```
import matplotlib as mpl
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from sklearn.preprocessing import MinMaxScaler
from scipy import stats
import seaborn as sns
import tensorflow as tf
from tensorflow import keras
import sklearn
import sys
import io

n_steps = 50
forecast = 10

def plot_learning_curves(loss, val_loss):
    plt.figure()
    plt.plot(np.arange(len(loss)), loss, "b.-", label="Training loss")
    plt.plot(np.arange(len(val_loss)), val_loss, "r.-", label="Validation loss")
    plt.gca().xaxis.set_major_locator(mpl.ticker.MaxNLocator(integer=True))
    plt.legend(fontsize=14)
    plt.xlabel("Epochs")
    plt.ylabel("Loss")
    plt.grid(True)

#LOAD DATA
data_west = pd.read_csv('denoised_data_1016_west.csv')
data_west_o = np.array(data_west.FLOW)
# #EXRTEND DATA
array_to_concatinate = data_west_o[288:]
for iter in range (35):
    data_west_o = np.concatenate([data_west_o,array_to_concatinate])

# #SCALE AND RESHAPE DATA
scaler = MinMaxScaler()
array = data_west_o.reshape(-1, 1)
array_scaled = scaler.fit_transform(array)
flow_reshaped = array_scaled[:(len(array_scaled) - (len(array_scaled) % (n_steps+forecast
print(flow_reshaped.shape)

# #TRAIN SET, VALIDATION SET, TEST SET
test = int(0.7 * flow_reshaped.shape[0])
valid = int(0.9 * flow_reshaped.shape[0])

X_train= flow_reshaped[:test, :n_steps] #first 50, last 10
X_valid = flow_reshaped[test:valid, :n_steps]
X_test = flow_reshaped[valid:, :n_steps]

#prepare targets
Y = np.empty((flow_reshaped.shape[0], n_steps, forecast))
for step_ahead in range(1, forecast + 1):
    Y[:, :, step_ahead - 1] = flow_reshaped[:, step_ahead:step_ahead + n_steps, 0]

y_train = Y[:test]
y_valid = Y[test:valid]
y_test = Y[valid:]

# # NEW MODEL TO FIT HYPERPARAMETERS
model = keras.models.Sequential([
    keras.layers.SimpleRNN(20, return_sequences=True, input_shape=[None, 1]),
    keras.layers.SimpleRNN(20, return_sequences=True),
    keras.layers.TimeDistributed(keras.layers.Dense(forecast))
])

def last_time_step_mse(Y_true, Y_pred):
    return keras.metrics.mean_squared_error(Y_true[:, -1], Y_pred[:, -1])

model.compile(loss="mse", optimizer="adam",  metrics=[last_time_step_mse])
```

```
early_stopping_cb = keras.callbacks.EarlyStopping(patience=10, restore_best_weights=True)
history = model.fit(X_train, y_train, epochs=700,
                    validation_data=(X_valid, y_valid), callbacks=[early_stopping_cb])

model.save("rnn_1016_west.h5")
plot_learning_curves(history.history["loss"], history.history["val_loss"])


#50 minutes forecast
flow_unscaled = array[:(len(array) - (len(array) % (n_steps + forecast)))].reshape(-1, (n
y_test_unscaled = flow_unscaled[valid:, n_steps:, 0]
y_real_rescaled = y_test_unscaled[-1, :].reshape(-1, 1)
print(y_real_rescaled.shape)

flow_not_reshaped = array[:(len(array) - (len(array) % (n_steps+forecast)))]

#flow prediction
y_pred = model.predict(X_test[-1, :].reshape(-1, n_steps, 1)) #shape (1, 50, 10)
y_pred = y_pred[-1,-1,:].reshape(-1,1)
y_pred_rescaled = scaler.inverse_transform(y_pred).reshape(-1, 1) #shape (10, 1)
print(y_pred_rescaled.shape)

#time
time_not_reshaped = np.array(data_west['TIME'][:(len(data_west['TIME']) - (len(data_west[
time_reshaped = np.array(data_west['TIME'][:(len(data_west['TIME']) - (len(data_west['TIM
    reshape(-1, (n_steps+forecast), 1)

valid_time = int(0.9 * time_reshaped.shape[0])
y_time_test = time_reshaped[valid_time:, n_steps:, 0]
