IE877 Foundations of Neural Networks
Sp 2005

SEC 23122
Class Room: 210EB
Class Time: M-W- 2:30 – 3:45
Blackboard URL: http://blackboard.wichita.edu or .

Instructor: Janet M. Twomey, Ph.D.
EB 120H
Voice-mail: 978 - 5908
E-mail janet.twomey@wichita.edu

Office hours: 1:00 – 2:00 M-W, 4:00-500 T-H.

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Appointment: Contact me by e-mail for other times. Generally I do not see students regarding classes before 3:00 unless an appointment is made in advance.

Textbook: *Fundamentals of Neural Networks* by Laurene Fausett, Prentice Hall, 1994. There will be supplemental assigned readings.

Objectives: This course is designed to introduce students to the theory and practical applications of artificial neural networks. Neural networks are a broad class of computing mechanisms with active research in many disciplines including all fields of engineering, physics, psychology, biology, mathematics, business, medicine, and computer science. Student will explore and investigate issues related to neural modeling through readings, lectures and hands-on projects.

Course emphasis will be on the practical use neural networks for industrial problems such as pattern recognition, predictive and interpretive models, pattern classification, optimization and clustering. Application areas include quality control, economic forecasting, process monitoring and control, robotics control, economic analysis models, diagnostic models, combinatorial optimization and machine vision. Neural networks are used as components within larger systems such as expert, decision support, and on-line monitoring systems.

Course Structure: This is a project and research oriented course designed to give graduate students a foundation from which to explore areas of their own interest. The course can accommodate almost any application and/or theoretical interest within an analytic framework. Course work will take the form of critical reading, literature searches, project identification and design, experiment design, actual experimentation, analysis and validation of results, extensions and areas of future research.

Software: Neural networks are implemented in simulation software. The NeuralWare package software is available for students on the engineering computer network. Students should be comfortable with learning new software.

Other Resources: To be handed out.

Activities: This may be subject to minor changes:

Activity	Weight
Article Review (oral and written) (x2)	15%
Take Home Tests on Network Development (x2)	40%
Homework: (3-5)	5%
Major Project (oral and written)	35%
Class Participation	5%
	1.00%

ART Code
LMDFZIVCCVC

Article reviews:
Students are to select two articles (1 - application and 1 - theoretical) of interest to them for review and presentation to the class. Upon presentation, students will hand in a 1 page review with a copy of the article to the instructor. Do not select articles from the WEB unless they have been published elsewhere.

Application articles: Students should emphasize the use of neural networks in the solution of a problem, and not on the theoretical working of the networks. Students should however describe network architecture, training algorithm, selection of data, and test results. In the write up students should provide some critique or evaluation on the merits of a neural network approach.

Theoretical articles: Students should select an article that addresses the theoretical foundations of neural networks (network design, training issues, training algorithms, etc.). These may be classic articles or very recent. In the report students should provide some insight as to the impact that the research has on the field.

Take Home Tests on Network Development:
Two significant take home tests will be given that address issues related to network development – 1) Mutli-layered perceptron trained by backpropagation, 2) Self-organizing networks (Kohonen, LVQ, ART).

Homework*:*
Text book assignments. Approximately 3 to 5 homework assignments will be given through out the term. Not all homework will be graded, but credit for completion will be given.

Final project:
This is a major investigation of your own choosing using a selected network paradigm. Students will report on their projects in both written and oral form. This project should include some literature review. Project topics should be discussed with the instructor during the semester.

Grading policy:
The evaluation of your work is my professional judgment and is not subject to negotiation. Last date to withdraw with a **"W"**: April 1.
Do not plan on leaving early for Winter break. No accommodations will be made for any one who does not follow this recommendation.

Extra Credit: NONE

Academic Honesty: You are expected to abide by WSU's academic honesty policy (see page 7 of 2005-00 Undergraduate Catalog or page 10 of 2005-01 Graduate Bulletin for a description of this policy). The following excerpt from the policy is provided for your guidance:

"Students who compromise the integrity of the classroom are subject to disciplinary action on the part of the University. Violations of classroom standard include:

1. Cheating in any form, whether in formal examinations or elsewhere.
2. Plagiarism, using the work of others as your own without assigning proper credit to the source
3. Misrepresentation of any work done in the classroom or in preparation for class
4. Falsification, forgery, or alteration of any documents pertaining to academic records
5. Disruptive behavior in a course of study or abusiveness toward faculty or fellow students."

