Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 7:
Artificial Neural Networks and Their Applications

Authors: Nicky Sandhu and Ralph Finch

7 Artificial Neural Networks and Their Applications

Introduction

Artificial Neural Networks (ANNs) are composed of many simple elements called neurons connected with each other through links. The neuron model as shown in Figure 7-1 shows how a network transforms its input into and output.

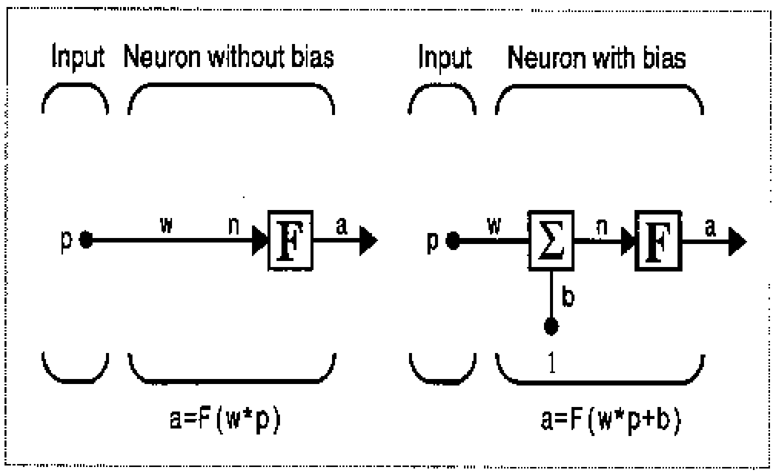

Figure 7-1. Single Input Neuron (Matlab 1994)

A neuron with a single input and output is shown in Figure 7-1. The input **p** is multiplied by a weight **w**. A bias term is then added to the weighted input. The transfer function **F** takes this sum and produces output **a**. **w** and **b** are adjustable scaler parameters of the neuron. The transfer function is defined by function such as log-sigmoid. A few of the common transfer functions are illustrated in Figure 7-2.

An extension of the single input-single output neuron is the multiple input single output neuron as shown in Figure 7-3. Two or more such neurons may be combined to form a layer of neurons as shown in Figure 7-4. Two or more such layers in series as shown in Figure 7-5 constitute an artificial neural network.

Figure 7-5 illustrates a feed-forward type of ANN. If the outputs are fed back as inputs the ANN is a recurrent type.

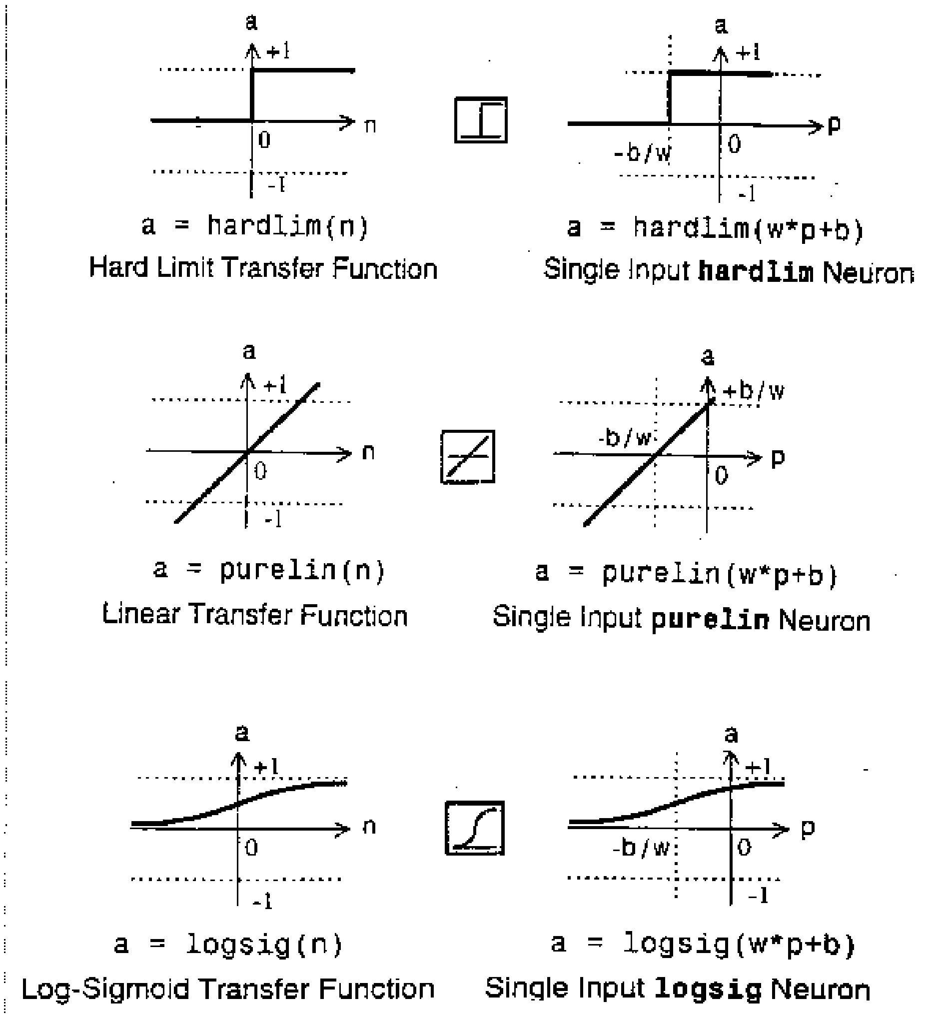

Figure 7-2. Transfer Functions (Matlab 1994)

