KAUNAS UNIVERSITY OF TECHNOLOGY

INFORMATICS FACULTY

INTRODUCTION TO ARTIFICIAL INTELLIGENCE DATA ANALYSIS LAB 2 WORK REPORT

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1. The first task that should implement our program is to draw a diagram of sun plum activity during 1700-2014.

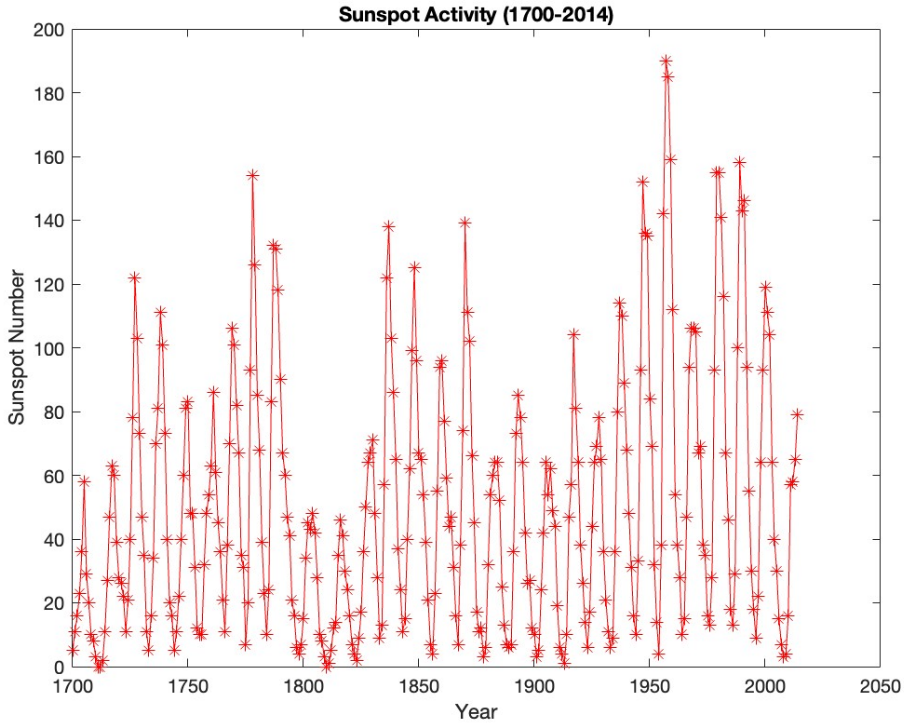

Fig.1: Sunspot Activity from 1700 to 2014.

2. To premise that next year's plum forecast is possible based only on two previous years, the order of the autoregressive model is set as 2. Therefore, the neuron has two inputs, and matrices are created that include input and output data.

```
Size of Matrix P:
     2   313

Size of Matrix T:
     1   313
```

Fig.2: Sizes of P and T matrices.

3. A 3D graph was plotted for the graphical analysis of inputs and outputs.

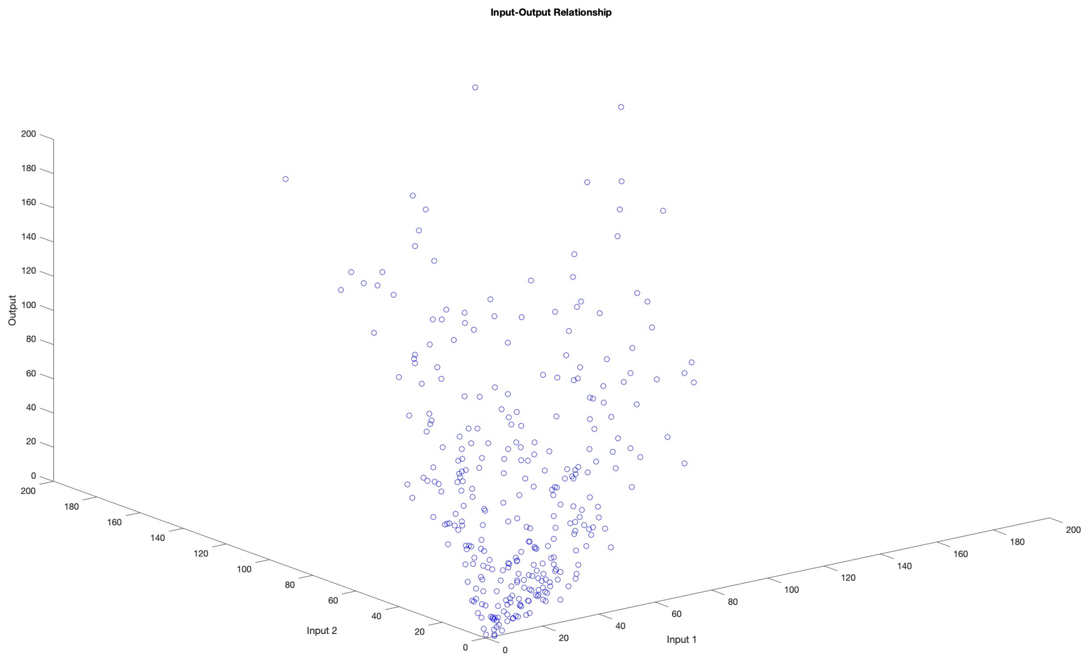

Fig.3: Input-Output Relationship.