Incomplete ("I") Grade: Like other grades, "I" is given at discretion of the course instructor. I will give an incomplete ("I") grade only if you have been making satisfactory progress in a course except for work that could not be completed due to circumstances beyond your control (such as, illness, serious accident, death in family, natural disaster, etc.). You will be asked to produce evidence. If incomplete works due to these extraordinary events take place before the last date to withdraw, and can not be completed before the end of the semester, then you should withdraw from the course. I will not give "I" for you to leave early for the winter break. Incomplete for a course must be removed by the end of the next semester or the "I" will change to "F."

Disability Services: If you have a physical, psychiatric/emotional, medical, or learning disability that may impact on your ability to carry out assigned course work, I would encourage you to contact the Office of Disability Services (DS). The office is located in Room 173 of Grace Wilkie Hall Annex, 316-978-3309 (voice, tty). DS will review your concerns and determine, with you, what accommodations are necessary and appropriate for you. All information and documentation of your disability is confidential and will not be released by DS without your written permission.

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Date	Topic	Chapter
JAN 19	Overview of course.	
24	Introduction to Neural Networks?	1
26	Simple learning rules and networks, Application article by instructor	2
31	Simple learning rules and networks	2
FEB 2	Simple learning rules and networks	2
7	Simple learning rules and networks	2
9	Multi-layered perceptron trained by backpropagation Networks	6
14	Multi-layered perceptron trained by backpropagation Networks	6
16	**Lab Time Room 209**	6
21	Multi-layered perceptron trained by backpropagation Networks	6
23	Multi-layered perceptron trained by backpropagation Networks Network Model building and validation	6
28	No class -work on take home test 1	6
MAR 2	Multi-layered perceptron trained by backpropagation Networks More on validation	
7	Associative Networks **Take home Test 1 due** (MLP trained by Backpropagation)	4
9	Competitive Networks (Kohonen, LVQ)	4
14	Competitive Networks (Kohonen, LVQ)	4
16	Competitive Networks (Kohonen, LVQ)	4
21	SPRING BREAK	
23	SPRING BREAK	
28	Competitive Networks (Kohonen, LVQ) ART	5
30	Lab Time Room 209	
APR 4	Hopfield Network Special Networks (Recurrent, Committee, and Modular, Radial Basis Nets)	7
6	Hopfield Network Special Networks (Recurrent, Committee, and Modular, Radial Basis Nets)	7
11	Work on take home test 2	
13	**Take home Test 2 due** (Kohonen, LVQ, ART)	
18	Research Topics	
20	Work on projects and meet with instructor	
25	Work on projects and meet with instructor	
27	Work on projects (out of town)	
MAY 2	Work on projects and meet with instructor	
4	Final project due: Written report, Project Presentations	
9	Project Presentations **LAST DAY**	

Academic Dishonesty at Wichita State University

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3. Misrepresentation of any work done in the classroom or in preparation for class
4. Falsification, forgery, or alteration of any documents pertaining to academic records
5. Disruptive behavior in a course of study or abusiveness toward faculty or fellow students."

Plagiarism and How to Avoid It

According to Baker (p.277) plagiarism can be thought of as a sort of 'steeling', where the writer uses others words or ideas as if they were her/his own. Plagiarism can result in expulsion from school, the loss of your job, and or a lawsuit.

You can avoid plagiarism by giving proper giving proper credit to the source. Credit to the source is given primarily in two forms, footnotes and references. The following rules for quoting and paraphrasing, and examples there of were taken from J. Lannon's book on *Technical Writing*, pp. 171 – 173.

Quoting Your Source

Lannon states "when you borrow the exact wording, whether the words were written or spoken (as in an interview or presentation) or whether they appeared in electronic form, you must place quotation marks around all borrowed material." (p. 171)

Example:

> "Neither electro magnetic field nor electromagnetic radiation cause cancer per se, most researchers, most researchers agree. What they may not do is promote cancer. Cancer is a multistage process that requires an "initiator" that makes a cell or group of cells abnormal. Everyone has cancerous cells in his or her body. Cancer- the disease as we think of it – occurs when these cancerous cells grow uncontrollably." (Prinksy, pp. 29-30)

Paraphrasing

Lannon states that we paraphrase "not only to preserve the original idea, but also to express it in a clear, simple, direct or emphatic way - without distorting the idea."

