

lstm_single_feature

May 29, 2023

1 SINGLE FEATURE PREDICTION USING THE SAME SINGLE FEATURE WITH LSTM SEQ2SEQ

1.1 HERE WE USED: 12h for running the running inference over the next 1h

```
[1]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn import preprocessing
from keras.models import Sequential, save_model, load_model
from keras.layers import Bidirectional, LSTM, Dropout, Dense
from sklearn.metrics import mean_squared_error
from math import sqrt
from sklearn.metrics import mean_absolute_percentage_error
import os
import time
from tensorflow.keras.callbacks import CSVLogger, EarlyStopping
from tensorflow.keras.layers import BatchNormalization, ConvLSTM2D, RepeatVector
from keras.layers.core import Dense, Dropout, Activation, Flatten, Reshape
from tensorflow.keras.layers import TimeDistributed

import tensorflow as tf
# physical_devices = tf.config.list_physical_devices('GPU')
# tf.config.experimental.set_memory_growth(physical_devices[0], enable=True)

models_path = "../saved_models/normal/may2023"
# read dataset may2023
df = pd.read_pickle("../data/20230319_RTU_Dataset_PPC-Lab/combined_may2023.
↳pkl")
```

2023-05-29 18:04:04.791639: I tensorflow/core/util/port.cc:110] oneDNN custom operations are on. You may see slightly different numerical results due to floating-point round-off errors from different computation orders. To turn them off, set the environment variable `TF_ENABLE_ONEDNN_OPTS=0`.

2023-05-29 18:04:04.995189: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFlow binary is optimized to use available CPU instructions in performance-critical operations.

To enable the following instructions: AVX2 AVX512F AVX512_VNNI FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.

```
[2]: # Data Loader Parameters
BATCH_SIZE = 128
EPOCHS = 5
BUFFER_SIZE = 100

# LSTM Parameters
EVALUATION_INTERVAL = 200
PATIENCE = 5
PAST_WINDOW_SIZE = 144                # ----- 12H
FUTURE_WINDOW_SIZE = 12              # ----- 1H
STEP = 5

# Reproducibility
SEED = 13
tf.random.set_seed(SEED)
```

```
[22]: def create_sequence(dataset, target, window, future):
    x_sequence, y_sequence = [], []
    for index in range(len(dataset) - window - future):
        x_sequence.append(dataset[index: index + window])
        y_sequence.append(target[index + window: index + window + future])
    return (np.asarray(x_sequence), np.asarray(y_sequence))

def plot_train_history(history, title):
    loss = history.history['loss']
    val_loss = history.history['val_loss']

    epochs = range(len(loss))

    plt.figure()

    plt.plot(epochs, loss, 'b', label='Training loss')
    plt.plot(epochs, val_loss, 'r', label='Validation loss')
    plt.title(title)
    plt.legend()

    plt.show()

def multivariate_multioutput_data(dataset, target, start_index, end_index,
    history_size, target_size, step):
    data = []
    labels = []

    start_index = start_index + history_size
```

```

    if end_index is None:
        end_index = len(dataset) - target_size

    for i in range(start_index, end_index):
        indices = range(i-history_size, i, step)
        data.append(dataset[indices])
        labels.append(target[i:i+target_size])

    return np.array(data)[:,:,:,np.newaxis,np.newaxis], np.array(labels)[:,:,:
↪,np.newaxis,np.newaxis]

def create_time_steps(length):
    return list(range(-length, 0))

def multivariate_data(dataset, target, start_index, end_index, history_size,
                      target_size, step, single_step=False):
    data = []
    labels = []

    start_index = start_index + history_size
    if end_index is None:
        end_index = len(dataset) - target_size

    for i in range(start_index, end_index):
        indices = range(i-history_size, i, step)
        data.append(dataset[indices])

        if single_step:
            labels.append(target[i+target_size])
        else:
            labels.append(target[i:i+target_size])

    return np.array(data)[:,:,:np.newaxis], np.array(labels)[:,:,:np.newaxis]

def evaluate_predictions(predictions_seq, y_test_seq):
    MSE = []
    for pred in range(len(y_test)):
        mse = mean_squared_error(y_test_seq[pred], predictions_seq[pred])
        MSE.append(mse)
    return MSE

def find_max_error(predictions, y_test, mean_mse, std_mse):
    max_errors = 0
    for pred in range(len(y_test)):
        mse = mean_squared_error(y_test[pred], predictions[pred])
        if mse > mean_mse + std_mse:
            max_errors += 1

