# Neural Networks Re-Exam

19 January 2012

This is a "closed book" exam: you are not allowed to use any notes, books, etc. Please read the questions carefully, formulate your answers clearly, and in English, 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 50 marks overall)**

**(A) (2 marks)** Why did ANN research become popular again in the 1980s?

**(B) (2 marks)** Probability density estimation, finish the sentence or write down the formula: Posterior probability equals to...

**(C) (2 marks)** Classification: When is a decision boundary optimal? (formula or clear explanation)

**(D) (2+2 marks)** Binary classification: please provide the formulae for two possible discriminant functions.

**(E) (2 marks)** Multivariate Gaussians: $\Sigma = \begin{bmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{bmatrix}, \sigma_1^2 > \sigma_2^2$, please draw the contour lines of the pdf. (in other words, draw circles/ellipsoids, sketch some axes as well.)

**(F) (4+2 marks)** $p(x) = \frac{K}{N \cdot V}$ Please describe this equation (in what context did we learn about it, what does it describe, what do the letters represent?). What method can be derived when we fix K to be equal to, say, 5?

**(G) (2+2+2+2 marks)** Let us consider a single layer perceptron with two inputs, a bias, and one output.

- Sketch the network, clearly marking the places of the input ($x_1$ , $x_2$), the weights ($w_i$), and the output ($y$).
- Draw possible decision boundaries (represented by the network) for each of the following three cases: a) $w_o = 0$, b) $w_1 = 0$, c) $w_o = w_2$. (a plot with three boundaries shown)

**(H) (2+2+2 marks)** When should backpropagation stop? Please write down three possible strategies (one sentence for each chosen possibility).

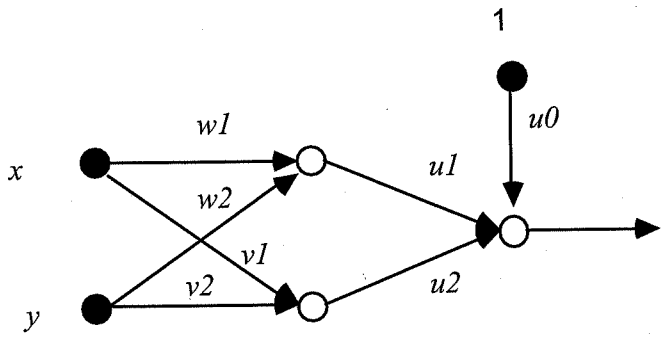
**(I) (2+2+2+2 marks)** Sketch a possible encoder network with four inputs (just nodes and connections). What can you say about the compression of the following encoder networks: a) 4:3:4, b) 4:2:4, c) 4:1:4? Justify your answers.

**(J) (2+2 marks)** Please describe two methods for weight initialisation. (If you don't know the formula for the not so obvious method, try to describe the main idea only.)

**(K) (6 marks)** Is the first layer of an RBF network trained in a supervised manner? Justify your answer.

**2. Backpropagation (26 marks; see breakdown below)**

Let us consider a feed-forward network shown in figure below. Here we assume that the hidden units have no bias and that all the units use the sigmoid activation function $s(a)$, which has the property $s'(a) = s(a)(1-s(a))$.




**(A) (4 marks)** Express the output of this network as a function of nine variables: $x$, $y$, $w_1$, $w_2$, $v_1$, $v_2$, $u_0$, $u_1$, $u_2$ (write a formula).

**(B) (4 marks)** Express the error made by the network on the input pattern $(x,y)$ and the target output $t$ as a function of $w_1$, $w_2$, $v_1$, $v_2$, $u_0$, $u_1$, $u_2$ (write a formula).

**(C) (5 marks)** Describe the gradient descent minimisation algorithm.

**(D) (5 marks)** Formulate the backpropagation algorithm (give the weight update rules).

**(E) (4 marks)** How many multiplications are needed for a single pass of the backpropagation algorithm?

**(F) (4 marks)** Explain the concepts of batch learning and incremental learning.

**3. The NETtalk System (14 marks overall)**

Describe the NETtalk system following the leading questions below.

**(A) (3 marks)** What was the purpose of the system?

**(B) (3 marks)** What was used as training set?

**(C) (3 marks)** How were the inputs and outputs represented?

**(D) (3 marks)** What was the network architecture?

**(E) (2 marks)** What accuracies were achieved?