS & NETWORKS) (27)

NEURO COMPUTING AND APPLICATIONS

SUBJECT CODE: 2722710

SEMESTER: II

Type of course: Major Elective-III

Prerequisite(s):

- Linear algebra, multivariate calculus, probability theory and knowledge of a programming language(s) like MATLAB® or scilab or C
- Courses on image processing, computer vision and machine learning are recommended, but not required.

Rationale:

Neural networks are model free estimators and are drastically different from traditional computers. Neural networks are able to generalize their processing knowledge, once trained. Supervised neural networks learn to do the task from examples of desired input/output behavior. These properties are well-suited for modeling tasks in ill-structured domains like Image processing like speech recognition, robotics and medical diagnosis.

This course will cover basic neural network architectures, their learning algorithms and their applications in *image processing* (face or figure print recognition), *computer vision*, *data classification*, *clustering*, *pattern recognition*, *function approximation*, *system identification*, etc. Three forms of learning will be introduced (i.e., *supervised*, *unsupervised* and *reinforcement learning*) and applications of these will be discussed. The students will have a chance to try out several of these models on practical problems.

This course is intended to be an advanced level course suited for post graduate degree aspirant students in Electronics or Computer Engineering who primarily intend doing post graduate or doctoral research in the areas of neural networks and computer vision. In literature researcher may find many open problems in this areas suitable for investigation by Master's students leading to a professional paper or master thesis.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	ESE (V)		PA (I)			
		ESE			OEP	PA	RP			
3	2#	0	4	70	30	30	0	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Introduction to Artificial neural Networks: Motivation, Why neural networks, Biological neural networks, Benefits-Useful properties and capabilities, Basic ANN Model, ANN terminologies	04	10
2	Fundamental Models of Artificial Neural Networks McCullo-Pitts Model, Learning rules – Hebbian, Perceptron, Delta(W-H), Competitive, Heb net- Linear separability	04	10
3	Single layer and Multi layer Perceptron (MLP) Networks Single layer Perceptron, ADLINE, architecture and algorithm Back Propagation Algorithm, Selection of parameters, examples, XOR problem, Heuristics to make BP algorithm better	06	15
4	Associative Memory Networks Hetro associative and Auto associative networks – training Algorithms, examples	05	10
5	Radial Basis function Networks Introduction, architecture, training algorithms, XOR problem, Comparison of RBF and MLP	03	8
6	Adaptive Resonant Theory Introduction, ART fundamentals, stability-plasticity dilemma, ART1 and ART2 , example problems	03	10
7	Self organizing maps Introduction, Kohonen SOM, Linear Vector Quantization (LVQ)	03	8
8	Support Vector Machines Introduction, Optimal Hyper plane for linearly /non-linearly separable patterns, examples of XOR and pattern recognition	03	7
9	Introduction to Dynamically Driven Recurrent Networks Introduction, State-space model, NARX model, CPN networks	03	7
10	Applications of neural Network Brief discussion of applications of neural network in bioinformatics, knowledge extractions, Forecasting, healthcare, robotics , recognition	05	15

Reference Books:

1. Haykin, Simon, *Neural Networks. A Comprehensive Foundation.*, Second Edition, Prentice-Hall, Inc., New Jersey, 1999
2. Haykin, Simon, *Neural Networks and Learning Machine*, Pearson Higher Education, 2009
3. S. N. Sivanandam, S. N Deepa, *Introduction to Neural Networks Using Matlab 6.0*, Tata McGraw-Hill Education, 2006
4. Jacek M. Zurada, *Introduction to Artificial Neural Systems*, PWS Publishing Company, 1995
5. Mohamad H. Hassoun, *Fundamentals of Artificial Neural Networks*, The MIT Press, 1995
6. Bishop, C.M., *Neural Networks for Pattern Recognition*, Oxford University Press, Oxford, UK, 1995.
7. James A. Anderson, *An Introduction to Neural Networks*, by , The MIT Press, 1995
8. Fredric M. Ham and Ivica Kostanic: *Principles of Neuro computing for Science & Engineering*, McGraw-Hill, 2001

Course Outcome:

