

Transfer Entropy Neural Network

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Transfer Entropy was introduced in Chapter ?? It can be stated as the amount of resolved uncertainty in future of Y by past values of X given past values of Y . It uses independence relation instead of correlation based method used in Granger Causality.

Its limitations are twofold:

1. It is only defined for two sequences
2. It is mathematically difficult to estimate for two time series without knowledge underlying joint and conditional probability distributions.

There exist libraries in R programming language like `RTransferEntropy` which calculate transfer entropy. However, prior knowledge of lag of x and lag of y is required to estimate the Transfer Entropy accurately using this library. To overcome this issue we decided to build a neural network. The transfer entropy can accurately estimate transfer entropy and the associated lags (x -lag, y -lag, and linked lag) for two time series sequences. The inherent advantage of the neural network is that we need not input the lag variables as required by other libraries which calculate transfer entropy.

0.1 Training and Testing of TENN

Transfer Entropy Neural Network (TENN) is a two layered neural network, please refer Figure 1. The output of TENN consists of the transfer entropy value, the lag between independent and dependent sequences, the lag of the dependent sequence, and the lag of independent sequence. Data was generated based on Vector autoregression models with varying lags. The generated data was then passed on to the library "RTransferEntropy" to calculate the appropriate transfer entropy.

A large dataset of 50,000 points were generated and utilized to train the neural network based on MSE. It was tested on 6000 time series whose transfer entropy were also generated using the same `RTransferEntropy` package. Figure 2 shows the training error of TENN. It can be seen that the training error decreases to 0.1 and stays there. Figure 3 shows that the testing error also stays around 0.1 indication that TENN does not overfit Transfer Entropy prediction.

Figure 4 shows the training error fluctuates as we train the model. It indicated we need a better functional approximator than the current TENN to estimate x -lag. Even though, 5 suggests that the error is low, the error fluctuation persists. The same can inference can be drawn for Y -lag and XY lag from the Figures 6, 7, 8, 9.

0.1.1 Summary

In Chapter ?? we explain the need for a neural network for estimation of transfer entropy and associated lags. Next, we explain the dataset generation process for the two layered Transfer Entropy Neural Network (TENN). We conclude with a discussion on the training and testing errors of TENN.