print(y_time_test[-1, :].shape)

def plot_prediction(y_real_resacled, y_pred_rescaled, flow_not_reshaped, time_not_reshape
    plt.figure()
    plt.title("50 minutes prediction", fontsize=14)
    plt.plot(time_not_reshaped[-300:-forecast], flow_not_reshaped[-300:-forecast], 'b-')
    plt.plot(y_time_test[-1, :], y_real_resacled, 'ro-', label = 'Real values')
    plt.plot(y_time_test[-1, :], y_pred_rescaled, 'gx-', label = 'Predicted values')
    plt.legend(loc="upper left")
    plt.xlabel("Time")
    plt.ylabel('Volume')

plot_prediction(y_real_rescaled, y_pred_rescaled, flow_not_reshaped, time_not_reshaped, y

plt.show()
```

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(10545, 60, 1)
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow/pythe
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the
Train on 7381 samples, validate on 2109 samples
Epoch 1/700
7381/7381 [==============================] - 4s 593us/sample - loss: 0.0213 - l
Epoch 2/700
7381/7381 [==============================] - 3s 467us/sample - loss: 0.0075 - l
Epoch 3/700
7381/7381 [==============================] - 4s 519us/sample - loss: 0.0070 - l
Epoch 4/700
7381/7381 [==============================] - 4s 527us/sample - loss: 0.0069 - l
Epoch 5/700
7381/7381 [==============================] - 4s 537us/sample - loss: 0.0068 - l
Epoch 6/700
7381/7381 [==============================] - 4s 532us/sample - loss: 0.0067 - l
Epoch 7/700
7381/7381 [==============================] - 4s 553us/sample - loss: 0.0067 - l
Epoch 8/700
7381/7381 [==============================] - 4s 523us/sample - loss: 0.0067 - l
Epoch 9/700
7381/7381 [==============================] - 4s 527us/sample - loss: 0.0067 - l
Epoch 10/700
7381/7381 [==============================] - 4s 528us/sample - loss: 0.0067 - l
Epoch 11/700
7381/7381 [==============================] - 4s 537us/sample - loss: 0.0067 - l
Epoch 12/700
7381/7381 [==============================] - 4s 509us/sample - loss: 0.0067 - l
Epoch 13/700
7381/7381 [==============================] - 4s 525us/sample - loss: 0.0067 - l
Epoch 14/700
7381/7381 [==============================] - 4s 498us/sample - loss: 0.0067 - l
Epoch 15/700
7381/7381 [==============================] - 4s 535us/sample - loss: 0.0067 - l
Epoch 16/700
7381/7381 [==============================] - 4s 534us/sample - loss: 0.0067 - l
Epoch 17/700
7381/7381 [==============================] - 4s 506us/sample - loss: 0.0066 - l
Epoch 18/700
7381/7381 [==============================] - 4s 521us/sample - loss: 0.0066 - l
Epoch 19/700
7381/7381 [==============================] - 4s 536us/sample - loss: 0.0067 - l
Epoch 20/700
7381/7381 [==============================] - 4s 551us/sample - loss: 0.0066 - l
Epoch 21/700
7381/7381 [==============================] - 4s 558us/sample - loss: 0.0066 - l
Epoch 22/700
7381/7381 [==============================] - 4s 541us/sample - loss: 0.0066 - l
Epoch 23/700
7381/7381 [==============================] - 4s 550us/sample - loss: 0.0066 - l
Epoch 24/700
7381/7381 [==============================] - 4s 552us/sample - loss: 0.0066 - l
Epoch 25/700
7381/7381 [==============================] - 4s 553us/sample - loss: 0.0066 - l
Epoch 26/700
7381/7381 [==============================] - 4s 532us/sample - loss: 0.0066 - l
Epoch 27/700
7381/7381 [==============================] - 4s 526us/sample - loss: 0.0066 - l
