**SysEng 5212/ EE 5370**

**INTRODUCTION TO NEURAL NETWORKS AND APPLICATIONS**

**Spring 2020**

**Midterm Examination**

**Open Book, Open Homework Solutions, Notes, Open Internet**

**March 10, 2020**

I certify that for this exam, I did not receive any material and/or help in any form or by any means - electronic, mechanical, recording or otherwise, from anybody. All the information provided in this test is mine. Sources and due credit are provided for all the reference material that I utilized from the Internet and lecture notes and homework solutions.

**Name: Ryan Patton**

**Date and Time: 03/10/2020**

**Signature:**

**YOUR TEST CANNOT BE GRADED WITHOUT THIS SIGNATURE PAGE**

**INSTRUCTIONS:**1. You have 150 Minutes to work on this test: 4:00pm – 6:30 pm US CDT.  
2. All questions are mandatory. Show all your computations and assumptions in order to receive full credit.  
3. Use of MATLAB is optional as you can do all the test by hand. You will not be penalized if you do your computation in MATLAB   
4. All solutions must be uploaded as zip file on CANVAS by 6:30 pm US CDT, after which the exam solutions will not be accepted.

**QUESTIONS**

1. How can we ensure that the decision boundary (separating hyperplane) of a perceptron does not always pass through the origin? (5 points)

We can ensure that the decision boundary (separating hyperplane) of a perceptron does not always pass through the origin by tuning network parameters. To tune network parameters, including weights and biases, a learning process if used where a learning algorithm makes use of past experience to iteratively adapt network parameters until a solution is found.

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2. Explain what is meant by k-fold cross validation? If you had a dataset with 600 data samples, how would you setup 3-fold cross validation? (5 points)

K-fold cross validation uses new data inputs to evaluate a machine learning model. K refers to the number of groups a data sample may be split into. You would say the data would be split into 4-fold cross validation if k=4 for a data set. Cross-validating helps test the model’s ability to predict new data that wasn’t used in estimating to avoid overfitting or selection bias (especially with a relatively small dataset of 600!). For a dataset with 600 data samples with 3-fold cross validation it could be setup by partitioning the sample data into 3 complementary subsets where it would undergo two rounds of cross-validation with different partitions (1 training set and 2-fold subsets). The results from each 2-fold subsets would be averaged over the rounds to estimate the model’s performance.

<https://machinelearningmastery.com/k-fold-cross-validation/>

<https://en.wikipedia.org/wiki/Cross-validation_(statistics)>

3 What does the generalization capability of a machine learning algorithm mean? What factors does generalization depend on? (5 points)

Generalization capability refers to a model’s ability to react to new data. An example would be running a training set of data through the machine learning algorithm and seeing how accurate the predictions are from the new data. Generalization depends on the data set not being underfitted, the data isn’t specific enough to capture relevant information so it is unable to make accurate predictions for training or new data, and overfitted, it accurately models the training data but it is too specific to where it will fail to make accurate predictions with new data because it learned the training data too well.

<https://wp.wwu.edu/machinelearning/2017/01/22/generalization-and-overfitting/>

4. Consider the perceptron with a symmetric hardlimit activation function shown below. For a given input sample x = [0.8 0.2], the desired response is y = -1. Using the given weights and biases, determine whether the perceptron gives the correct response. (5 points)



4\_Perceptron-1.pdf – Perceptron Learning Rule

5. For a network with 30 free parameters and a 1% mean square error estimate, what is the minimum number of training samples required for good generalization? (5 points)

Generally, use at least ten times the number of parameters, 300

https://stats.stackexchange.com/questions/257292/minimum-training-size-for-simple-neural-net

6. Do a large of number of input features in the training data always ensure better generalization? What issues can arise with the use of 'too many' input features? (5 points)

It doesn’t always ensure better generalization. With too many input features, the data can be overfitted leading to increased model complexity. There’s a greater chance of redundancy in features and of features that are not related being used for prediction

https://datascience.stackexchange.com/questions/33580/too-much-inputs-overfitting

7. For the given input X having a target value of d = 0.5, train a linear neuron with the LMS weight update rule for two iterations. The initial weights and biases are given below. Use a learning rate of 0.1. Report your final weights, bias at the end of two interactions and your MSE plot. (20 points)



8. Consider the multilayer feedforward network in the figure below. Assume that an input x = [1,1] with a target d = 0.9 is presented to the network. Neuron 1 and 2 are the hidden layer nodes, and neuron 3 is the output node. The figure also shows the initial weights and biases for all synaptic connections. Each neuron uses a specialized activation function. The activation functions and the corresponding neuron are listed below.

Neuron 1: cos(x)

Neuron 2: (1-e-2x )-1

Neuron 3: (1+e-3x)-1

a) Setup the expressions for one complete pass (forward and backward) through the standard backpropagation algorithm. Also setup the weight update expressions for all neurons in the network. Only setup the solution, do not solve. (25 points)

b) Train the network for two iterations with a learning rate of 0.2. List the final weights and biases of the trained network. Plot the MSE learning curve. (25 points)

A Step by Step Backpropogation Example