Time series modeling.

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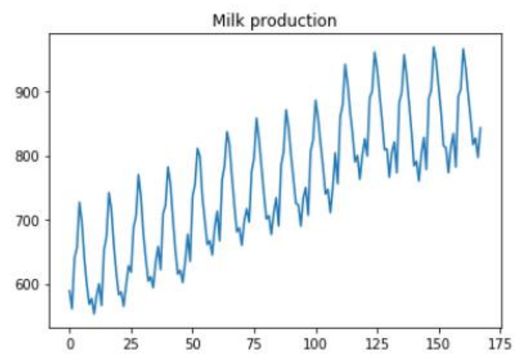
1. Introduction.

The aim of this work is to study and compare three different types of neural networks for the analysis and prediction of time series.

2. Input data.

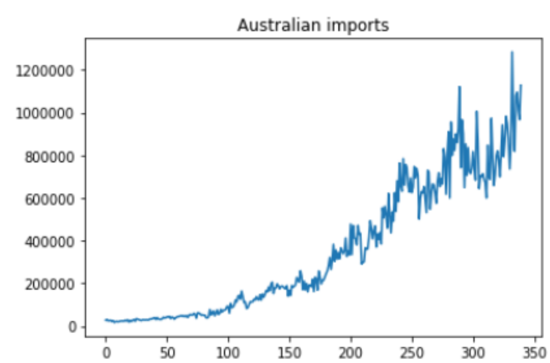
For work was selected two different datasets. The first series contains data on milk production(length = 168). The series contains a pronounced seasonal trend and there is an obvious upward trend over time. The following graph shows the time series.

The graph:



The second series contains data on the import of products in Australia and has a large scatter of data.

The graph:

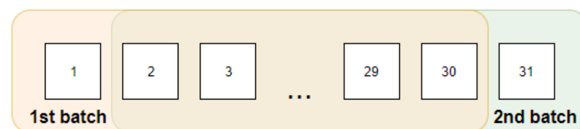


3. Data pre-processing.

Each series is divided into batches of a given value (in this work = 30).

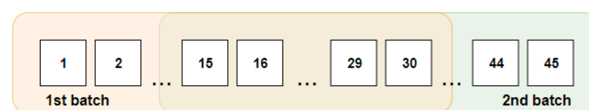
2 different partitioning methods are used:

1. Each package moves forward just for one element. The neural network will predict only one next value for each batch.



For the first batch will be predicted element №31

2. Each batch moves forward for 15 elements, it means that for each batch will be predicted 15 next values.



For the first batch will be predicted next 15 values and the second batch starts from element №45.

4.Used models.

For work was used 3 different types of neural networks:

1.Convolutional neural network

The model of convolutional neural network applying 2 hidden layer feed forward neural net. Weights and biases will be updated during training.

input data: tensor of batch size

output data: tensor of batch size (contains predicted values)

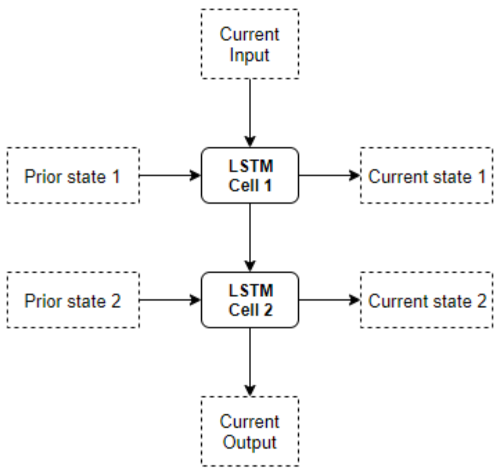
2.Recurrent neural network

The model contains 100 hidden layers, one input and one output. The output contains a tensor with predicted values for each batch.

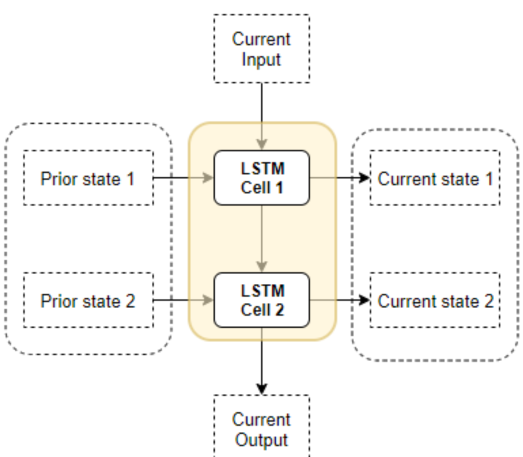
3. Long short-term memory network

For this model was wrapped ten LSTM cells into a ten layer cell to make them look and behave as a single cell.