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Epoch 28/700
7381/7381 [==============================] - 4s 539us/sample - loss: 0.0066 - l
Epoch 29/700
7381/7381 [==============================] - 4s 529us/sample - loss: 0.0066 - l
Epoch 30/700
7381/7381 [==============================] - 4s 524us/sample - loss: 0.0066 - l
Epoch 31/700
7381/7381 [==============================] - 4s 518us/sample - loss: 0.0066 - l
Epoch 32/700
7381/7381 [==============================] - 4s 513us/sample - loss: 0.0066 - l
Epoch 33/700
7381/7381 [==============================] - 4s 502us/sample - loss: 0.0066 - l
Epoch 34/700
7381/7381 [==============================] - 4s 502us/sample - loss: 0.0066 - l
Epoch 35/700
7381/7381 [==============================] - 4s 520us/sample - loss: 0.0066 - l
Epoch 36/700
7381/7381 [==============================] - 4s 522us/sample - loss: 0.0066 - l
Epoch 37/700
7381/7381 [==============================] - 4s 531us/sample - loss: 0.0066 - l
Epoch 38/700
7381/7381 [==============================] - 4s 545us/sample - loss: 0.0066 - l
Epoch 39/700
7381/7381 [==============================] - 4s 552us/sample - loss: 0.0066 - l
Epoch 40/700
7381/7381 [==============================] - 4s 521us/sample - loss: 0.0066 - l
Epoch 41/700
7381/7381 [==============================] - 4s 505us/sample - loss: 0.0066 - l
Epoch 42/700
7381/7381 [==============================] - 4s 513us/sample - loss: 0.0066 - l
Epoch 43/700
7381/7381 [==============================] - 4s 516us/sample - loss: 0.0066 - l
Epoch 44/700
7381/7381 [==============================] - 4s 520us/sample - loss: 0.0066 - l
Epoch 45/700
7381/7381 [==============================] - 4s 527us/sample - loss: 0.0066 - l
Epoch 46/700
7381/7381 [==============================] - 4s 502us/sample - loss: 0.0066 - l
Epoch 47/700
7381/7381 [==============================] - 4s 539us/sample - loss: 0.0065 - l
Epoch 48/700
7381/7381 [==============================] - 4s 526us/sample - loss: 0.0065 - l
Epoch 49/700
7381/7381 [==============================] - 4s 522us/sample - loss: 0.0065 - l
Epoch 50/700
7381/7381 [==============================] - 4s 522us/sample - loss: 0.0065 - l
Epoch 51/700
7381/7381 [==============================] - 4s 515us/sample - loss: 0.0065 - l
Epoch 52/700
7381/7381 [==============================] - 4s 505us/sample - loss: 0.0065 - l
Epoch 53/700
7381/7381 [==============================] - 4s 489us/sample - loss: 0.0065 - l
Epoch 54/700
7381/7381 [==============================] - 4s 524us/sample - loss: 0.0065 - l
Epoch 55/700
7381/7381 [==============================] - 3s 442us/sample - loss: 0.0065 - l
Epoch 56/700
7381/7381 [==============================] - 3s 467us/sample - loss: 0.0065 - l
Epoch 57/700
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7381/7381 [==============================] - 4s 523us/sample - loss: 0.0064 -
Epoch 58/700
7381/7381 [==============================] - 4s 524us/sample - loss: 0.0064 -
Epoch 59/700
7381/7381 [==============================] - 3s 455us/sample - loss: 0.0064 -
Epoch 60/700
7381/7381 [==============================] - 4s 493us/sample - loss: 0.0064 -
Epoch 61/700
7381/7381 [==============================] - 3s 467us/sample - loss: 0.0064 -
Epoch 62/700
7381/7381 [==============================] - 3s 441us/sample - loss: 0.0064 -
Epoch 63/700