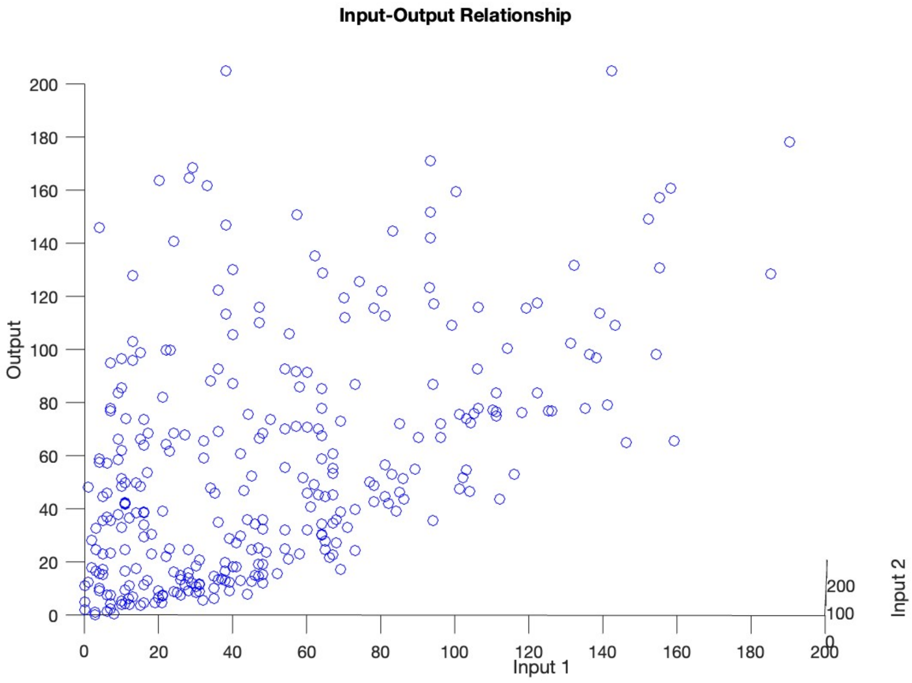

Fig.4: Input1-Output Relationship.

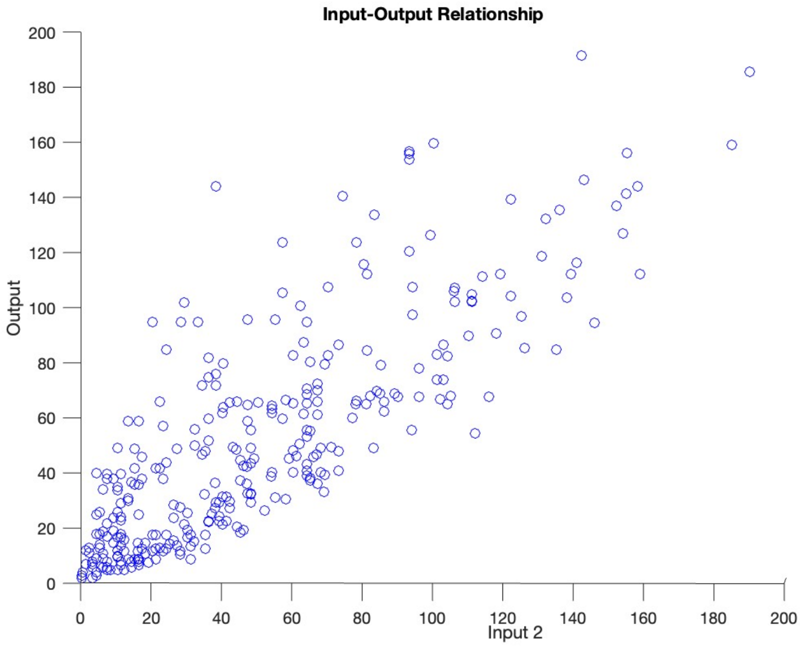

Fig.5: Input2-Output Relationship.

The distribution of Input 2 appears to be more correlated with the output compared to Input 1. Therefore, the weight coefficient of Input 2 should be larger than that of Input 1.

4. To train the model and calculate the optimal values of neuron weight coefficients (parameters of the autoregressive model), fragments of the first 200 members from the inputs P and outputs T dataset are selected. After that, two new matrices, Pu and Tu, are defined.

```
Size of Pu matrix:
     2   200

Size of Tu matrix:
     1   200
```

Fig.6: Sizes of Pu and Tu matrices.