```

```

    return max_errors

def multi_step_plot(history, true_future, prediction):
    plt.figure(figsize=(18, 6))
    num_in = create_time_steps(len(history))
    num_out = len(true_future)

    plt.plot(num_in, history, label='History')
    plt.plot(np.arange(num_out)/STEP, np.array(true_future), 'bo',
             label='True Future')
    if prediction.any():
        plt.plot(np.arange(num_out)/STEP, np.array(prediction), 'ro',
                 label='Predicted Future')
    plt.legend(loc='upper left')
    plt.show()

def my_mean_absolute_percentage_error(y_true, y_pred):
    error = 0
    for i in range(len(y_true)):
        if y_true[i] != 0:
            error += abs((y_true[i] - y_pred[i]) / y_true[i])

    mape = (error / len(y_true)) * 100
    return mape

```

```

[4]: # Normalizing the values
standard_scaler = preprocessing.StandardScaler()
print(df.head())
scaled_df = standard_scaler.fit_transform(df[['MEM_USAGE', 'CPU_USAGE', 'PS1_V',
↪ 'TEMP']])
print(scaled_df[:10])
print(scaled_df[:,1])

training_size = int(len(scaled_df) * 0.8)

print('Size of the dataset: %d' % (len(scaled_df)))
print('Size of training: %d' % (training_size))

```

	MEM_USAGE	CPU_USAGE	PS1_V	TEMP
0	35.555417	27.343750	5.435294	28.687
1	35.555417	6.367041	5.435294	28.687
2	35.555417	7.142857	5.435294	28.687
3	35.555417	27.306273	5.435294	28.687
4	35.555417	5.639098	5.435294	28.687
[0.48139574	1.13540371	0.74576055]	
[0.48139574	-0.66263387	0.74576055]	
[0.48139574	-0.59613411	0.74576055]	

```
[ 0.48139574  1.13219134  0.74576055]
[ 0.48139574 -0.7250302   0.74576055]
[ 0.48139574 -0.73742406  0.74576055]
[ 0.48139574 -0.6369512   0.74576055]
[ 0.48139574 -0.91168167  0.74576055]
[ 0.48139574 -0.63268673  0.74576055]
[ 0.48139574 -0.27087286  0.74576055]]
[ 1.13540371 -0.66263387 -0.59613411 ... -0.69409514 -0.51872237
 -0.07440583]
```

Size of the dataset: 3733

Size of training: 2986

```
[5]: scaled_df
```

```
[5]: array([[ 0.48139574,  1.13540371,  0.74576055],
           [ 0.48139574, -0.66263387,  0.74576055],
           [ 0.48139574, -0.59613411,  0.74576055],
           ...,
           [-1.80536352, -0.69409514,  0.98794801],
           [-1.80536352, -0.51872237,  0.98794801],
           [-1.80536352, -0.07440583,  0.98794801]])
```

2 SINGLE FEATURE CPU

```
[6]: x_train_multi, y_train_multi = multivariate_data(scaled_df[:, 1], scaled_df[:, 1],
           ↪1], 0,
           training_size,
           ↪PAST_WINDOW_SIZE,
           FUTURE_WINDOW_SIZE, STEP)
x_val_multi, y_val_multi = multivariate_data(scaled_df[:, 1], scaled_df[:, 1],
           training_size, None,
           ↪PAST_WINDOW_SIZE,
           FUTURE_WINDOW_SIZE, STEP)
```

```
[7]: x_train_multi.shape
```

```
[7]: (2842, 29, 1)
```

```
[8]: y_train_multi.shape
```

```
[8]: (2842, 12, 1)
```

```
[9]: train_data_multi = tf.data.Dataset.from_tensor_slices((x_train_multi,
           ↪y_train_multi))
train_data_multi = train_data_multi.cache().shuffle(BUFFER_SIZE).
           ↪batch(BATCH_SIZE).repeat()
```

```
val_data_multi = tf.data.Dataset.from_tensor_slices((x_val_multi, y_val_multi))
val_data_multi = val_data_multi.batch(BATCH_SIZE).repeat()
```

2023-05-29 18:04:06.758710: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
<https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-pci#L344-L355>

2023-05-29 18:04:06.781102: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
<https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-pci#L344-L355>

2023-05-29 18:04:06.781266: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
<https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-pci#L344-L355>

2023-05-29 18:04:06.783288: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
<https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-pci#L344-L355>

2023-05-29 18:04:06.783407: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
<https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-pci#L344-L355>

2023-05-29 18:04:06.783474: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
<https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-pci#L344-L355>

2023-05-29 18:04:07.469399: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
<https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-pci#L344-L355>