Paraphrasing is **not** 'changing a few words' or 'reshuffling them".

Example (based on the quote above):

> Prinksy explains that electromagnetic waves probably do not directly cause cancer. However they might contribute to the uncontrollable growth of those cancer cells normally present, - but controlled- in the human body. (Prinksy, pp. 29-30)

References

Baker, S. (1982) *The Practical Stylist: With Readings*, New York: Harper and Row, Publishers, p. 322
.

Lannon, J. (1997) *Technical Writing,* Addison-Wesly, pp. 171-173.

Prinsky, M. A., (1995) *The EMF book: What You Should Know about Electromagnetic Radiation, and Your Health*, New York: Warner.

Other resources on plagiarism:
http://www.web-miner.com/plagiarism#students

Haris, R.A. (2001) The Plagiarism Handbook: Strategies for Preventing, Detecting, and Dealing with Plagiarism, Los Angeles: Pyrczak, Pub.

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In Class NEURALWARE Assignment

IRIS DATA

Problem: Classify Iris species into 3 classes Setosa, Versicolor, and Virginica.
Classification is based upon sepal length and width, and petal length and width.

Your network will have 4 inputs and 3 outputs in the form of 0's and 1's.

Training data is provided in Ir2_tra.nna. This is a text file of n = 75.
Test data is provided in Ir2_tes.nna. This is a text file of n = 75.

You are to build, train, and test a backpropagation network to correctly classify the data.

Use Excel to examine your results.
Training set results in Ir2_tra.nnr
Test set results in Ir2_tes.nnr

Turn in a report containing;
1. Network architecture, training parameters and stopping conations for the best network found.
2. Percent correct classification of the training and test set results. DO NOT turn in your data.

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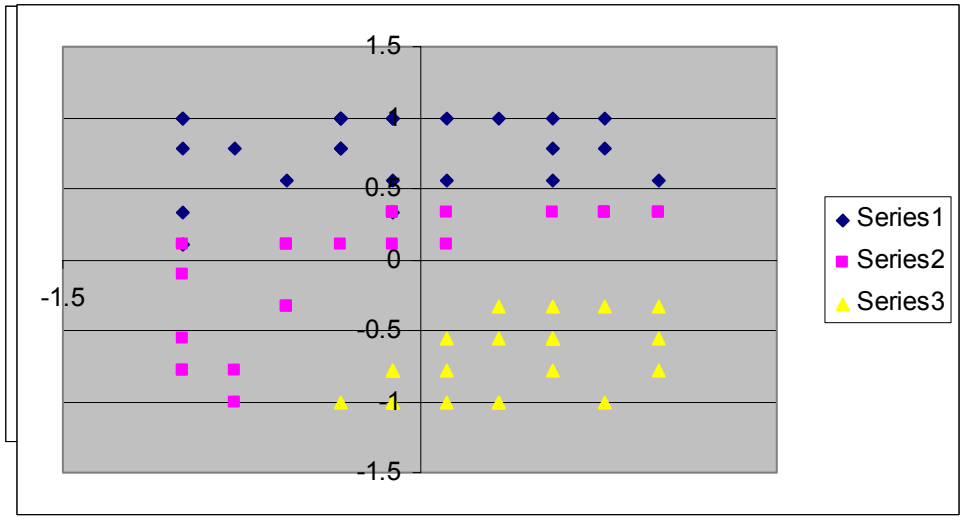
In Class NEURALWARE Assignment
SOM and ART 1

SOM:
Problem: Classify Iris species into 3 classes Setosa, Versicolor, and Virginica.
Classification is based upon sepal length and width, and petal length and width.

Build the best SOM that you can. Remember it has only inputs (4 inputs). Hand in an EXCELL result of your best network like the one below, based upon training data



ART 1:
Given the data (ART1.nna) experiment with ART training parameters (vigilance) and give results of two examples as below.

