Neural Network Laboratory Work – 7

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LSTM USAGE

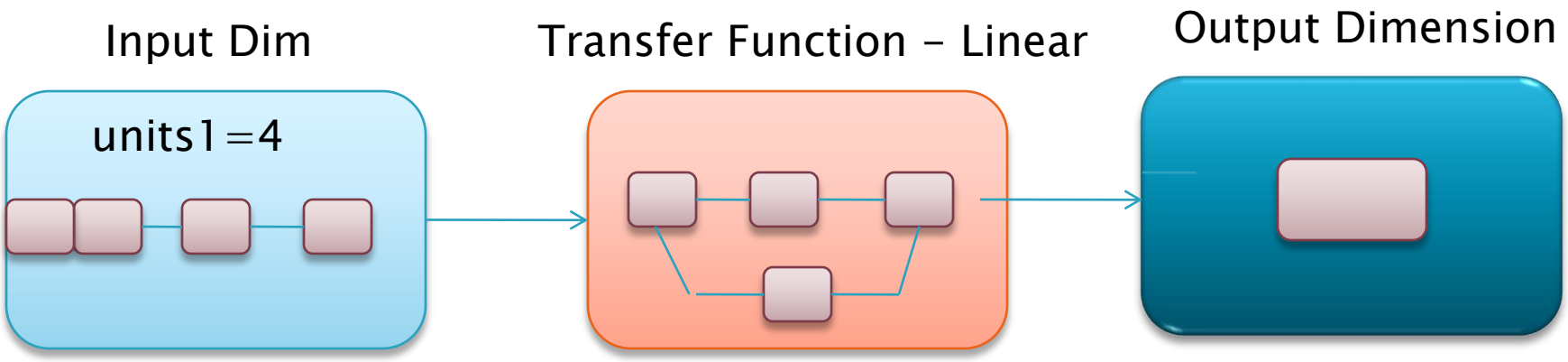
- **LSTM** networks are well-suited to classifying, processing and making predictions based on time series data.

- Since there can be lags of unknown duration between important events in a time series.

- LSTMs were developed to deal with the vanishing gradient problem that can be encountered when training traditional RNNs.

LSTM Layers

- Input Gate: decides which values from the input updates the memory state.
- Forget Gate: decides what information to throw away from the block. Output
- Gate: decides what to output based on input and the memory of the block



LSTM and Dense Layer – Parameters,Output and Shape

```
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
C:\Users\RAVINTHIRAN\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:528: FutureWarning: Passing (type, 1) or
'1type' as a synonym of type is deprecated; in a future version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
C:\Users\RAVINTHIRAN\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:529: FutureWarning: Passing (type, 1) or
'1type' as a synonym of type is deprecated; in a future version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
C:\Users\RAVINTHIRAN\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:530: FutureWarning: Passing (type, 1) or
'1type' as a synonym of type is deprecated; in a future version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
C:\Users\RAVINTHIRAN\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:535: FutureWarning: Passing (type, 1) or
'1type' as a synonym of type is deprecated; in a future version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])

WARNING:tensorflow:From C:\Users\RAVINTHIRAN\Anaconda3\lib\site-packages\tensorflow\python\framework\op_def_library.py:263: col
ocate_with (from tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.

_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 4)                 128
_________________________________________________________________
dense_1 (Dense)              (None, 2)                 10
=================================================================
Total params: 138
Trainable params: 138
Non-trainable params: 0
_________________________________________________________________
WARNING:tensorflow:From C:\Users\RAVINTHIRAN\Anaconda3\lib\site-packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from
tensorflow.python.ops.math_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Epoch 1/25
796/796 [==============================] - 2s 2ms/step - loss: 11.9908
Epoch 2/25
796/796 [==============================] - 0s 253us/step - loss: 10.5282
```

