Performance of neural network model in estimating daily maximum and minimum temperature in Jaffna

A. Thevakaran[1], D.U.J. Sonnadara[2]

[1]*Department of Physics, University of Jaffna, Thirunelvely, Jaffna*

[2]*Department of Physics, Faculty of Science, University of Colombo*

Background

Serially complete climate data are required as input for climate dependent models such as crop and insect development, soil erosion and evapotranspiration (DeGaetano *et al* 1995). One of the main problems of using series climate data is missing records. Often daily maximum and minimum temperature are used by climate scientists as proxies for climate change studies. Therefore, the development of methods to estimate missing maximum and minimum temperature observations is important. Sri Lanka has a reasonable infrastructure to measure climate observations with 22 main meteorological stations covering many parts of the island and having climate observations dating back to the 1870's. However, the weather stations in the northern and eastern parts of the country experienced problems in maintaining continuous weather records during the period from 1984 to 2000 due to the hostilities in the region. Although the recording weather observations were resumed in 2001, no attempts on the reconstruction of missing observations have been reported.

The methods of estimating the monthly, seasonal or yearly mean meteorological observations are derived by averaging, interpolation, multiple linear regressions *etc* (Huth and Nemesova 1995). However the estimation of daily measurements is often difficult due to high variability influenced by spatial and temporal changes. The main objective of this work is to develop a technique to reconstruct the missing daily maximum and minimum temperature in Jaffna using artificial neural networks.

Methodology

In this work, a feed forward back propagation algorithm was used to develop the neural network model to estimate the daily maximum and minimum temperature data. The Levenberg-Marquardt learning rules were used due to its rapid convergence advantage (Ustaoglu *et al* 2008). A nonlinear transfer function tan-sigmoid was used in the hidden layer and a linear transfer function purelin was used in the output layers. The sum of the weighted inputs and the bias forms the input to the transfer function of the hidden layer of the neural network.

Daily standard departures of temperature in the Mannar, Anuradhapura, Puttalam, and Trincomalee stations were used to derive the inputs for the network and standard departures of temperature in Jaffna were taken as the target output of the network .Ten years of data were used to train and validate the network while five years of data were used to test the network. The predicted values were compared with the actual values (by converting the standard departures to actual temperature) to estimate the accuracy of the network output.

Results

The comparison between the observed and estimated daily maximum temperature in Jaffna (1976-1980) is shown in Figure 1. The gradient of the fitted line is 0.84 with a linear correlation coefficient of 0.88. The standard deviation of the difference between the actual and predicted values is 0.7 ^{0}C. Similarly, the comparison between the observed and estimated daily minimum temperature in Jaffna is shown in Figure 2. The gradient of the fitted line is 0.78 with a linear correlation coefficient of 0.86. The standard deviation of the difference between the actual and predicted values is 1.0 ^{0}C.

Since in both these cases the gradient is not equal to unity, the extreme values of maximum and minimum temperature will show higher deviations.

It can be seen that the accuracy of the network for daily minimum temperature is slightly lower than for the maximum temperature. A closer inspection shows that the accuracy of the estimation varies by month due to changes in the seasonal temperature cycle. Thus, one can improve the accuracy of the estimation by training the network for each month separately.

Conclusions

The preliminary results of a neural network model in estimating the missing daily maximum and minimum temperature of Jaffna were discussed. Standard departures of serially complete daily maximum and minimum temperature records of 10 years (1966-1975) in 4 neighboring stations, Mannar, Anuradhapura, Puttalam and Trincomalee were used as the inputs to train the neural network model. The performance of the model was tested by using an unused 5 years data set (1976-1980). The accuracies of the maximum and minimum temperature estimations were ±0.7°C and ±1.0°C respectively. The accuracy of estimation is higher for the maximum temperature compared to the minimum temperature. The results can be improved by training the network to estimate each month separately.

