T-61.5130 Machine Learning and Neural Networks
Examination 24th October 2011/Karhunen

1. Answer briefly (using a few lines) to the following questions or items:
   (a) Define the basic logistic sigmoidal function. Draw a figure describing coarsely its overall behavior.
   (b) What is the main deficiency of simple perceptron?
   (c) Explain what is so-called bias-variance dilemma.
   (d) Name the methods that you know for selecting the centers of radial-basis function networks.
   (e) What are the two major phases in the SOM (self-organizing map) learning algorithm?
   (f) Draw the schematic diagram of focused neuronal filter.

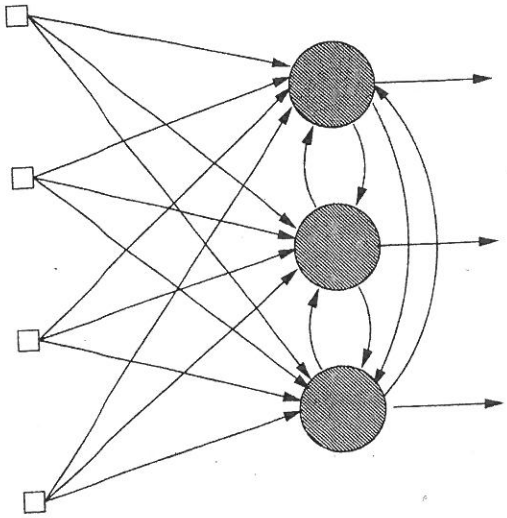
2. Explain what are the main properties of neural networks distinguishing them from other standard types of computing. Discuss the main benefits (and drawback) of neural networks and computing.

3. Consider the general linear model for modeling a scalar variable

$$y : y(\mathbf{x}, \mathbf{w}) = \sum_{j=0}^{M-1} w_j \phi_j(\mathbf{x})$$

   where $\mathbf{x}$ is data vector, $\mathbf{w}$ is M-dimensional weight vector with elements $w_0, w_1, ..., w_{M-1}$, and the $\phi_j(\mathbf{x})$, $j = 1, ..., M-1$ are some basis functions which can be nonlinear. Often $\phi_0(\mathbf{x}) = 1$ is the dummy 'basis function' corresponding to the bias term w_0. You have at your disposal N input-output training pairs $(t_i, \mathbf{x}_i)$. Model the dependence between input vector $\mathbf{x}$ and scalar output t using the general linear model above. Fit the model to the training data using the least-squares method with the added weight decay regularizer $0.5\lambda \mathbf{w}^T \mathbf{w}$.

4. Consider the neural network having the structure shown in the figure on the reverse side. Construct a mathematical expression for the output signal y_j of neuron j in the network. You can use a suitable notation for the input signals and weights of the network. For simplicity, we assume that there are no bias terms. The activation function $\varphi(v)$ is a sigmoidal type nonlinear function.



A SCHEMATIC DIAGRAM OF THE NEURAL NETWORK.