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7381/7381 [==============================] - 4s 512us/sample - loss: 0.0064 -
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7381/7381 [==============================] - 4s 505us/sample - loss: 0.0064 -
Epoch 66/700
7381/7381 [==============================] - 4s 494us/sample - loss: 0.0063 -
Epoch 67/700
7381/7381 [==============================] - 3s 461us/sample - loss: 0.0063 -
Epoch 68/700
7381/7381 [==============================] - 4s 481us/sample - loss: 0.0063 -
Epoch 69/700
7381/7381 [==============================] - 4s 480us/sample - loss: 0.0063 -
Epoch 70/700
7381/7381 [==============================] - 4s 483us/sample - loss: 0.0063 -
Epoch 71/700
7381/7381 [==============================] - 3s 453us/sample - loss: 0.0063 -
Epoch 72/700
7381/7381 [==============================] - 3s 442us/sample - loss: 0.0063 -
Epoch 73/700
7381/7381 [==============================] - 3s 444us/sample - loss: 0.0063 -
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7381/7381 [==============================] - 4s 483us/sample - loss: 0.0063 -
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Epoch 76/700
7381/7381 [==============================] - 3s 450us/sample - loss: 0.0063 -
Epoch 77/700
7381/7381 [==============================] - 4s 510us/sample - loss: 0.0063 -
Epoch 78/700
7381/7381 [==============================] - 4s 503us/sample - loss: 0.0063 -
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7381/7381 [==============================] - 4s 511us/sample - loss: 0.0063 -
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Epoch 81/700
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7381/7381 [==============================] - 4s 495us/sample - loss: 0.0063 -
Epoch 85/700
7381/7381 [==============================] - 4s 477us/sample - loss: 0.0063 -
Epoch 86/700
7381/7381 [==============================] - 3s 436us/sample - loss: 0.0063 -
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Epoch 87/700
7381/7381 [==============================] - 3s 420us/sample - loss: 0.0063 - 
Epoch 88/700
7381/7381 [==============================] - 3s 420us/sample - loss: 0.0063 - 
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7381/7381 [==============================] - 4s 520us/sample - loss: 0.0062 - 
Epoch 116/700
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7381/7381 [==============================] - 4s 487us/sample - loss: 0.0062 - 
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Epoch 123/700
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Epoch 132/700
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Epoch 133/700
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Epoch 137/700
7381/7381 [==============================] - 3s 467us/sample - loss: 0.0062 - 
Epoch 138/700
7381/7381 [==============================] - 4s 494us/sample - loss: 0.0061 - 
Epoch 139/700
7381/7381 [==============================] - 3s 467us/sample - loss: 0.0061 - 
Epoch 140/700
7381/7381 [==============================] - 3s 462us/sample - loss: 0.0061 - 
(10, 1)
(10, 1)
(10,)
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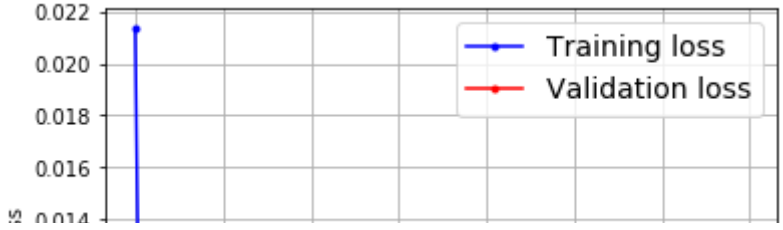
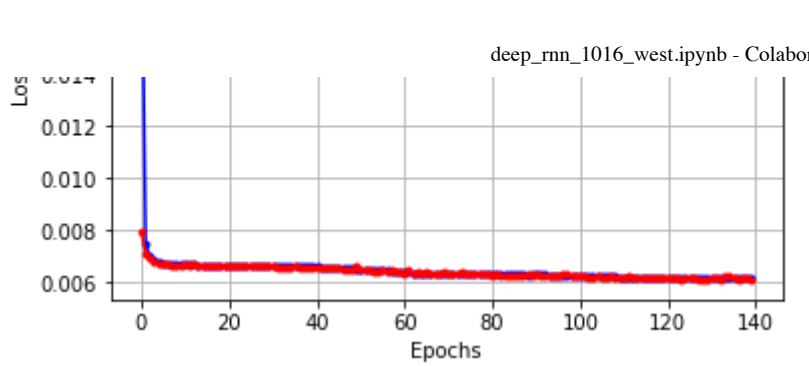
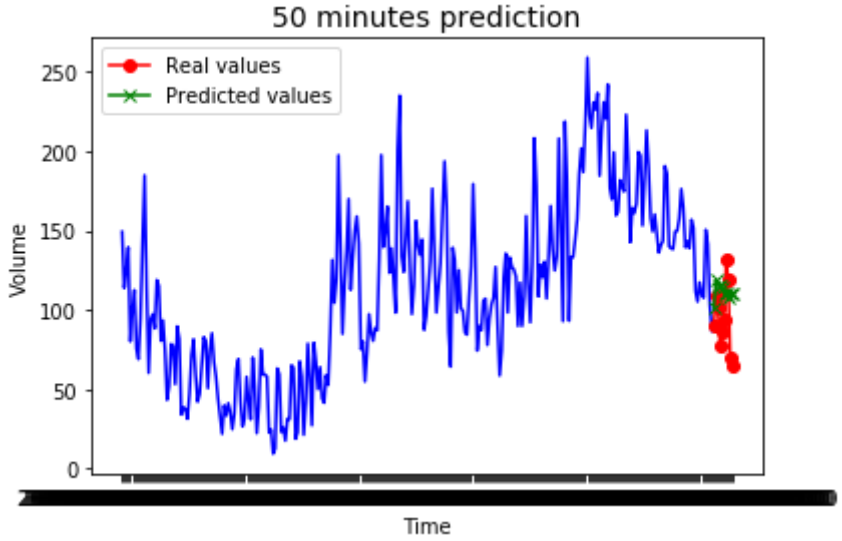



0.012
0.010
0.008
0.006
0
20
40
60
80
100
120
140
Epochs


50 minutes prediction
Real values
Predicted values
250
200
150
100
50
0
Volume
Time