T-61.5130 Machine Learning and Neural Networks
Examination 21st May 2015/Karhunen

(Voit vastata tenttiin myös suomeksi.)

1. Answer briefly (using a few lines) to the following questions or items:
   (a) For what purpose and where is moment term used?
   (b) What is cross-validation?
   (c) Which are the two main criteria for measuring non-Gaussianity?
   (d) Explain briefly ϵ-insensitive cost function.
   (e) Which neural network method is based on competitive learning?
   (f) Explain briefly what is NARX model.

2. Figure 1 on the reverse side of this sheet presents the schematic diagram of a 2-2-2-1 feedforward network. The function $\varphi(\cdot)$ is some sigmoid function. Denote the output signal of the network by y, and its input signals are x_1 and x_2.
   (a) Write explicitly out the input-output mapping defined by the network. You can use suitable auxiliary notations and assume that the bias terms are zero.
   (b) Assume that all the neurons of the network operate in their linear region. What is the input-output mapping in this special case?

3. Both principal component analysis (PCA) and independent component analysis (ICA) are based on the simple linear model

$$\mathbf{x}(t) = \mathbf{A}\mathbf{s}(t) = \sum_{i=1}^{n} s_i(t)\mathbf{a}_i$$

   where $\mathbf{x}(t)$ is the observed data vector at index value t, and $\mathbf{A}$ is a multiplying coefficient matrix whose i:th column vector is $\mathbf{a}_i$. The vector $\mathbf{s}(t)$ contains the components $s_i(t)$ whose mixtures the data vectors are. It is assumed that all the vectors in the above model have the same dimensionality n and that $\mathbf{A}$ is an $n \times n$ square matrix.

   Answer briefly on general level (you need not present mathematical details) to the following items:
   (a) Of which criteria one can derive a PCA solution?
   (b) What properties do the coefficients $s_i(t)$ and vectors $\mathbf{a}_i$ have after estimation of the principal components?
   (c) Of which criteria ICA solution can be derived?
   (d) What properties do the coefficients $s_i(t)$ and vectors $\mathbf{a}_i$ have after estimation of independent components?
   (e) What methods you know for estimating the independent components?
   (f) What are the main benefits and drawbacks of PCA and ICA when compared to each other?

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4. Using the LMS (Least Mean Square) algorithm, derive a learning algorithm for the focused neuronal filter shown in Figure 2 below. (You may drop the subscript j off for simplicity here.)

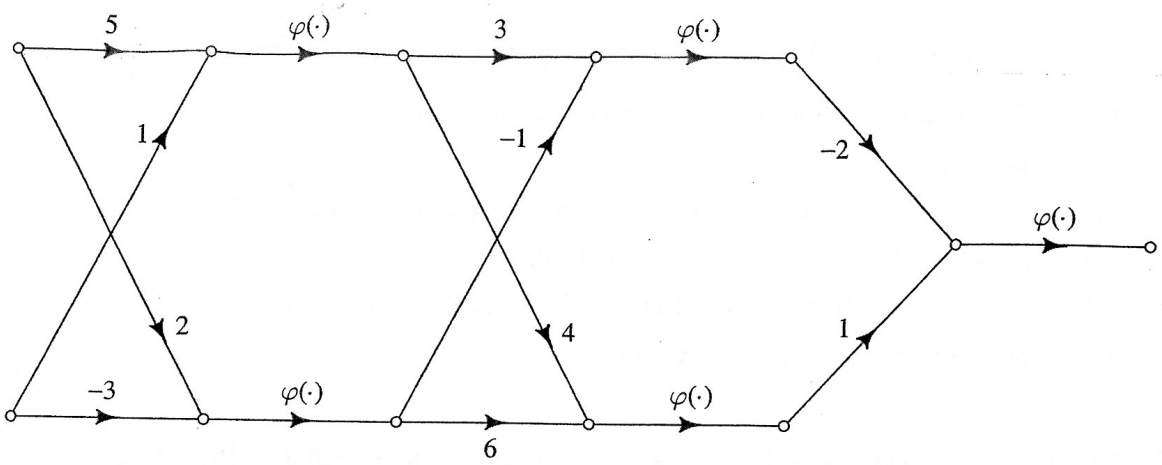

FIGURE 1: A 2-2-2-1 FEEDFORWARD NETWORK

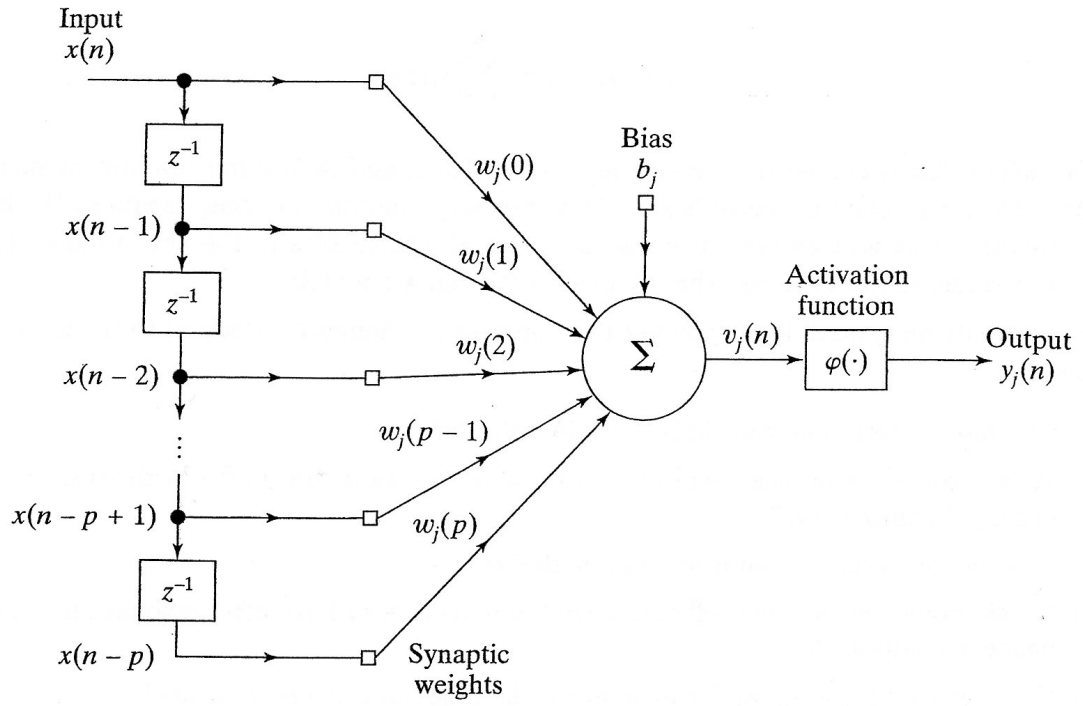

FIGURE2: FOCUSED NEURONAL FILTER