Loss per Epochs – 25 (Epochs)

```
WARNING:tensorflow:From C:\Users\RAVINTHIRAN\Anaconda3\lib\site-packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from
tensorflow.python.ops.math_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Epoch 1/25
796/796 [==============================] - 2s 2ms/step - loss: 11.9908
Epoch 2/25
796/796 [==============================] - 0s 353us/step - loss: 10.53830s - loss: 1
Epoch 3/25
796/796 [==============================] - 0s 317us/step - loss: 9.3632
Epoch 4/25
796/796 [==============================] - 0s 305us/step - loss: 8.3565
Epoch 5/25
796/796 [==============================] - 0s 318us/step - loss: 7.3819
Epoch 6/25
796/796 [==============================] - 0s 318us/step - loss: 6.3636
Epoch 7/25
796/796 [==============================] - 0s 311us/step - loss: 5.3146
Epoch 8/25
796/796 [==============================] - 0s 328us/step - loss: 4.2645
Epoch 9/25
796/796 [==============================] - 0s 302us/step - loss: 3.2893
Epoch 10/25
796/796 [==============================] - 0s 316us/step - loss: 2.7580
Epoch 11/25
796/796 [==============================] - 0s 318us/step - loss: 2.4526
Epoch 12/25
796/796 [==============================] - 0s 301us/step - loss: 2.2268
Epoch 13/25
796/796 [==============================] - 0s 337us/step - loss: 2.0504
Epoch 14/25
796/796 [==============================] - 0s 318us/step - loss: 1.9048
Epoch 15/25
796/796 [==============================] - 0s 307us/step - loss: 1.7805
Epoch 16/25
796/796 [==============================] - 0s 308us/step - loss: 1.6727
Epoch 17/25
```