1	0	0	0	0
0	0	0	0	1
1	0	0	0	0
0	0	0	0	1

Vigilance = .5
leaning rate = .8
inputs = 2 5
ouput = 5

0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	1

Vigilance = .7
leaning rate = .8
inputs = 2 5
ouput = 5

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Backpropagation
TAKE HOME TEST
Due Oct 10

In your write up you must discuss what are the expected results of each question, what where the results of your experiments, and why they may be different. Results should include RMSE for training and test sets. Plot final results.

SMOOTH FUNCTION APPROXIMATION:

1) Experiment with building a 'good' network. Use 70% of data for training and 30% for testing. In the selection of the best network use following network design aspects individually: You are to design an experiment changing those parameters. Report on the best network.
   a) Number of layers.
   b) Number of hidden nodes. (too many, too few, and best)
   c) Training rate. (high vs. low) Keep same for all layers.

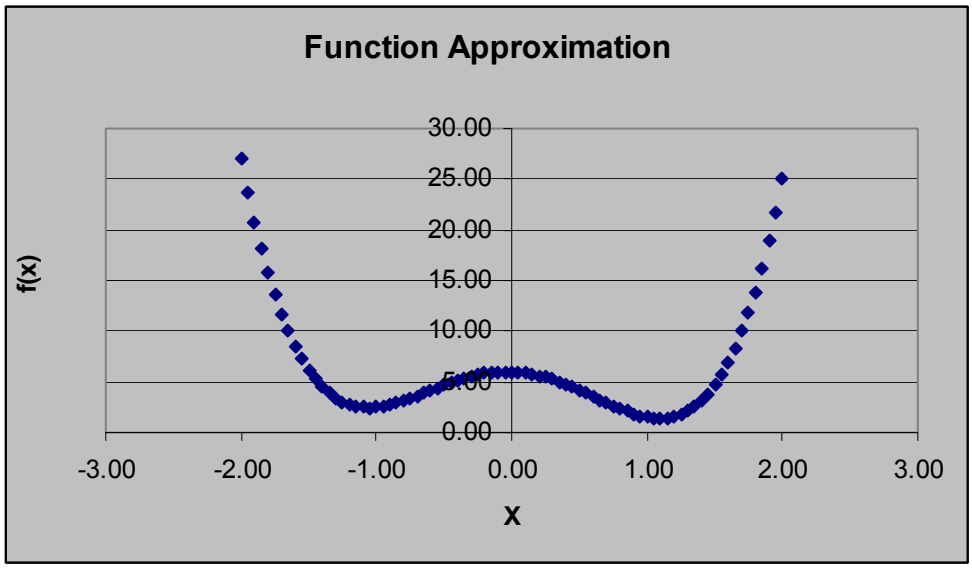
2) Experiment with testing outside the limits of the training data. Build and test a network based upon the training and test sets below.

Training set – randomly 10 training pairs between -0.5 and 0.5.
Test set 1 – test on the remaining points from the above training set.
Test set 2 – points from –2.0 to -0.5 and 0.5 to 2.0.

EXTRA CREDIT FOR A
NOISY FUNCTION APPROXIMATION AND STOP TRAINING

3) Use Stop Training method to get the best network (save best in NeuralWare). Use noisy data with a 60%/20%/20% split for training set, stop training set, and test set. Test again using the smooth data.

$F(x) = 3x^4 - 7x^2 - 0.5x + 6$



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Backpropagation
Model building Homework**:**

GRADING
100 points

In your write up you must discuss what are the expected results of each question, what where the results of your experiments, and ***why they may be different***. Results should include RMSE for training and test sets. ***Plot*** final results.

FUNCTION APPROXIMATION

1 Experiment with building a 'good' network. Use 70% of data for training and 30% for testing. In the selection of the best network use following network design aspects individually: You are to design an experiment changing those parameters. Report on the best network. **50 points**	
a. Number of layers.	
b. Number of hidden nodes. (too many vs. too few)	
c. Training rate. (high vs. low) Keep same for all layers.	
2. Experiment with testing outside the limits of the training data. Build and test a network based upon the training and test sets below. Training set – randomly 10 training pairs between -0.5 and 0.5. Test set 1 – test on the remaining points from the above training set. Test set 2 – points from –2.0 to -0.5 and 0.5 to 2.0. .**40 points**	
4) 3. Use Stop Training method to get the best network (save best in NeuralWare). Use noisy data with a 60%/20%/20% split for training set, stop training set, and test set. Test again using the smooth data. **10 points**	

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SOM and ART1
Model building Homework II
Due Nov 14th

Create a file with the first four letters (smaller font) from project 4.5 in book. These are letters A, B, C, D. Use a binary encoding with the dots = 0 and # = 1. Take those four exemplars and create four more versions of each exemplar by changing only one bit each (flip bit from 0 to 1 or 1 to 0). You now have a training set of 20 vectors and four classes. Test your network by creating a test file (4 more letters) of the same letters with more corrupt bits (>1 bit corrupt bits).