5. An artificial neuron of the structure is created, after which its weight coefficients are calculated using the training data matrices Pu and Tu.

```
Neuron weight coefficient values:
Weights:
   -0.6761    1.3715

Bias:
   13.4037
```

Fig.7: Weights and Bias value of neuron.

6. To check the forecast quality of the model using network simulation, a testing of the developed model is performed. The values from the first 200 years were used for training, and the model's outputs are compared with the real values known during the analyzed period.

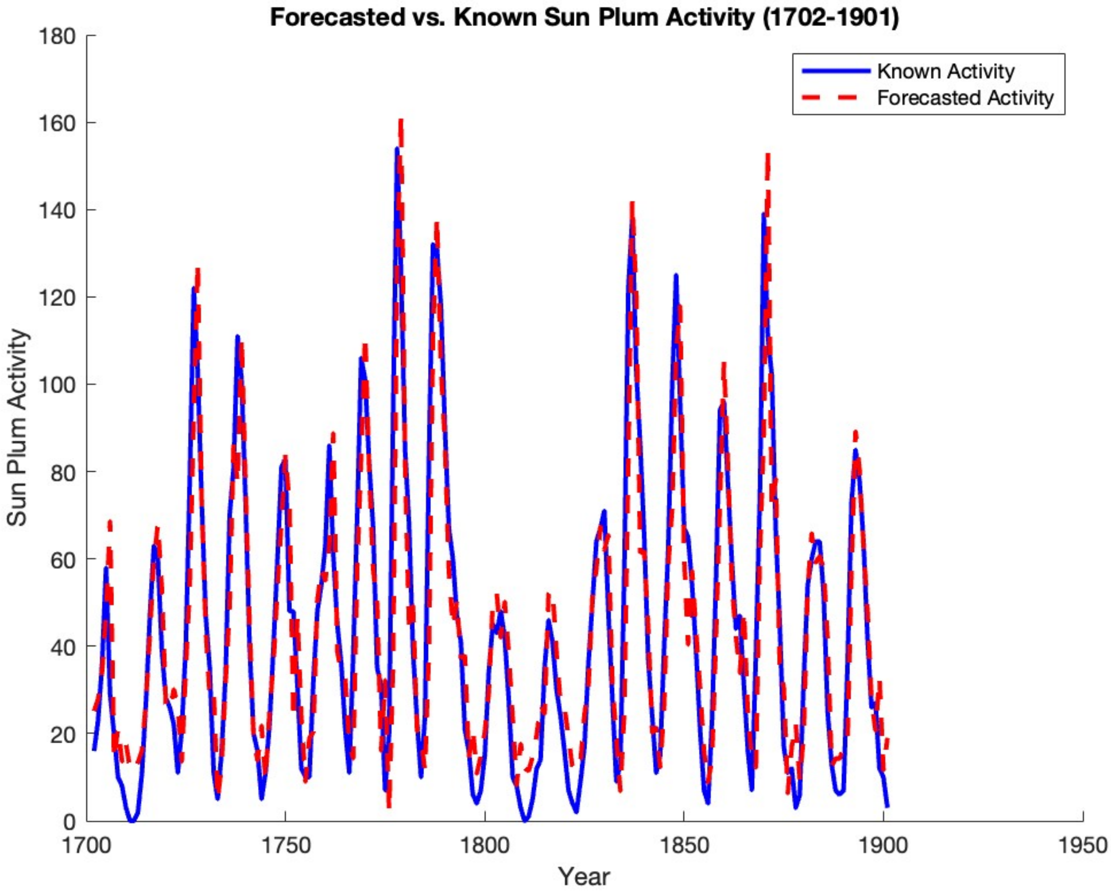

Fig.8: Comparing of Forecasted vs. Known Sun Plum Activity (1702-1901).