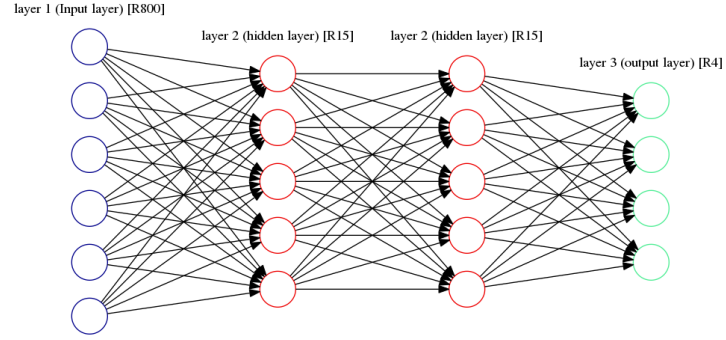


Figure 1: Transfer Entropy Neural Network

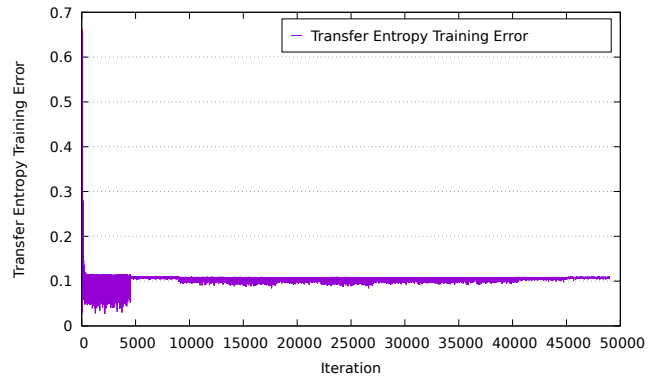


Figure 2: Training error on TENN

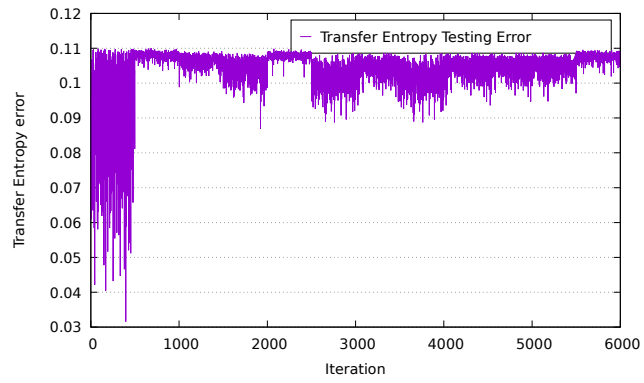


Figure 3: Testing error on TENN

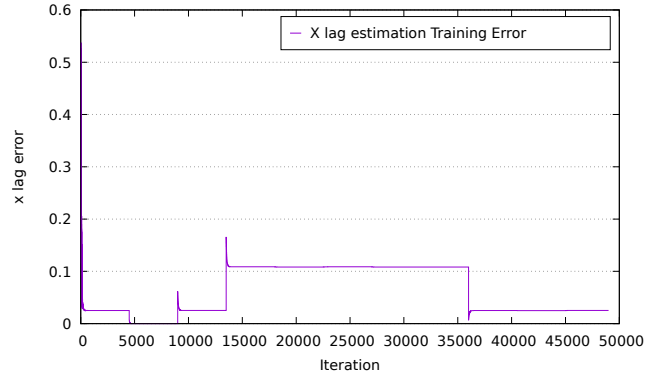


Figure 4: Lag of X- Training error of TENN

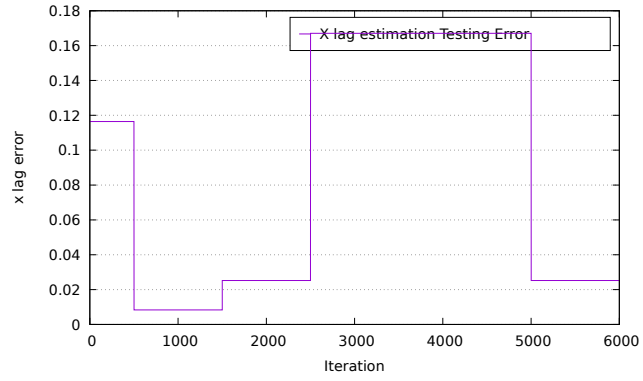


Figure 5: lag of X- Testing error of TENN

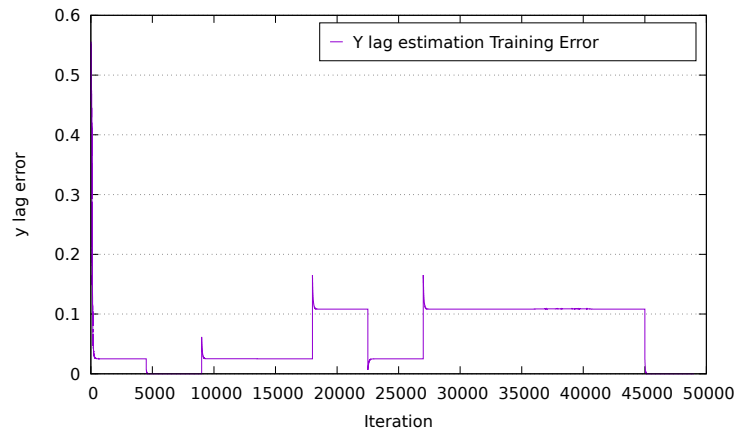


Figure 6: lag of Y- Training error of TENN

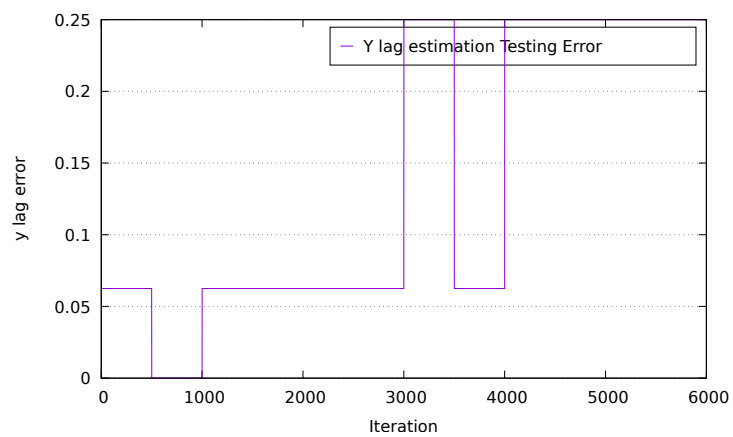


Figure 7: lag of Y- Testing error of TENN

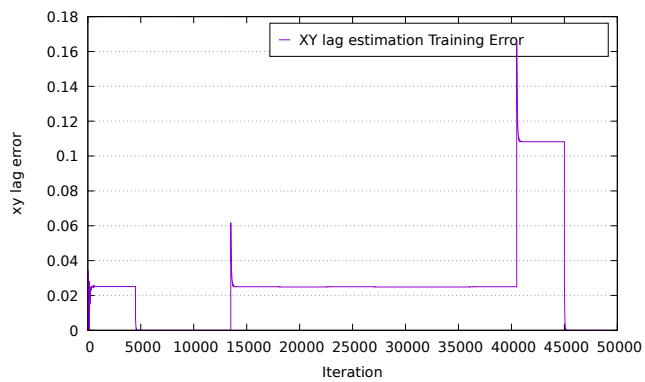


Figure 8: lag of Y to X - Training error of TENN

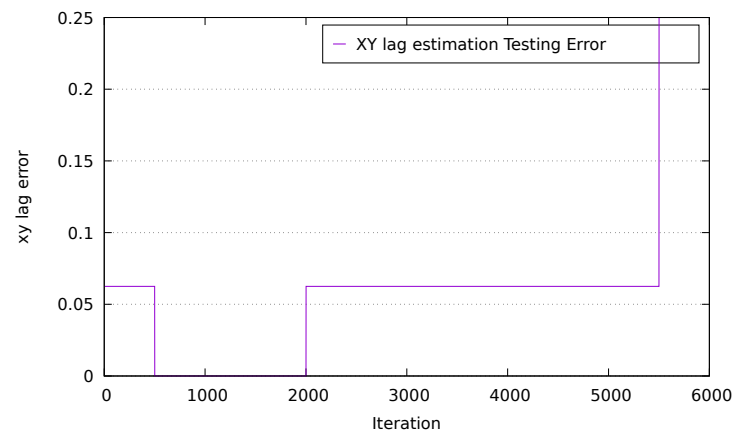


Figure 9: lag of Y to X- Testing error of TENN