Determine the SOM and the ART1 networks classification.

1. **SOM** – limit your experimentation to the size of your map (the number of nodes) neighborhood size and the learning coefficient. Keep all else constant.

2. **Art1** – limit your experimentation to changes in vigilance and the number of nodes.

Include results and training parameters of your best networks. Make sure you discuss the expected consequences and your experimental results of changing the network parameters listed above

Also compare and contrast training using two different paradigms (do not include a discussion of the software). Which gave better results?

No more than 5 pages. So summarize with tables.

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SOM and ART1
Model building Homework II
Due Nov 14th
100 Points

Grading Scheme

1. **SOM** – limit your experimentation to the size of your map (the number of nodes) neighborhood size and the learning coefficient. Keep all else constant.
40 pts
Include results and training parameters of your best networks
Make sure you discuss the expected consequences and your experimental results of changing the network parameters listed above.

2. **Art1** – limit your experimentation to changes in vigilance and the number of nodes.
40 pts
Include results and training parameters of your best networks.
Make sure you discuss the expected consequences and your experimental results of changing the network parameters listed above

3. Also compare and contrast training using two different paradigms (do not include a discussion of the software). Which gave better results?
20 pts

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THEORETICAL ARTICLE REVIEW
TWO TYPED PAGES

	Article Name	Student name
	What Size Net Gives Valid Generalization	Said
	What Size Net Gives Valid Generalization	Sukardi
	What Size Net Gives Valid Generalization	Sidharth
	Neural Network and the Bias/variance Dilemma	Dania
	Neural Network and the Bias/variance Dilemma	Walleed
	Neural Network and the Bias/variance Dilemma	Mohit
	Cascade Learning Architecture	Mario
	Cascade Learning Architecture	Shashi
	Cascade Learning Architecture	Vishwas
	Theory of Backpropagation	Arvind
	Theory of Backpropagation	Charles
	Theory of Backpropagation	George
	Progress in Supervised Neural Networks	Ashwini
	Progress in Supervised Neural Networks	David H.
	Progress in Supervised Neural Networks	Kim Chea
	How Neural Network Work	Murad
	How Neural Network Work	Rodney
	How Neural Network Work	Kavitha

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Final Projects

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I. FINAL WRITTEN PROJECT REPORT

A. The written report should be no longer **than 6 pages**. You may place data in appendices.

Make good use of tables and plots.

B. Include reference material. There is a strong penalty for plagiarism.

C. Besides the usual criteria (format, well written, statement of problem, etc.). You must **demonstrate your understanding of the training approach that you have taken in your project and why this particular network is appropriate for the problem you have chosen.**

D. Written reports are due at May 6 at 4:10. Projects not turned in will result in an incomplete grade report. The 'I' will turn into an 'F' after May 21.

II. Project presentation:

A. Prepare a 10 min. presentation with overheads.

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Final Projects

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CRITERIA FOR GRADING WRITTEN PROJECT

Following are the criteria that will be used to grade your project. Note: you must convey to me your understanding of neural networks in your report.

CRITERIA	POINTS
Content (75 points)	
Introduction to general area (problem); Description of purpose; Research question/premise; **Are ANN appropriate for this problem?**	10
Methodology Is the chosen ANN paradigm appropriate for the given problem? Data coding appropriate? Experiment(s) conducted were appropriate for the problem as stated? Were a sufficient number of experiments conducted?	35
Results and Validation of results Conclusions; discussion relevance, implications	30
Written Presentation (25 points) Clarity Use of chart, tables, etc. References **Within the allotted 6 PAGES (If not subtract 5 point)**	25
TOTAL POINTS	