MSE,RMSE and Correlation – Training and Testing Data

```
Epoch 17/25
796/796 [==============================] - 0s 326us/step - loss: 1.5801
Epoch 18/25
796/796 [==============================] - 0s 335us/step - loss: 1.4999
Epoch 19/25
796/796 [==============================] - 0s 309us/step - loss: 1.4259
Epoch 20/25
796/796 [==============================] - 0s 321us/step - loss: 1.3596
Epoch 21/25
796/796 [==============================] - 0s 304us/step - loss: 1.3011
Epoch 22/25
796/796 [==============================] - 0s 312us/step - loss: 1.2481
Epoch 23/25
796/796 [==============================] - 0s 309us/step - loss: 1.1977
Epoch 24/25
796/796 [==============================] - 0s 314us/step - loss: 1.1526
Epoch 25/25
796/796 [==============================] - 0s 310us/step - loss: 1.1156

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<Figure size 640x480 with 2 Axes>

Train time series
                y1       y2
MSE           0.14     2.05
RMSE          0.37     1.43
Corr coef     0.93     0.89
Corr coef p   0.00     0.00

Test time series
                y1       y2
MSE           0.14     2.52
RMSE          0.37     1.59
Corr coef     0.92     0.86
Corr coef p   0.00     0.00
```
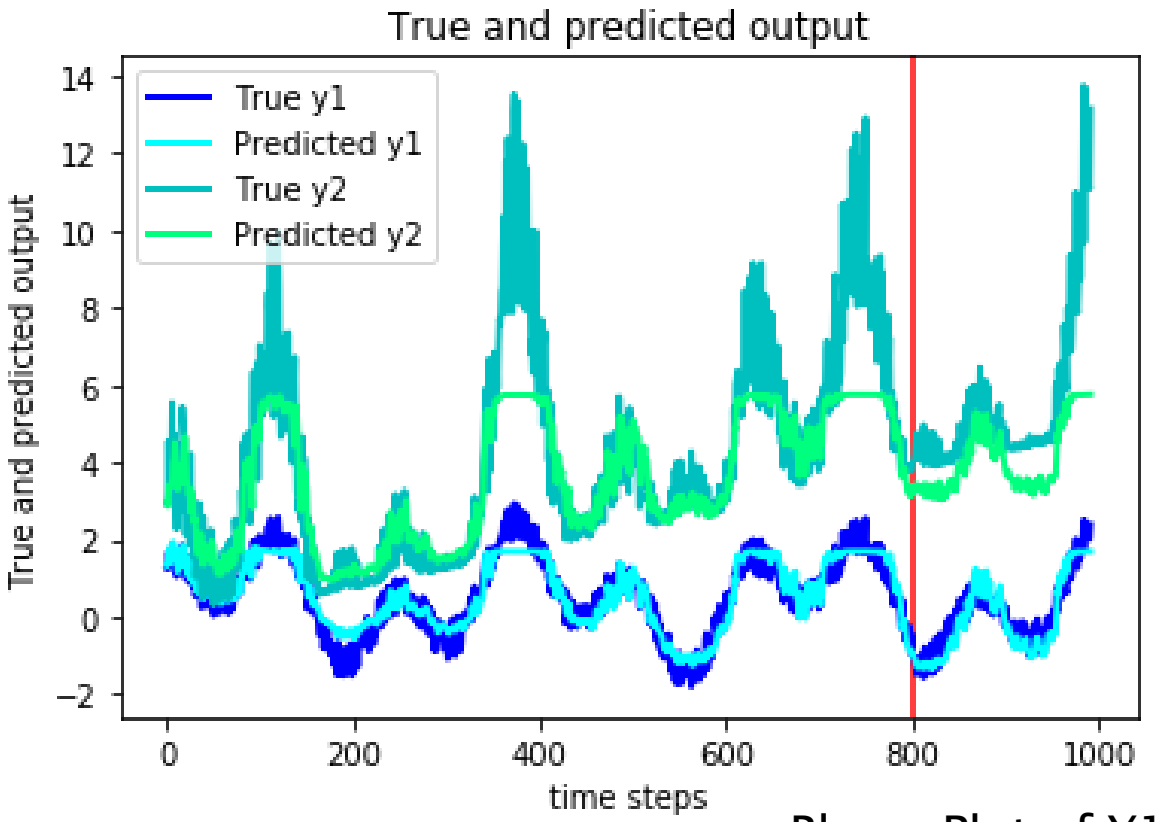
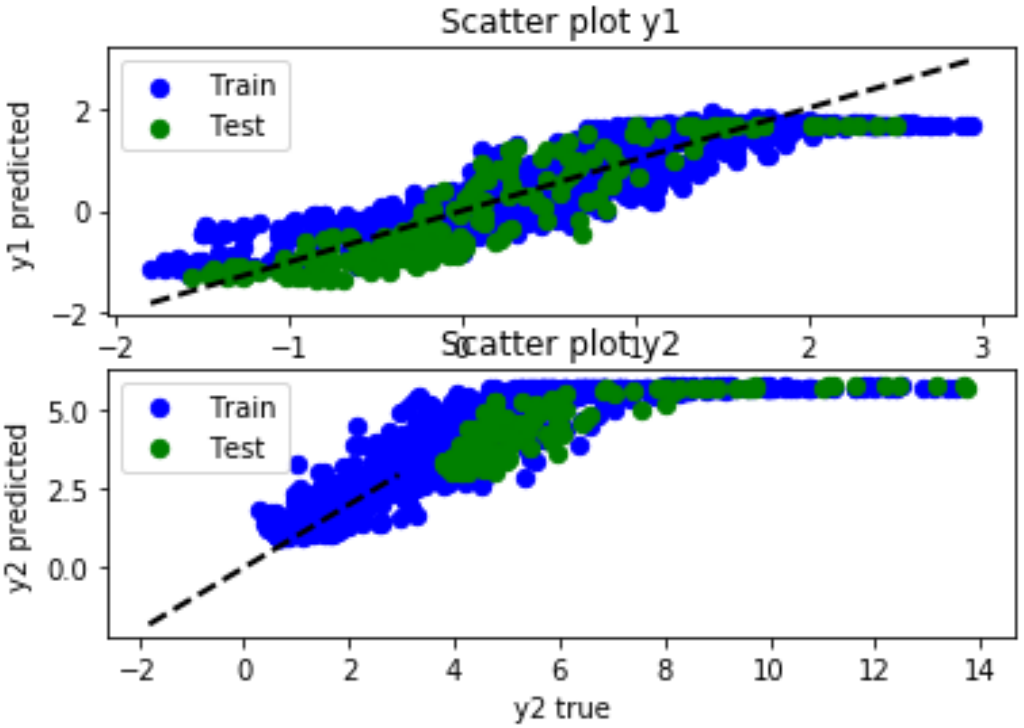