7. The same simulation is done for the rest of the data, and the forecasted values are compared with the known values.

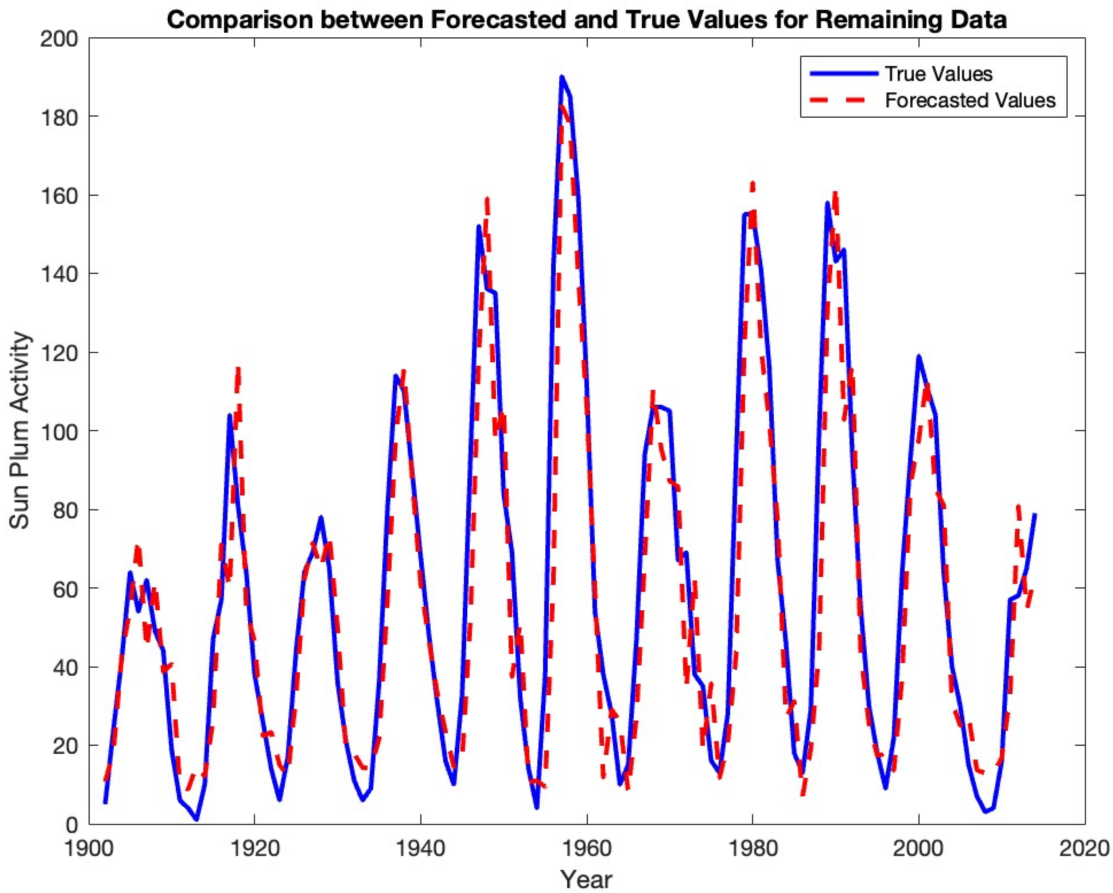

Fig.9: Comparing of Forecasted vs. Known Sun Plum Activity (1902-2014).

