Neural Networks Exam

7 January 2015

This is a "closed book" exam: you are not allowed to use any notes, books, etc. You are allowed to use a **simple** calculator. Please read the questions carefully, formulate your answers clearly, and use either English or Dutch, grouping answers to the same question together (e.g. 1A-1C should not be interrupted by 3D). Ideally, your answers should be short and concise, focusing on the (sub)problems/questions listed. There are 90 marks you can get by addressing the problems below, and 10 marks will be given to you for free. Your final grade for this exam will the total number of your marks divided by 10, which will then be rounded to the nearest half. Good luck!

1. Quick questions - short answers (for 40 marks overall)

(A) (2+2 marks) What important disadvantage of neural networks does the example of recognition tanks in images where it had learned to recognize blue skies exemplify? Explain why.

(B) (2 marks) Provide two examples of a decision function that can be used in a simple perceptron.

(C) (2+2 marks) Express Bayes' theorem and explain the concepts that are part of this formula.

(D) (2+2 marks) Name two approaches within the field of neuro evolution that have been treated during the course. Briefly explain the difference between them.

(E) (2 marks) What value of the decision function does a support vector have?

(F) (3+3 marks) Write down the perceptron convergence algorithm and explain each step. What does this algorithm precisely provide a guarantee on?

(G) (2+2 marks) Provide Cover's theorem and explain how it has been used as a source of inspiration for developing for instance RBF networks.

(H) (1+1+4 marks) Does the Backpropagation algorithm provide any guarantee on convergence? And will it always find the optimal solution? Provide arguments for your answers using the details of the algorithm.

(I) (2+2 marks) Explain the two main steps involved in training RBF networks.

(J) (2 marks) What role does the Lagrangian multiplier play in Support Vector Machines?

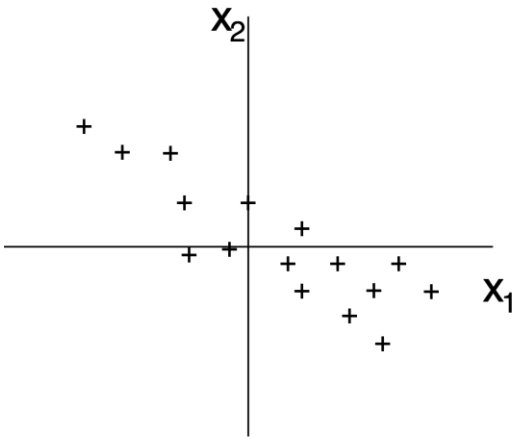
(K) (2 marks) Briefly illustrate the main concept behind the Quickpropagation approach as proposed by Fahlman. You can do so in a graphical way if you want.

2. Principal Component Analysis (24 marks, see breakdown below)
This assignment concerns principal component analysis.

(A) (2+4 marks) Name and explain one of the two techniques that have been treated during the lecture to find Principal Components. In this explanation, make clear what the precise steps in the approach are.

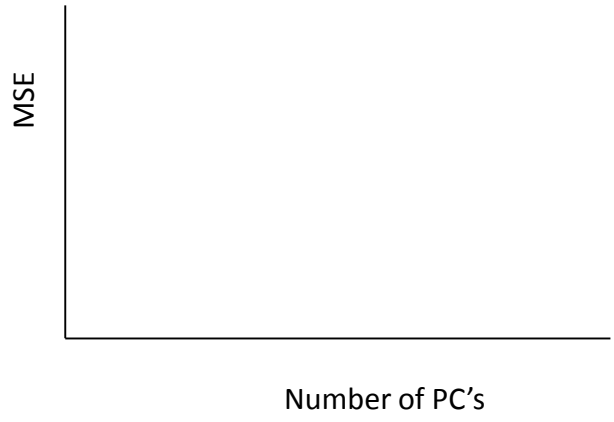
(B) (4 marks) Explain how PCAs can be used to enhance the performance of Neural Networks.

Consider the following dataset:



(C) (2+4 marks) Draw the first and second principal component in this graph and explain why you have drawn them in such a way.

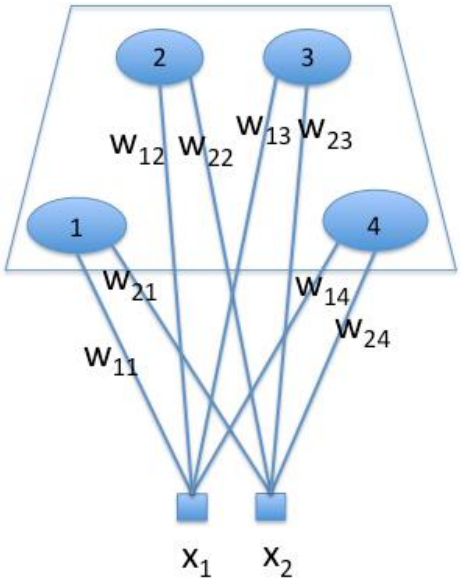
(D) (4 marks) Imagine we are going to use PCA for compression of an image and we would measure the error rate (in terms of the mean squared error between the original and reconstructed image) for different numbers of principal components. What would a plot with the number of principal components used on the x-axis and the error rate on the y-axis typically look like? Draw a figure (see the example below) and explain why you draw it in such a way.



(E) (2+2 marks) Would you call principal component analysis a supervised or unsupervised learning mechanism? Explain why.

3. Self-Organizing Maps (26 marks overall; see breakdown below)

Let us consider a self-organizing map as shown in the figure below.

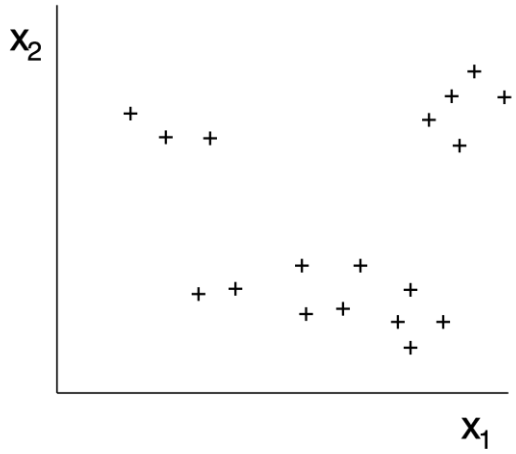


(A) (2 marks) Give the two prominent layouts of a self-organizing map.

(B) (3 marks) An input is received in the self-organizing map which is $<x_1, x_2> = <1, 1>$ and neuron 2 shows to be the winning neuron What does this say about the weights w_{12} and w_{22} of this neuron?

(C) (2+2 marks) Provide the formula used to update the weights in a self-organizing map and explain how the formula can be applied.

Imagine the following dataset:



(D) (3+3 marks) Draw the SOM network with 4 neurons as shown before in the figure showing the dataset after it has been trained with this data. Hereby, position each neuron based on its weight vector (i.e. draw neuron 1 on position $<w_{11}, w_{21}>$ and connect the neurons that are neighbors via a line. Explain why you position the neurons in this way.

(E) (3 marks) Calculate the lateral distance between neuron 1 and neuron 3 and explain how you come to your answer.

(F) (2+2 marks) Name the two different phases within the learning process of a self-organizing map, and explain what happens in each of these phases.

(G) (4 marks) Explain the concept of a contextual map. You can illustrate your explanation in any way you like.