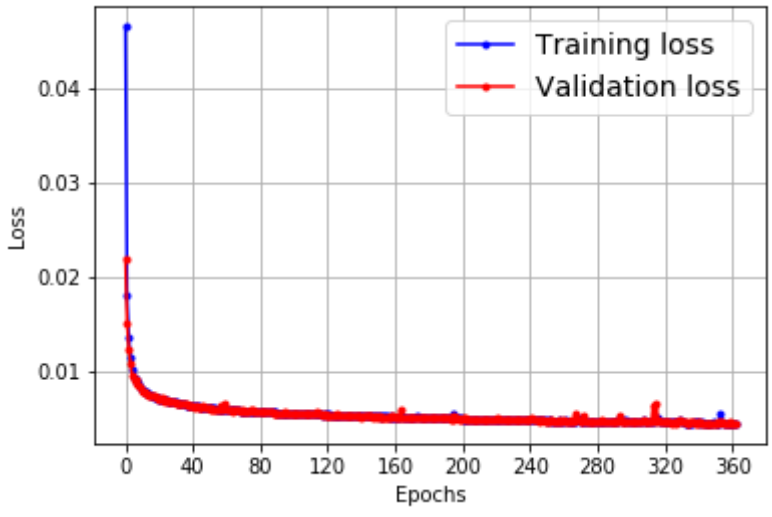
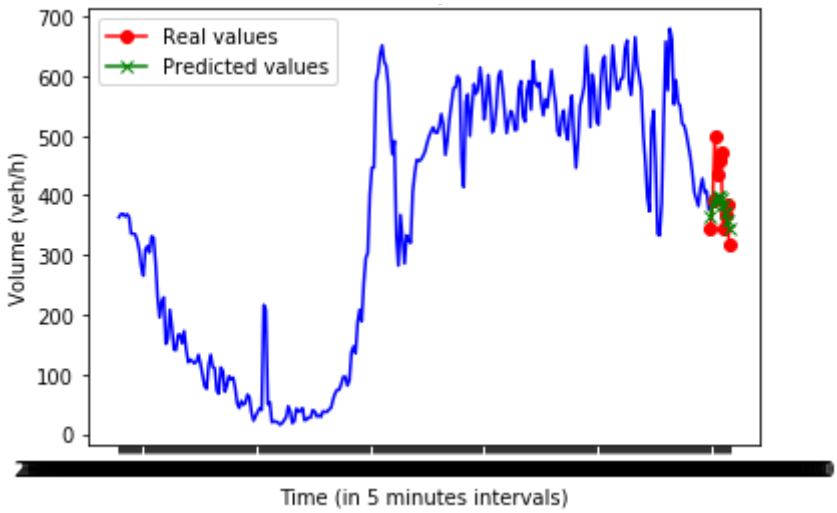
```
import matplotlib as mpl
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from sklearn.preprocessing import MinMaxScaler
from scipy import stats
import seaborn as sns
import tensorflow as tf
from tensorflow import keras
import sklearn
import sys
import io

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)

n_steps = 50
forecast = 10

#EXTRACT FLOW, Z SCORE, OUTLIERS
data_west = pd.read_csv('denoised_data_1015_east.csv')
data_west_o = np.array(data_west.FLOW)
print(data_west_o.shape)

#EXRTEND DATA
array_to_concatinate = data_west_o
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]
X_valid = flow_reshaped[test:valid, :n_steps]
X_test = flow_reshaped[valid:, :n_steps]
print(X_test.shape)
print(X_test[-1:].shape)

#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:]

#DEFINE AND COMPILE MODEL
model = keras.models.Sequential([
    keras.layers.LSTM(20, return_sequences=True, input_shape=[None, 1]),
    keras.layers.LSTM(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=15, 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("lstm_1015_west.h5")
plot_learning_curves(history.history["loss"], history.history["val_loss"])

#50 MINS PREDICTION
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 (in 5 minutes intervals)")
    plt.ylabel('Volume (veh/h)')

plot_prediction(y_real_rescaled, y_pred_rescaled, flow_not_reshaped, time_not_reshaped, y

plt.show()
```

```
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 345/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 346/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 347/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 348/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 349/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 350/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0046 - l
Epoch 351/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 352/700
7499/7499 [==============================] - 15s 2ms/sample - loss: 0.0045 - l
Epoch 353/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 354/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0055 - l
Epoch 355/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0046 - l
Epoch 356/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 357/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 358/700
7499/7499 [==============================] - 15s 2ms/sample - loss: 0.0045 - l
Epoch 359/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 360/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 361/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 362/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
Epoch 363/700
7499/7499 [==============================] - 14s 2ms/sample - loss: 0.0045 - l
(10, 1)
(10, 1)
(10,)
```



50 minutes prediction


Real values
Predicted values
Volume (veh/h)
Time (in 5 minutes intervals)
700
600
500
400
300
200
100
0