outputs and predictions as a function of time



Blue – Plot of Y1
Aqua – Predicted y1
Green – Predicted y2

Outputs and Prediction



Input and Output Dimesnion, Unit Steps

- N=1200 #number of time steps
- n=1000 #number of time steps for training
- step = 6

- Units = 6

Dense and LSTM layer

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_4 (LSTM)                (None, 6)                 240
_________________________________________________________________
dense_4 (Dense)              (None, 2)                 14
=================================================================
Total params: 254
Trainable params: 254
Non-trainable params: 0
_________________________________________________________________
Epoch 1/25
994/994 [==============================] - 2s 2ms/step - loss: 12.8537
Epoch 2/25
994/994 [==============================] - 0s 392us/step - loss: 10.4765
Epoch 3/25
994/994 [==============================] - 0s 401us/step - loss: 8.2814
Epoch 4/25
994/994 [==============================] - 0s 395us/step - loss: 6.1384
```

Dense and LSTM layer

```
994/994 [==============================] - 0s 404us/step - loss: 1.2927
Epoch 17/25
994/994 [==============================] - 0s 376us/step - loss: 1.2153
Epoch 18/25
994/994 [==============================] - 0s 395us/step - loss: 1.1452
Epoch 19/25
994/994 [==============================] - 0s 364us/step - loss: 1.0840
Epoch 20/25
994/994 [==============================] - 0s 399us/step - loss: 1.0293
Epoch 21/25
994/994 [==============================] - 0s 390us/step - loss: 0.9762
Epoch 22/25
994/994 [==============================] - 0s 375us/step - loss: 0.9286
Epoch 23/25
994/994 [==============================] - 0s 382us/step - loss: 0.8907
Epoch 24/25
994/994 [==============================] - 0s 390us/step - loss: 0.8573
Epoch 25/25
994/994 [==============================] - 0s 373us/step - loss: 0.8303
```

Train and Test Series

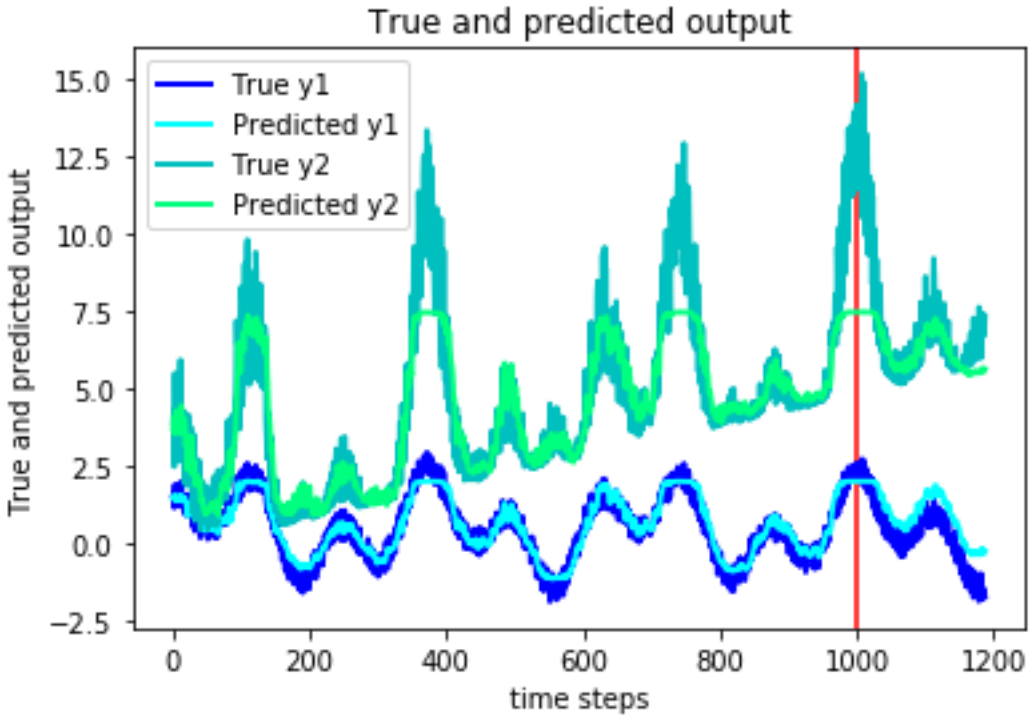
Train time series

	y1	y2
MSE	0.13	1.49
RMSE	0.36	1.22
Corr coef	0.94	0.90
Corr coef p	0.00	0.00

Test time series

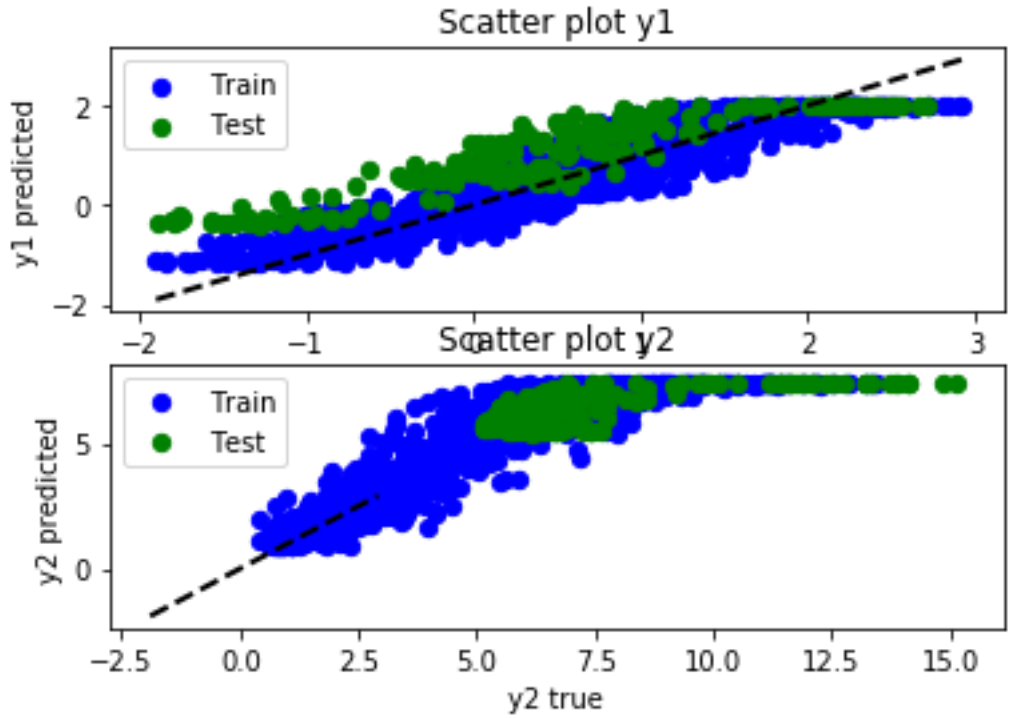
	y1	y2
MSE	0.61	4.30
RMSE	0.78	2.07
Corr coef	0.92	0.73
Corr coef p	0.00	0.00

outputs and predictions as a function of time



Blue – Plot of Y1
Aqua – Predicted y1
Green – Predicted y2

Outputs and Prediction



Thank You