References

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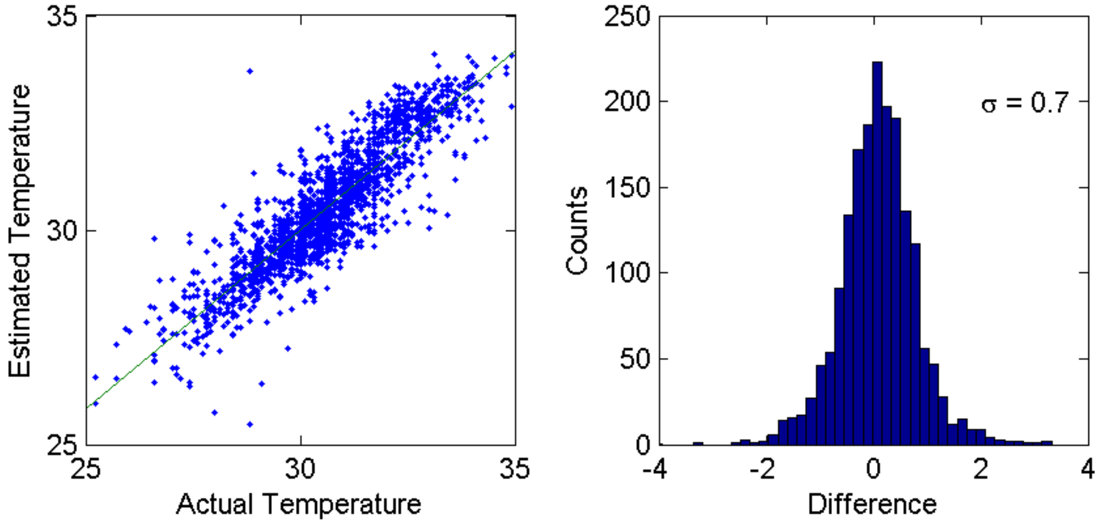

Figure 1: Comparison between the actual and estimated values for daily maximum temperature at Jaffna (a) Correlation (b) Difference

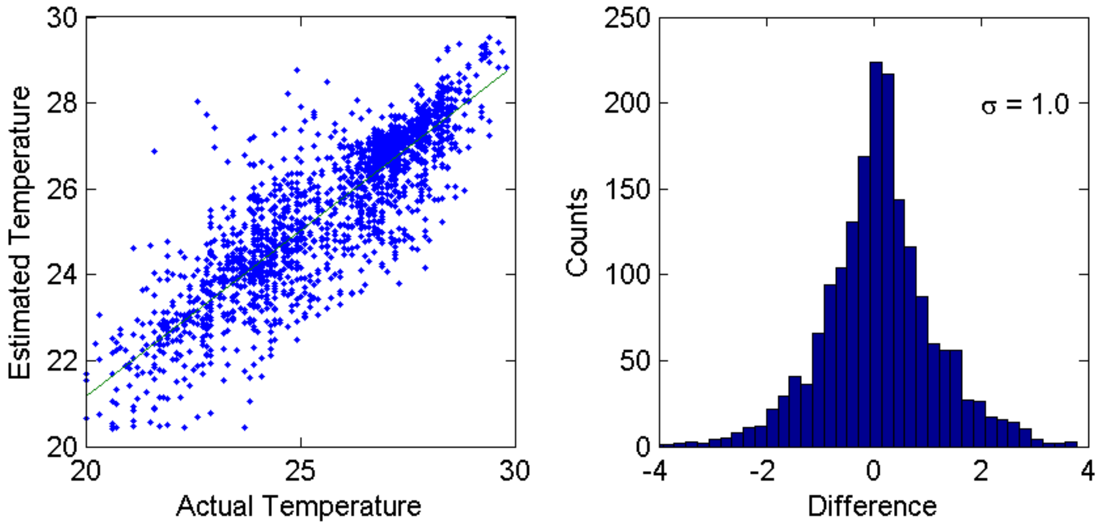

Figure 2: Comparison between the actual and estimated values for daily minimum temperature at Jaffna (b) Correlation (b) Difference