The pictures below show the difference between two separate cells following one after another and cells combined into one layer.



Two cells stacked on top of each other



Wrap two cells in one

5. Results

Every LSTM cell contain 30 units (can be interpreted as the analogy of hidden layer). The cell has one output and will be represented as a tensor.

All models have been trained in at 500 epochs when it predicts one value and at 1500 epochs when it predicts 15 next values. For training was using the full dataset.

The following page shows the resulting graphs for both data sets and for two ways of dividing into batches.

The blue graph always shows the original data and the orange predicted results. Two graphs at the top for the first series of data, bottom for the second series. The graphs on the left show the results of the prediction of only one value, and on the right side for predicting 15 values.

1. Convolutional neural network.

Figure 1 shows the results of the network. As can be seen from the graphs, the neural network seems to be "late" with the prediction. And the longer the prediction period, the greater the error.

2. Recurrent neural network

For both time series, the recurrent neural network showed excellent results. Especially for the first data set with a pronounced trend. As can be seen from the second time series, the network worse predicts data with a sharp change in values.

3. Long short-term memory network

The network, again, works well with time series with a seasonal trend, but with time series with abrupt changes in values, the network does not cope. The presence of network memory improves predictions on repetitive data and worsens predictions on series with no trend or seasonality.

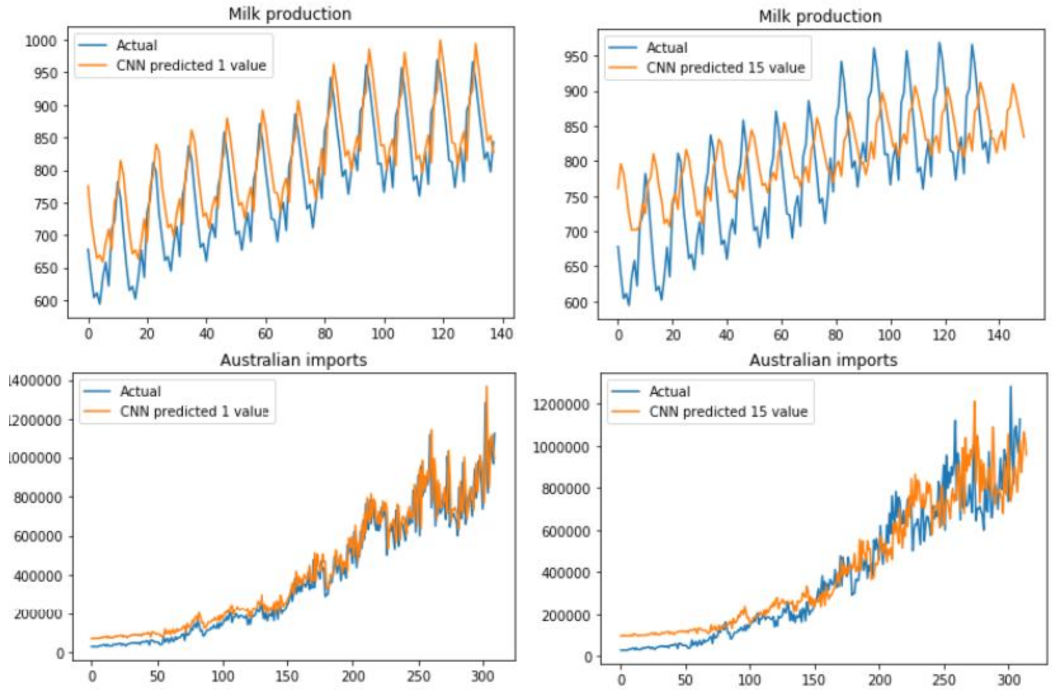


Figure 1: The results of the convolutional neural network.