8. The forecast error is calculated and shown on the diagram and histogram.

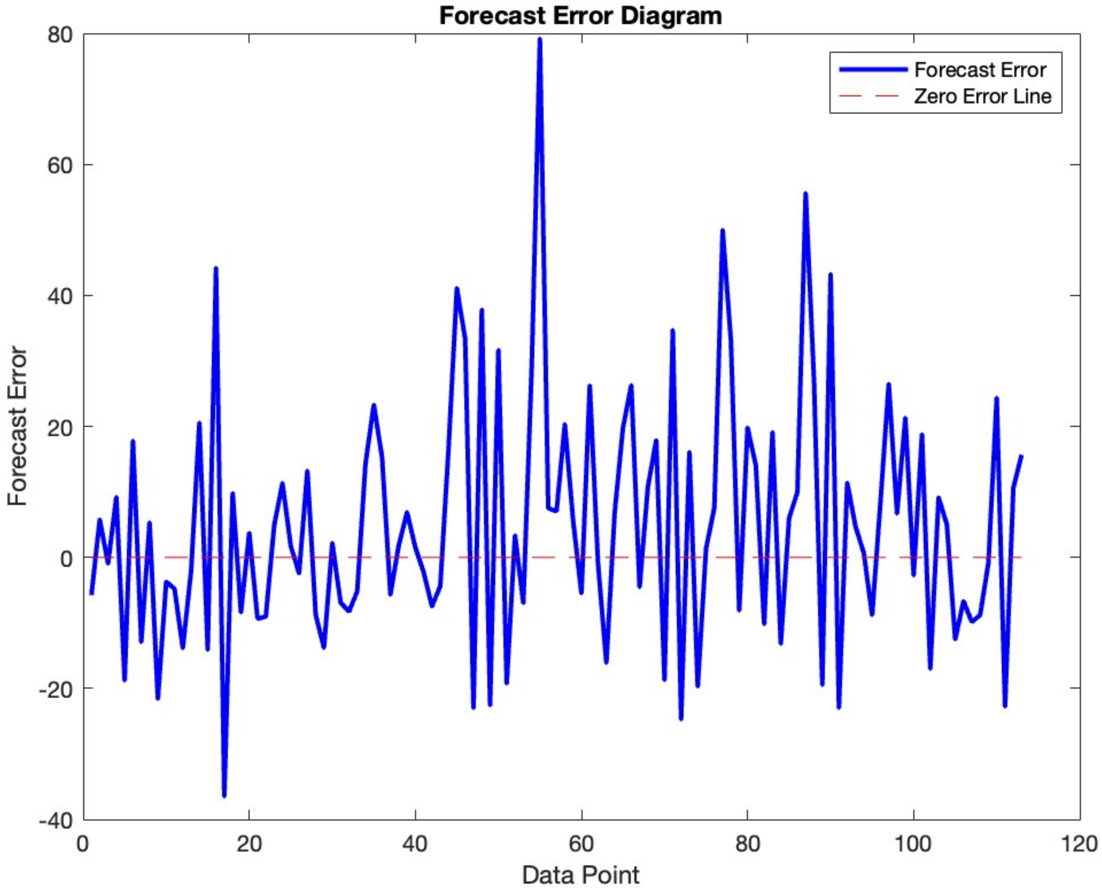

Fig.10: Forecast Error Diagram.

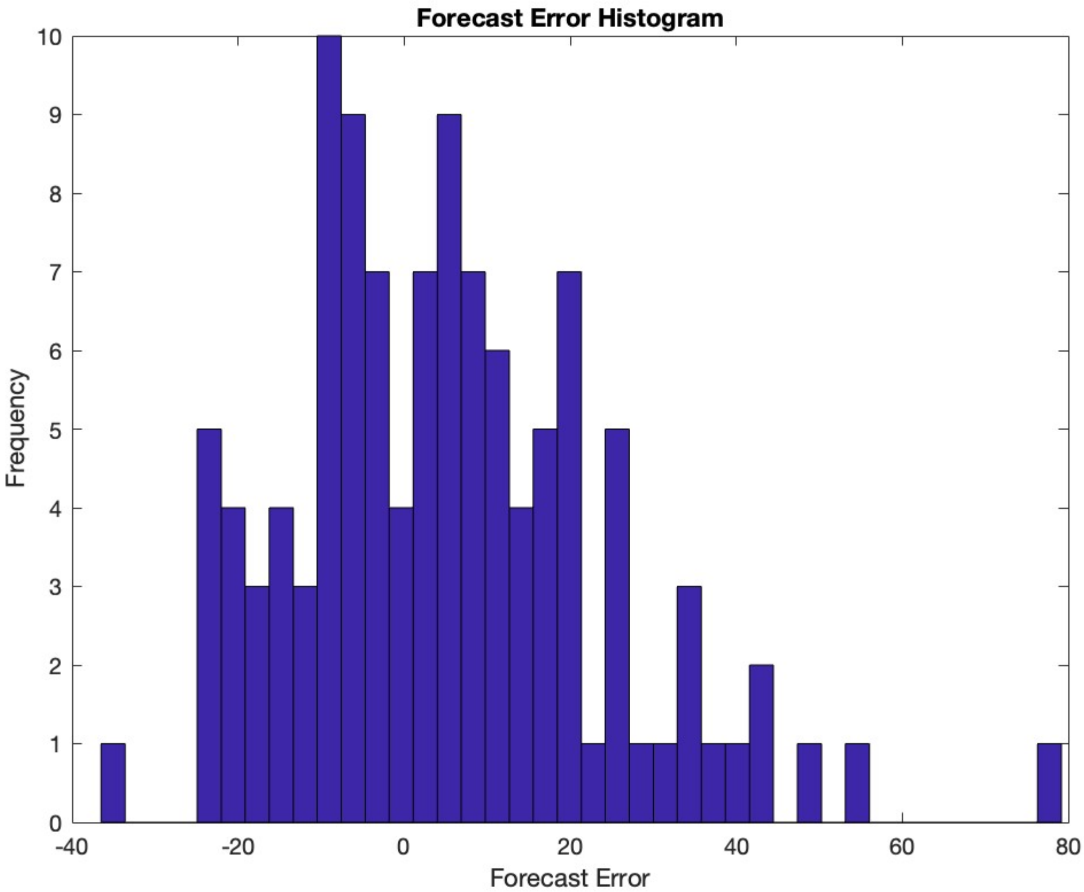

Fig.11: Forecast Error Histogram.

9. The Mean-Square-Error, MSE and MAD is calculated.

```
Mean Squared Error (MSE): 386.4042
Median Absolute Deviation (MAD): 10.768
```

Fig.12: MSE and MAD.

10. Using the "newlin" function, a single neuron is created with 0 input delay and a learning rate between 0 and 1. After that, to train the network, goal and epochs numbers are defined as 100 and 1000 respectively. Thus, new weight values of the neural network and new MSE and MAD for remaining dataset are calculated.

```
New weight coefficients:
Weights:
   -0.5851    1.4638

Bias:
    0.7731
```

Fig.13: New Weights and Bias values of neuron.

```
Mean Squared Error (MSE): 482.7703
Median Absolute Deviation (MAD): 12.6777
```

Fig.14: MSE and MAD for remaining dataset.

11. The procedure is repeated with the new parameters, and their impact on the learning process and forecasting quality is investigated.