2023-05-29 18:04:07.469514: I

```

tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-
pci#L344-L355
2023-05-29 18:04:07.469582: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:996]
successful NUMA node read from SysFS had negative value (-1), but there must be
at least one NUMA node, so returning NUMA node zero. See more at
https://github.com/torvalds/linux/blob/v6.0/Documentation/ABI/testing/sysfs-bus-
pci#L344-L355
2023-05-29 18:04:07.469649: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1635] Created device
/job:localhost/replica:0/task:0/device:GPU:0 with 14115 MB memory: -> device:
0, name: NVIDIA RTX A5000 Laptop GPU, pci bus id: 0000:01:00.0, compute
capability: 8.6

```

```

[10]: multi_step_model = tf.keras.models.Sequential()
multi_step_model.add(tf.keras.layers.LSTM(32,
                                          return_sequences=True,
                                          input_shape=x_train_multi.shape[-2:]))
multi_step_model.add(tf.keras.layers.LSTM(16, activation='relu'))
multi_step_model.add(tf.keras.layers.Dense(FUTURE_WINDOW_SIZE))

multi_step_model.compile(optimizer=tf.keras.optimizers.RMSprop(clipvalue=1.0),
                        loss='mae')
print(multi_step_model.summary())

```

WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as fallback when running on GPU.
Model: "sequential"

Layer (type)	Output Shape	Param #
lstm (LSTM)	(None, 29, 32)	4352
lstm_1 (LSTM)	(None, 16)	3136
dense (Dense)	(None, 12)	204

```

Total params: 7,692
Trainable params: 7,692
Non-trainable params: 0

```

None

```

2023-05-29 18:04:07.982659: I tensorflow/core/common_runtime/executor.cc:1197]

```

```
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32
```

```
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
2023-05-29 18:04:07.983393: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32
```

```
[[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 18:04:07.984119: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32
```

```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

```
[11]: for x, y in val_data_multi.take(1):
      print (multi_step_model.predict(x).shape)
```

```
2023-05-29 18:04:08.074001: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]
```

```
[[{{node Placeholder/_1}}]]
```

```
2023-05-29 18:04:08.299712: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32
```

```
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
```

```
2023-05-29 18:04:08.300588: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32
```

```
[[{{node gradients/split_grad/concat/split/split_dim}}]]
```

```
2023-05-29 18:04:08.301227: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32
```

```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

```
2023-05-29 18:04:09.328360: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_blas.cc:637] TensorFloat-32
will be used for the matrix multiplication. This will only be logged once.
```

```
2023-05-29 18:04:09.472841: I
```



```
tensorflow/compiler/xla/stream_executor/cuda/cuda_dnn.cc:424] Loaded cuDNN
version 8900
```

```
4/4 [=====] - 2s 7ms/step
(128, 12)
```

```
[13]: EPOCHS = 10
```

```
early_stopping = EarlyStopping(monitor='val_loss', patience = 3,
    ↪restore_best_weights=True)
multi_step_history = multi_step_model.fit(train_data_multi,
                                           epochs=EPOCHS,
                                           steps_per_epoch=EVALUATION_INTERVAL,
                                           validation_data=val_data_multi,
                                           validation_steps=EVALUATION_INTERVAL,
                                           callbacks=[early_stopping])
```

```
Epoch 1/10
```

```
200/200 [=====] - 3s 17ms/step - loss: 0.6398 -
val_loss: 0.6133
```

```
Epoch 2/10
```

```
200/200 [=====] - 3s 17ms/step - loss: 0.6398 -
val_loss: 0.6133
```

```
Epoch 3/10
```

```
200/200 [=====] - 3s 17ms/step - loss: 0.6406 -
val_loss: 0.6134
```