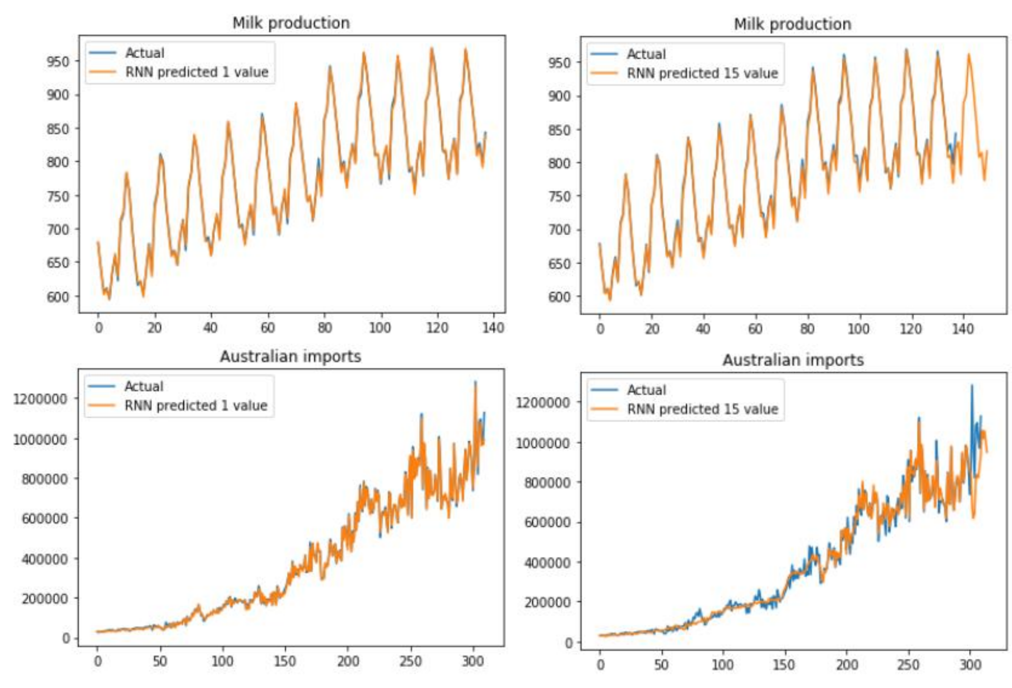


Figure 2: The results of the recurrent neural network.

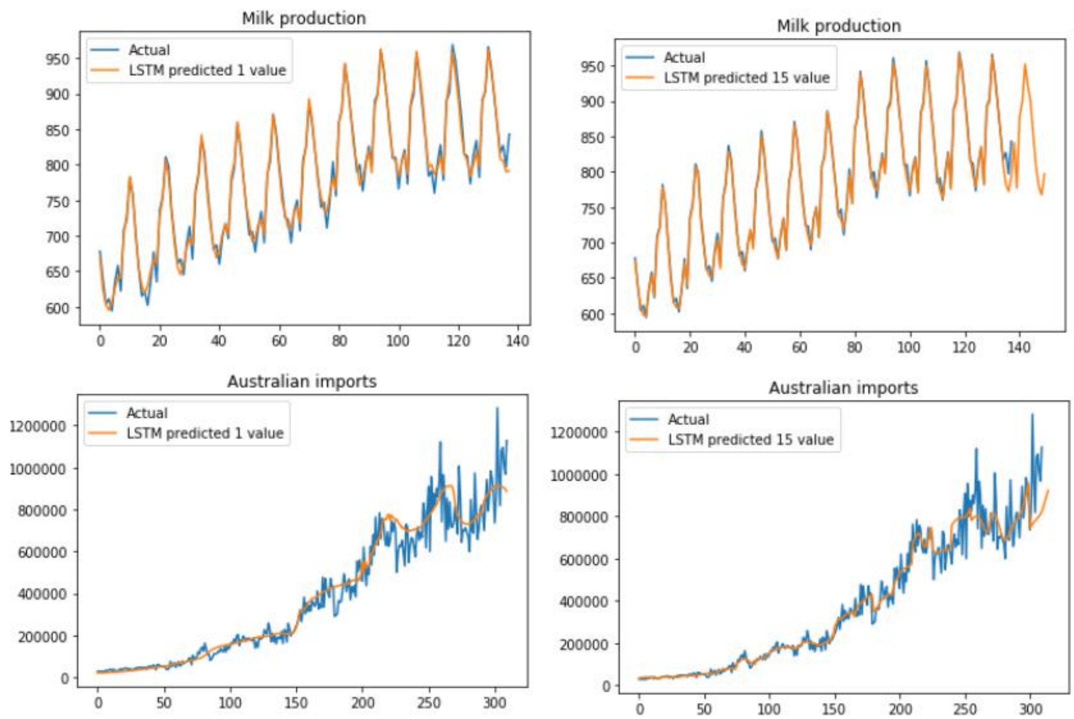


Figure 3: The results of the long short-term memory network.

6. Conclusion

This work shows that using neural networks it is possible to predict time series that contain systematic components. To improve network accuracy for time series without systematic components could be changed network parameters or building a more complex model. Also, more detailed analysis and conversion of the original series can improve the accuracy of predictions.

Used materials:

1. https://medium.com/themlblog/time-series-analysis-using-recurrent-neural-networks-in-tensorflow-2a0478b00be7
2. https://r2rt.com/recurrent-neural-networks-in-tensorflow-ii.html
3. https://mapr.com/blog/deep-learning-tensorflow/
4. https://www.oreilly.com/ideas/building-deep-learning-neural-networks-using-tensorflow-layers
5. https://opendatagroup.github.io/Knowledge%20Center/Tutorials/Tensorflow%20LSTM/