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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_south.csv')
data_west_o = np.array(data_west.FLOW)

#EXRTEND DATA
array_to_concatinate = data_west_o[175:]
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
#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:]

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

model = keras.models.Sequential()
model.add(keras.layers.InputLayer(input_shape=[None, 1]))
for rate in (1, 2, 4, 8) * 2:
    model.add(keras.layers.Conv1D(filters=20, kernel_size=2, padding="causal",
                              activation="relu", dilation_rate=rate))
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model.add(keras.layers.Conv1D(filters=10, kernel_size=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=1000,
                    validation_data=(X_valid, y_valid), callbacks=[early_stopping_cb])

model.save("vawenet_1014_south.h5")
plot_learning_curves(history.history["loss"], history.history["val_loss"])

#50 MIN FORECAST
#50 MIN FORECAST
#flow
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)

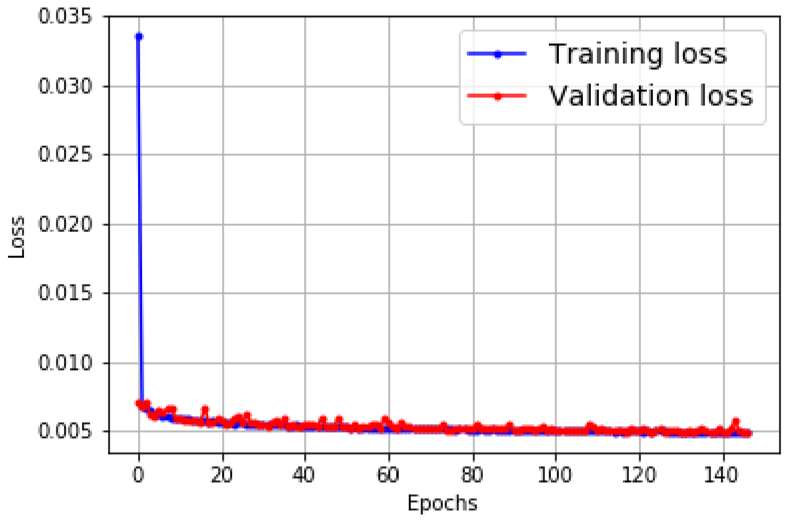
valid_time = int(0.9 * time_reshaped.shape[0])
y_time_test = time_reshaped[valid_time:, n_steps:, 0]
print(y_time_test[-1, :].shape)

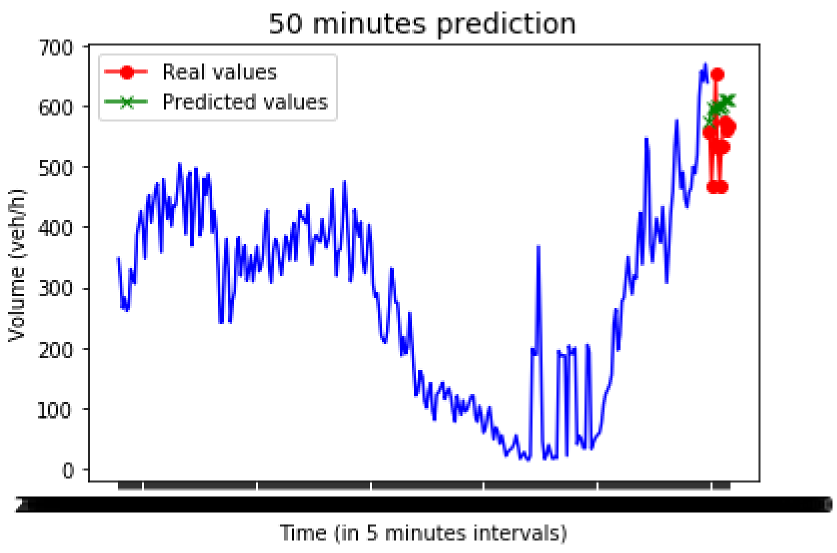
def plot_prediction(y_real_resacled, y_pred_rescaled, flow_not_reshaped, time_not_reshape
    plt.figure()
    plt.title("50 minutes prediction", fontsize=14)
    plt.plot(time_not_reshaped[-300:-forecast], flow_not_reshaped[-300:-forecast], 'b-')
    plt.plot(y_time_test[-1, :], y_real_resacled, 'ro-', 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()
```

```
7138/7138 [==============================] - 5s 693us/sample - loss: 0.0049 -
Epoch 137/1000
7138/7138 [==============================] - 5s 660us/sample - loss: 0.0049 -
Epoch 138/1000
7138/7138 [==============================] - 5s 696us/sample - loss: 0.0049 -
Epoch 139/1000
7138/7138 [==============================] - 5s 700us/sample - loss: 0.0049 -
Epoch 140/1000
7138/7138 [==============================] - 5s 695us/sample - loss: 0.0049 -
Epoch 141/1000
7138/7138 [==============================] - 5s 690us/sample - loss: 0.0049 -
Epoch 142/1000
7138/7138 [==============================] - 5s 683us/sample - loss: 0.0049 -
Epoch 143/1000
7138/7138 [==============================] - 5s 683us/sample - loss: 0.0049 -
Epoch 144/1000
7138/7138 [==============================] - 5s 683us/sample - loss: 0.0049 -
Epoch 145/1000
7138/7138 [==============================] - 5s 678us/sample - loss: 0.0049 -
Epoch 146/1000
7138/7138 [==============================] - 5s 681us/sample - loss: 0.0049 -
Epoch 147/1000
7138/7138 [==============================] - 5s 696us/sample - loss: 0.0049 -
(10, 1)
(10, 1)
(10,)
```


Training loss
Validation loss
Loss
Epochs


50 minutes prediction
Real values
Predicted values
Volume (veh/h)
Time (in 5 minutes intervals)