When keeping the goal parameter at 100 and increasing the number of epochs from 1000 to 100,000, MSE, MAD, and the weights and bias values were almost the same as the values obtained initially.

```
Mean Squared Error (MSE): 386.4809
Median Absolute Deviation (MAD): 10.7513
Goal Parameter: 100
Epoch Parameter: 100000
```

Fig.15: MSE and MAD when goal is same and epoch is increased.

Increasing the goal parameter from 100 to 300 while keeping the number of epochs constant reduced the magnitudes of the weights and bias coefficients while increasing MSE and MAD.

```
Mean Squared Error (MSE): 536.6961
Median Absolute Deviation (MAD): 12.5616
Goal Parameter: 300
Epoch Parameter: 1000
```

Fig.16: MSE and MAD when epoch is same and goal is increased.

12. To find the maximum value of the Learning Rate that enables the process convergence, a customized function called "maxlinlr" was used.

```
lr =

   8.2079e-07
```

Fig.17: The maximum learning rate value calculated with the function.

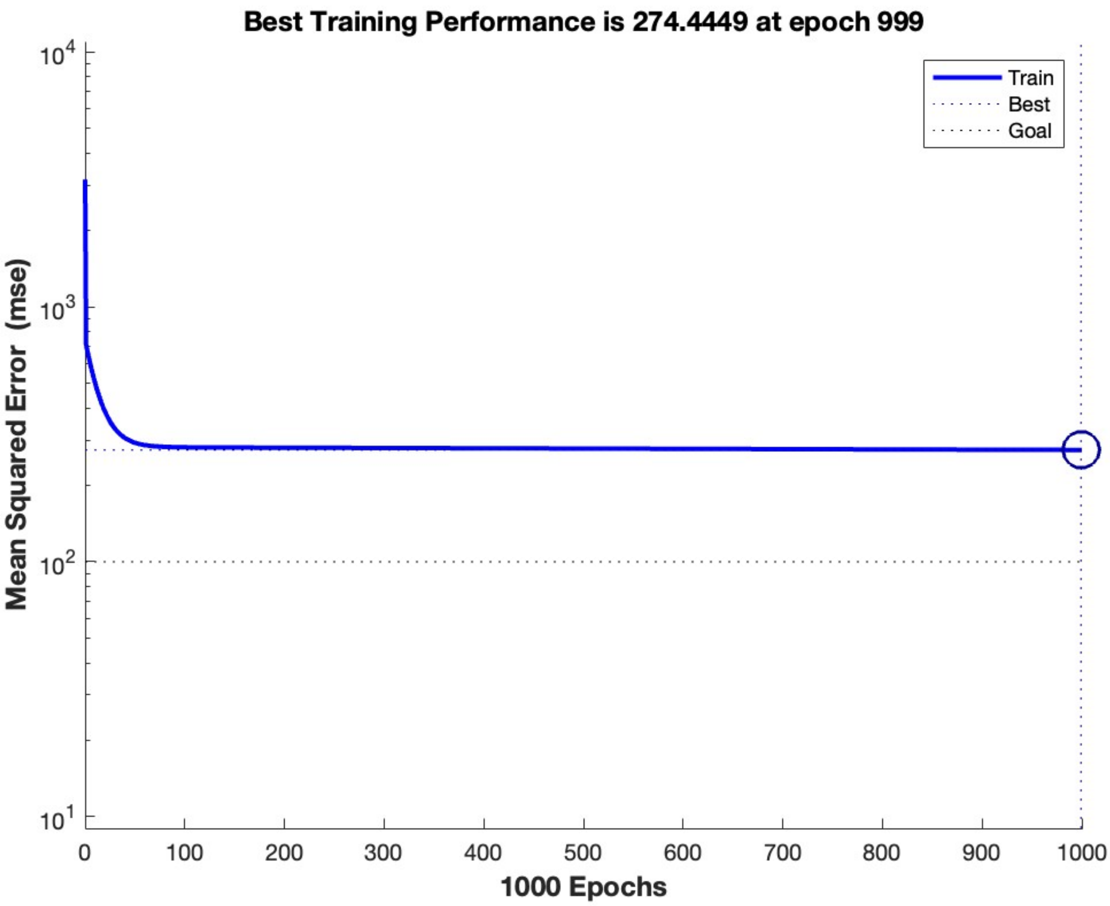

Fig.18: Training Performance

13. The number of network inputs is changed to n=6 and n=11, and correspondingly, the definitions of matrices P and T are redefined. After that, the impact of the model structure change on forecast quality is investigated.

For the default parameters, goal = 100 and epoch = 1000, the MSE significantly decreased compared to the n=2 case when n=6.

```
New weight coefficients:
Weights:
    0.2478   -0.2103    0.1452   -0.1044   -0.5420    1.4158

Bias:
    0.0847

Mean Squared Error (MSE): 398.8737
Median Absolute Deviation (MAD): 12.9509
```

Fig.19: Coefficients and Errors when n=6.

