2.5.2 Radial Basis Function Networks

After the FF networks, the radial basis function (RBF) network comprises one of the most used network models.

Figure 2.7 illustrates an RBF network with inputs $x_1,\ldots,x_n$ and output $\hat{y}$. The arrows in the figure symbolize parameters in the network. The RBF network consists of one hidden layer of basis functions, or neurons. At the input of each neuron, the distance between the neuron center and the input vector is calculated. The output of the neuron is then formed by applying the basis function to this distance. The RBF network output is formed by a weighted sum of the neuron outputs and the unity bias shown.

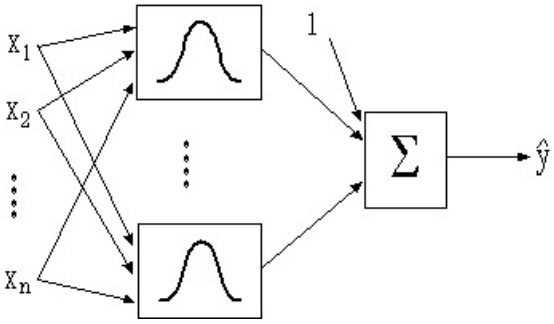

Figure 2.7. An RBF network with one output.

The RBF network in Figure 2.7 is often complemented with a linear part. This corresponds to additional direct connections from the inputs to the output neuron. Mathematically, the RBF network, including a linear part, produces an output given by

$$\hat{y}(\theta) = g(\theta, x) = \sum_{i=1}^{nb} w_i^2 e^{-\lambda_i^2 (x-w_i^1)^2} + w_{nb+1}^2 + \chi_1 x_1 + \ldots + \chi_n x_n \qquad (10)$$

where nb is the number of neurons, each containing a basis function. The parameters of the RBF network consist of the positions of the basis functions w_i^1, the inverse of the width of the basis functions λ_i, the weights in output sum w_i^2, and the parameters of the linear part $\chi_1,\ldots,\chi_n$. In most cases of function approximation, it is advantageous to have the additional linear part but it can be excluded by using the options.

The parameters are often lumped together in a common variable θ to make the notation compact. Then you can use the generic description $g(\theta,x)$ of the neural network model, where g is the network function and x is the input to the network.

In training, the network the parameters are tuned so that the training data fits the network model Eq. (2.10) as well as possible. This is described in Section 2.5.3 Training Feedforward and Radial Basis Function Networks.

In Eq. (2.10) the basis function is chosen to be the Gaussian bell function. Although this function is the most commonly used basis function, other basis functions may be chosen. This is described in Section 13.3, Select Your Own Neuron Function.

Also, RBF networks may be multi-output as illustrated in Figure 2.8.

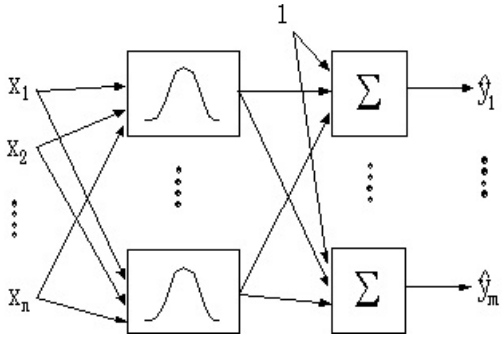

Figure 2.8. A multi-output RBF network.

FF networks and RBF networks can be used to solve a common set of problems. The built-in commands provided by the package and the associated options are very similar. Problems where these networks are useful include:

- Function approximation
- Classification
- Modeling of dynamic systems and time series

◂ Previous | Next ▸