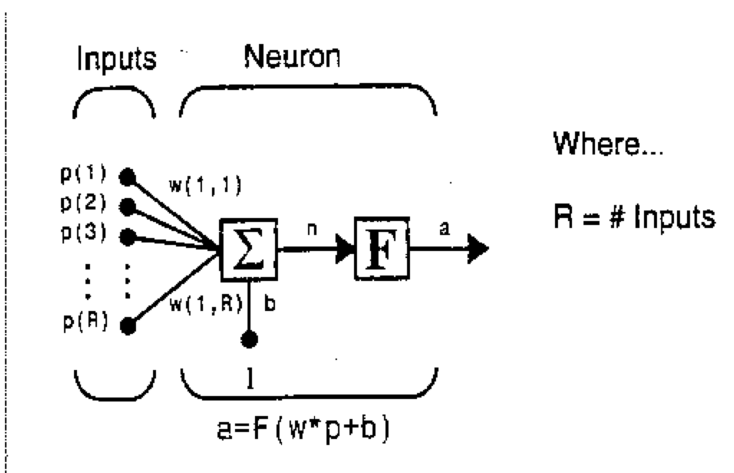

Figure 7-3. Multiple Input Neuron (Matlab 1994)

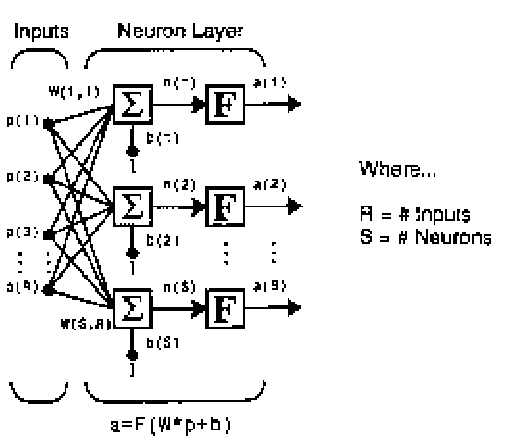

Figure 7-4. Single Layer of Neurons (Matlab 1994)

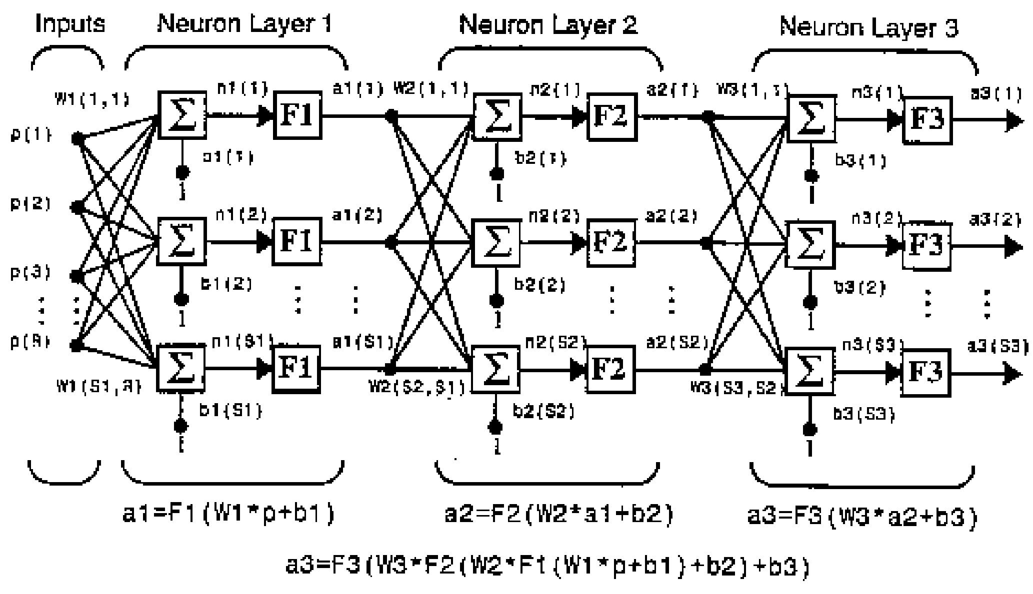

Figure 7-5. Neural Network (Matlab 1994)

Why Use ANNs

Artificial Neural Networks (ANNs) are widely used and well-suited for multiple non-linear regression. They can be interpreted as predicting the expected value of the conditional target distribution as a function of the input pattern. Neural networks are universal approximators, that is they are capable of modeling any function with a finite number of discontinuities to any desired degree of accuracy given sufficient number of hidden neurons. Thus no prior assumptions, such as determination of transfer functions need to be made about the nature of the relationship between the inputs and outputs. Minimal pre-processing is required and different types of inputs can be used in the same network. Once calibrated ANNs are fast and reasonably accurate.

Applications at DWR

Presently ANN's have been applied in the following areas:

- Estimation of salinity from flows and gate positions in the Sacramento - San Joaquin Delta. (See Chapter 9)
- Estimation of THM species. (See Chapter 8)

Future applications proposed are:

- A real time salinity prediction model for a day to day basis.
- Conversion equations for conversion between different measuring techniques of salinity such as TDS, EC and ion concentrations.
- Fish take estimation from flow conditions in the Sacramento - San Joaquin Delta.
- Reasonable emulation of sophisticated models such as ground water model to have significant cuts in run-time while giving reasonable results.

Almost anywhere where regression is used, it could be more accurate to use the ANNs.

References

Neural Network Toolbox User's Guide. Jan. 1994. Math Works, Inc.