When looking at the same parameters, for n=11, it is observed that the MSE decreased even further.

```
New weight coefficients:
Weights:
  Columns 1 through 6

    0.1048   -0.0522    0.1298    0.0807   -0.0041   -0.0030

  Columns 7 through 11

   -0.0107    0.1107   -0.1966   -0.3325    1.1569

Bias:
    0.0236

Mean Squared Error (MSE): 305.7656
Median Absolute Deviation (MAD): 10.1543
```

Fig.20: Coefficients and Errors when n=11.

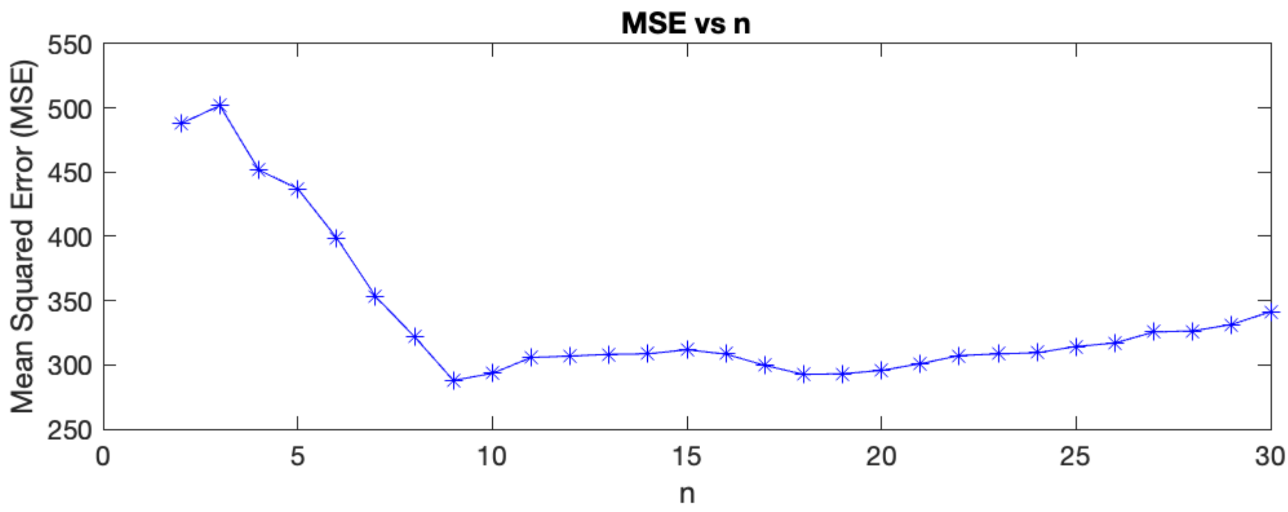

Fig.21: MSE values for n from 2 to 30.

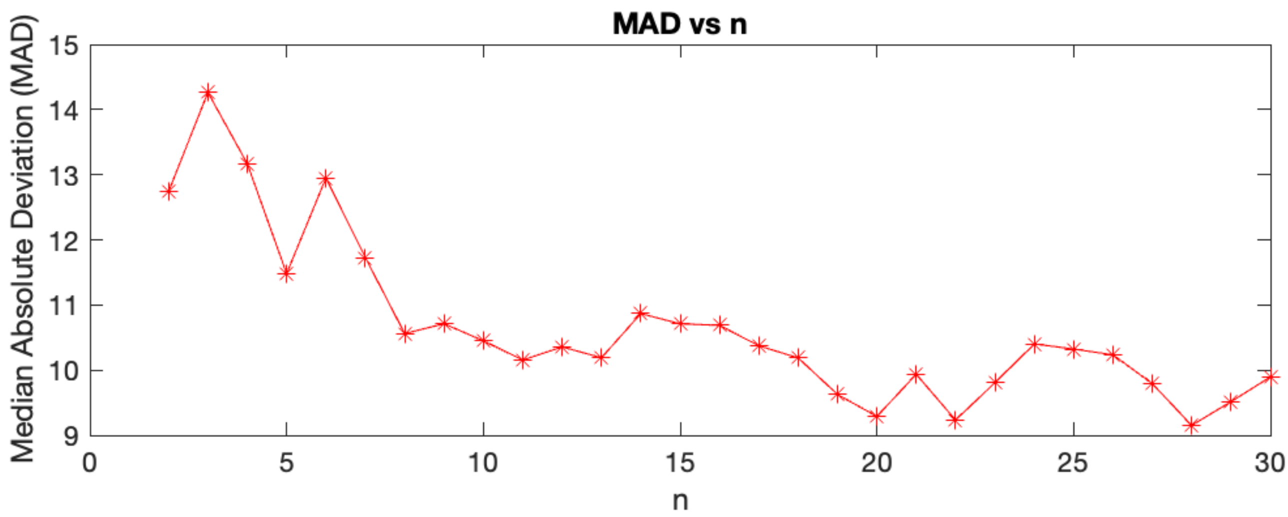

Fig.22: MAD values for n from 2 to 30.

