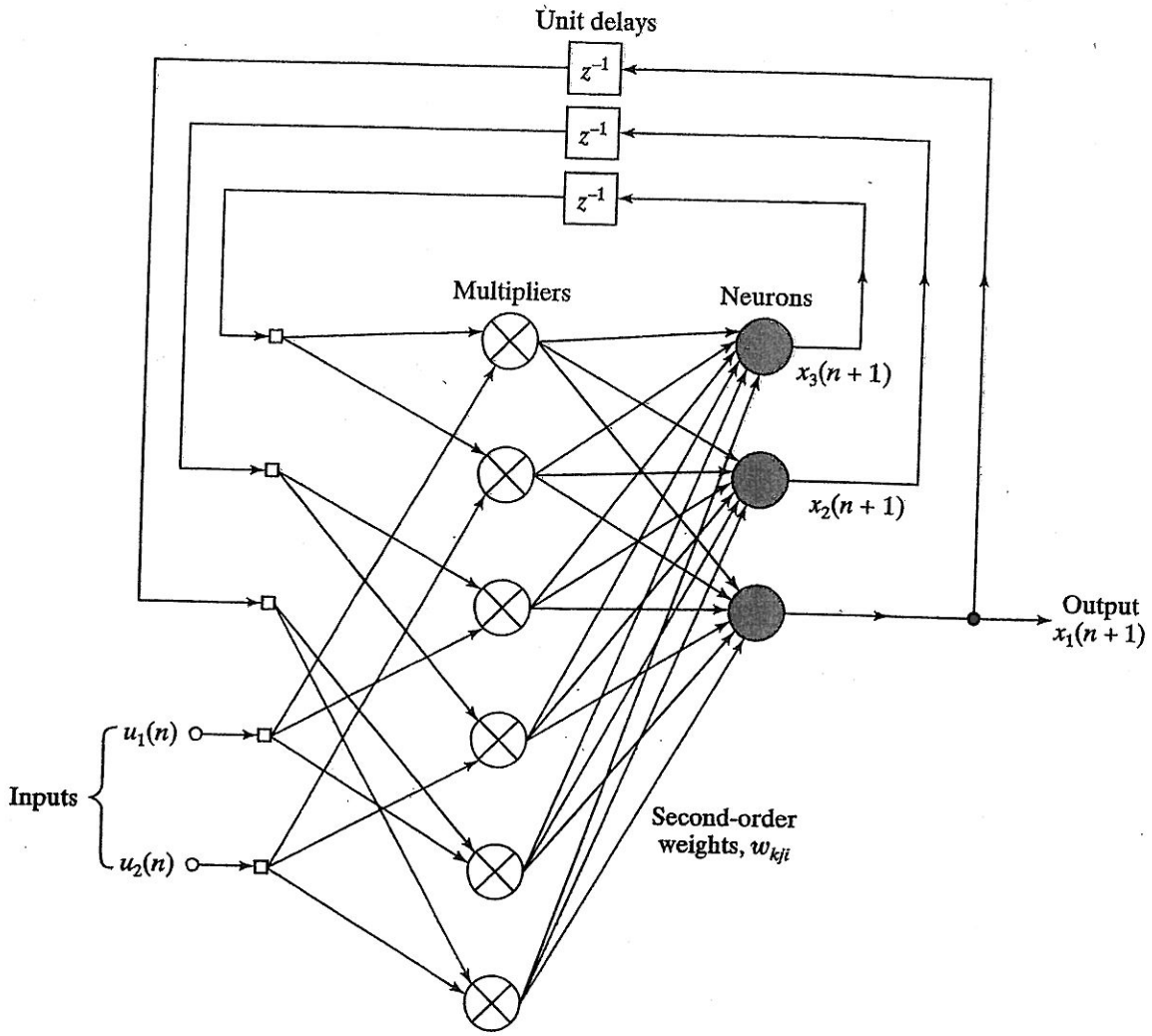
T-61.5130 Machine Learning and Neural Networks
Examination 19th December 2007/Karhunen

1. Answer briefly (using a few lines) to the following questions:
   (a) What for is Oja's rule used in neural computing?
   (b) What means the search-and-converge stategy?
   (c) Explain briefly the bias-variance decomposition.
   (d) What measures Kullback-Leibler divergence?
   (e) Explain briefly ϵ-insensitive cost function.
   (f) What is a Voronoi cell?

2. Assume that the relationship between the input vector $\mathbf{x}$ and the desired response (output) vector $\mathbf{d}$ is of the form
$$\mathbf{d} = \mathbf{h}(\mathbf{x}) + \mathbf{e}$$
where $\mathbf{h}(\mathbf{x})$ is the true mapping between $\mathbf{x}$ and $\mathbf{d}$ and $\mathbf{e}$ is the error or noise vector. Consider modeling the unknown true mapping $\mathbf{h}(\mathbf{x})$ by the output $\mathbf{y}(\mathbf{x}, \mathbf{w})$ of a neural network, where the vector $\mathbf{w}$ contains all the adjustable weights of the neural network. Assume that you have at your disposal N training pairs $(\mathbf{x}_i, \mathbf{d}_i)$ of the mapping. Show that if the training pairs are independent, and the noise vector $\mathbf{e}$ is Gaussian with zero mean and covariance matrix $\sigma^2\mathbf{I}$, the standard least-squares method and maximum likelihood method provide the same results.

3. Compare multilayer perceptron networks and support vector machines. Which general properties they have? What are their benefits and drawbacks when compared with each other?

4. The figure on the reverse side shows an example of a second-order recurrent network including some notation. Write out the dynamical equation(s) describing the operation of the network and its input-output mapping. The multiplier nodes, denoted by the symbol $\bigotimes$, multiply their inputs. The activation function used is the standard logistic sigmoidal function. Include also bias terms which are not shown in the figure for clarity.


Unit delays
z^{-1}
z^{-1}
z^{-1}
Multipliers
Neurons
$x_3(n+1)$
$x_2(n+1)$
Output
$x_1(n+1)$
Inputs
$u_1(n)$
$u_2(n)$
Second-order
weights, w_{kji}