After learning the course the students should be able to gain:

a) Subject-related Knowledge

1. Explain the biological and mathematical foundations of neural network models.
2. Explain the different types of neural networks and different types of learning models.
3. Develop mathematical competence for understanding neural networks,
4. Design single layer (perceptron) and multi-layer feed-forward neural networks;
5. Explain the differences between networks for supervised and unsupervised learning;
6. Understand and perform training of various neural networks like back propagation, Associative memories, ART ;
7. Explain the behavior of radial-basis function networks;
8. Understand unsupervised learning using Kohonen networks;
9. Understand dynamic neural networks;
10. Analyze the performance of neural networks.

b) Subject-related Skills

1. Develop multilayer neural networks for various applications;
2. Implement training algorithms for multilayer neural networks;

List of Tutorials:

- 1 Generate various functions like AND and OR functions etc using Mcculloch-Pits neural net.
- 2 Realize Exclusive -OR function using Mcculloch-Pits neural net program.
- 3 Generate NAND functions etc using Mcculloch-Pits neural net by program. Generalize program as below:
 - a) Program should be interactive and ask inputs like number of inputs, outputs, threshold weights etc.
 - b) For each of gates change the parameters and see the effect on output.
- 4 Generate AND function with bipolar inputs and target using Hebb net by program.
- 5 Generate AND function with bipolar inputs and target using Hebb net by program.
- 6 Train a particular function (e.g. $X^3 + 1$) for a proper training with back propagation network.
 - a) Visualize proper numbers of training pairs
 - b) Import various input, target pairs using “nntool”.
 - c) Train the network using matlab default parameters
- 7 For the given FF- BPN the generalized training as under:
 - d) Perform training using effective training, learning and error function.
 - e) Once proper training data realize, plug (fix) it to main program and test the performance over data not used while training.
- 8 For the given auto Associative network find weight matrix and test the network performance
- 9 For the given auto Hetro associative network find weight matrix and test the network performance
- 10 For the given associative network perform following:
 - a) Program should ask whether the network is auto or hetero.
 - b) Initialize necessary parameters like weights activation functions, input and target

vectors (max size four) etc.

- c) Find the weight matrix
- d) Test the output for inputs D any one of the vectors used during training ii) vectors out of those used for training
- e) Test the networks performance with one error in the input vector.

Increase error to two and repeat

11 For the given hetro associative network perform following:

Consider an example (discussed in class notes) in which for certain training pair, correct recall is possible while for other pair(s) it is not.

- If correct recall is not possible, generate training pair with one /two hamming distance. Then use Lyapunov function to find the energy of such pairs. Comment on the results.

12 For the Set of the input Vectors , apply Vector Quantization Clustering and group the vectors as under:

-System should take the input vector (2-D) and with the given threshold value should check following conditions:

- If input vector hamming distance (or any other) falls below any existing cluster(s), then current vector should be included in the current set (with minimum hamming distance).
- If input vector hamming distance (or any other) does not fall below any existing cluster(s), then current vector should generate new cluster.

Once all input vectors are inserted system should give output:

- a) **Command prompt output:** i) total number of clusters formed – ii) Threshold value, iii) cluster number followed by members in it.
- b) **Graphical output:** graphical view of the clusters formed.

- Repeat the problem with different thresholds and comment on the effect.

Design based Problems (DP)/Open Ended Problem:

The course project for neural application should be a significant part of the course. In this students should identify an application area, state the problem, apply artificial neural networks to solve the problem, present the result, and write a report.

1. Face Recognition Using Neural Networks
2. Applications of neural network in heart disease diagnosis
3. Applications of neural network in robot navigation
4. Fingerprint Recognition Using Neural Networks
5. Stock market prediction using neural networks
6. Neural network-based feature extraction from topographic maps
7. Noise cancellation using RBF networks

Major Equipment: - for normal laboratory not required. However, students may implement open ended problems on some DSP boards. Computers with following software may serve the purpose

List of Open Source Software/learning website:

MIT open courses: <http://ocw.mit.edu/courses/brain-and-cognitive-sciences/9-641j-introduction-to-neural-networks-spring-2005>

NPTEL website: <http://www.nptel.ac.in/courses/117105084/>

Open Source Software: Scilab or C **Other Software(s)** MATLAB® (if license available)

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website