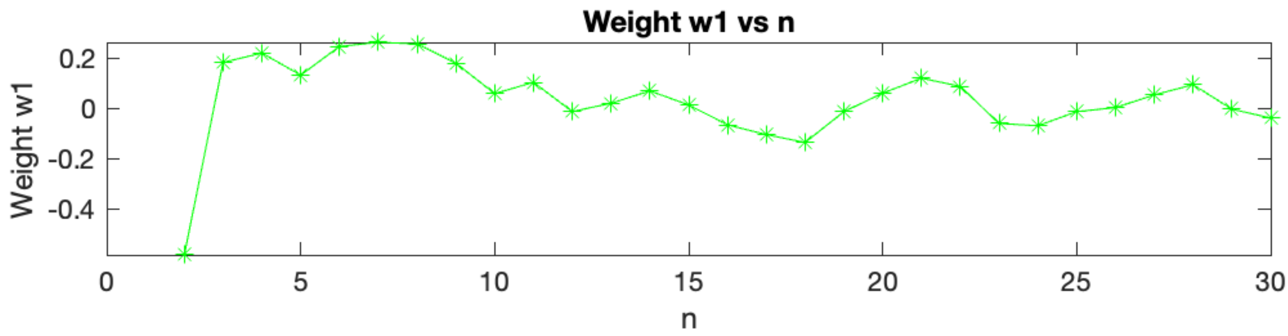

Fig.23: w1 values for n from 2 to 30.

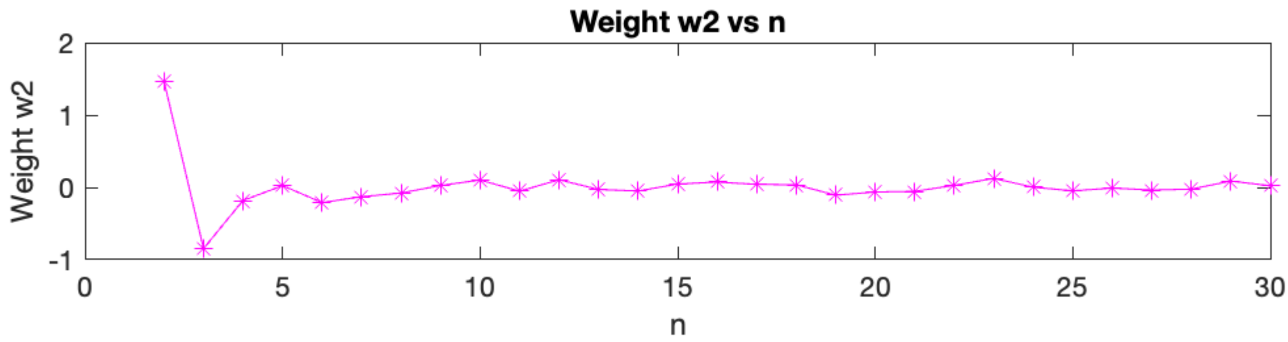

Fig.24: w2 values for n from 2 to 30.

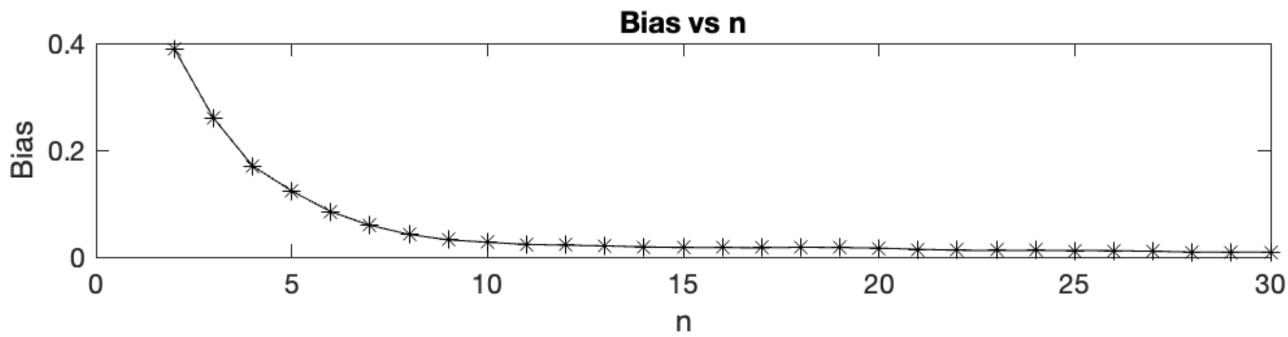

Fig.25: bias values for n from 2 to 30.