## T-61.5130 Machine Learning and Neural Networks Examination 14th December 2009/Karhunen

You are allowed to have in the examination a collection of mathematical formulas, but not any of the teaching material. (Voit vastata tenttiin myös suomeksi.)

- 1. Answer briefly (using a few lines) to the following questions or items:
  - (a) What for is Oja's rule used in neural computing?
  - (b) For which purpose is weight decay used?
  - (c) Explain briefly  $\epsilon$ -insensitive cost function.
  - (d) Which are the two main criteria used for measuring non-Gaussianity of a random variable or signal?
  - (e) Explain briefly how LVQ (learning vector quantization) differs from SOM (self-organizing map)?
  - (f) Explain briefly what is NARX model.
- 2. The neural network shown in Figure 1 on the reverse side of this sheet has the activation function  $\varphi(\cdot)$ , input vector  $\mathbf{x} = (x_1, x_2, x_3)^T$ , weights  $k_1$ ,  $k_2$ ,  $k_3$ , k,  $w_1$ ,  $w_2$  and  $w_3$ , and biases  $b_1$  and  $b_2$ .
  - (a) Present the general formula for the output y of the network.
  - (b) In the N-bit parity problem each component of the N-dimensional input vectors  $\mathbf{x}$  is a binary number 0 or 1. The correct value of the parity function is y = 0, if the sum of the components of the vector  $\mathbf{x}$  is even, and y = 1 if the sum is an odd number. The network shown in the figure can be used for solving the parity problem by choosing as the activation function the step function

$$\varphi(u) = \begin{cases} 1, & u > 0 \\ 0, & u \leq 0 \end{cases}$$

Examine whether the network of the figure solves the 3-bit parity problem correctly, when the parameters of the network are chosen to have the values  $w_1 = w_2 = w_3 = 1$ ,  $k_1 = k_2 = k_3 = 1$ , k = -2,  $k_1 = -0.5$ , and  $k_2 = -1.5$ .

- 3. Compare on a general level the similarities and differences between multilayer perceptron (MLP) networks and radial-basis function (RBF) networks.
- 4. Consider the cost function

$$\mathcal{E}(\mathbf{w}) = 2w_1^2 - w_1w_2 + 3w_2^2 + 7$$

where  $\mathbf{w} = [w_1, w_2]^T$  is a two-dimensional weight (parameter) vector.

- (a) Find the optimal value  $\mathbf{w}^*$  of the weight vector minimizing the cost function  $\mathcal{E}(\mathbf{w})$ .
- (b) Construct steepest descent algorithm for minimizing the cost function  $\mathcal{E}(\mathbf{w})$ .
- (c) Construct Newton's optimization algorithm for minimizing the cost function  $\mathcal{E}(\mathbf{w})$ .
- (d) How fast does Newton's optimization algorithm converge?

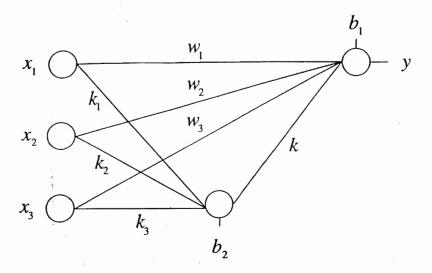


FIGURE 1