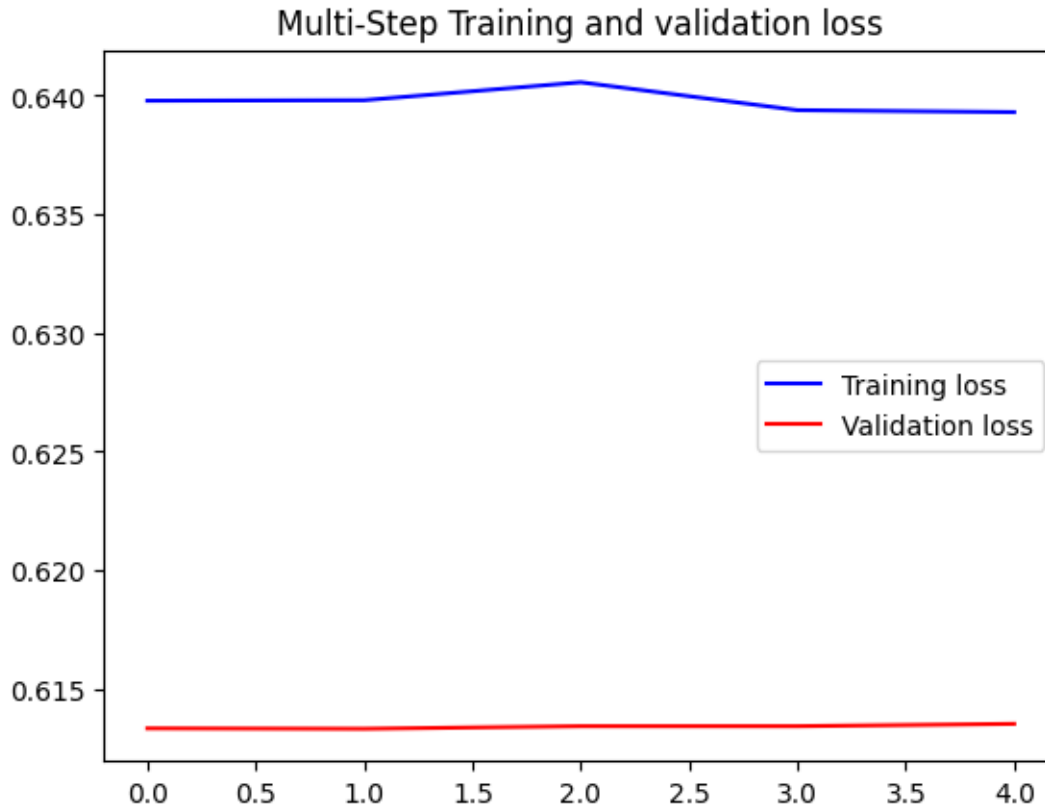
```
Epoch 4/10
```

```
200/200 [=====] - 3s 17ms/step - loss: 0.6394 -
val_loss: 0.6134
```

```
Epoch 5/10
```

```
200/200 [=====] - 3s 17ms/step - loss: 0.6393 -
val_loss: 0.6135
```

```
[14]: plot_train_history(multi_step_history, 'Multi-Step Training and validation_
    ↪loss')
```



```
[15]: multi_step_model.save('best_single_feature_cpu.h5')
```

```
[16]: from tensorflow import keras
multi_step_model = keras.models.load_model("./best_single_feature_cpu.h5")
```

WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as fallback when running on GPU.

2023-05-29 18:05:57.880013: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 18:05:57.880718: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

[[{{node gradients/split_grad/concat/split/split_dim}}]]

2023-05-29 18:05:57.881395: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an

error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

```
[17]: for x, y in val_data_multi.take(3):  
    print(x.shape)  
    print(multi_step_model.predict(x).shape)  
    multi_step_plot(np.squeeze(x[0]), np.squeeze(y[0]), multi_step_model.  
    ↪predict(x)[0])
```

2023-05-29 18:06:06.880992: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]

```
[[{{node Placeholder/_1}}]]
```

2023-05-29 18:06:07.038125: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

```
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
```

2023-05-29 18:06:07.038792: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

```
[[{{node gradients/split_grad/concat/split/split_dim}}]]
```

2023-05-29 18:06:07.039380: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

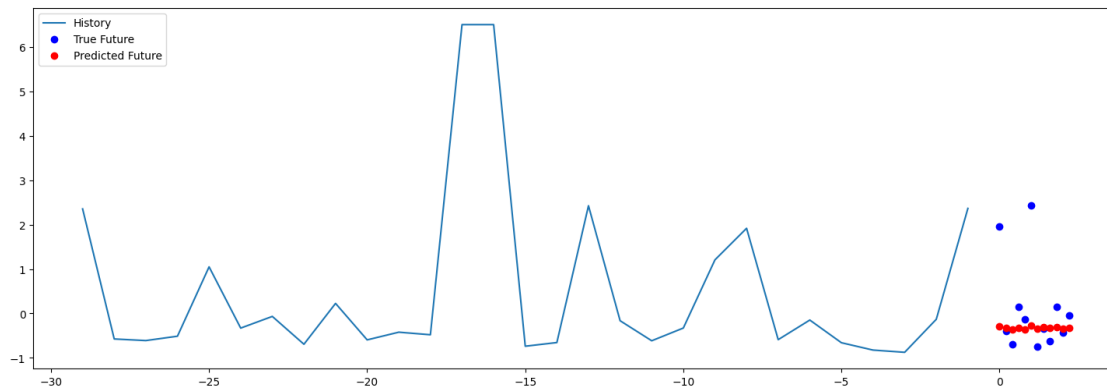
```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

(128, 29, 1)

4/4 [=====] - 0s 3ms/step

(128, 12)

4/4 [=====] - 0s 3ms/step

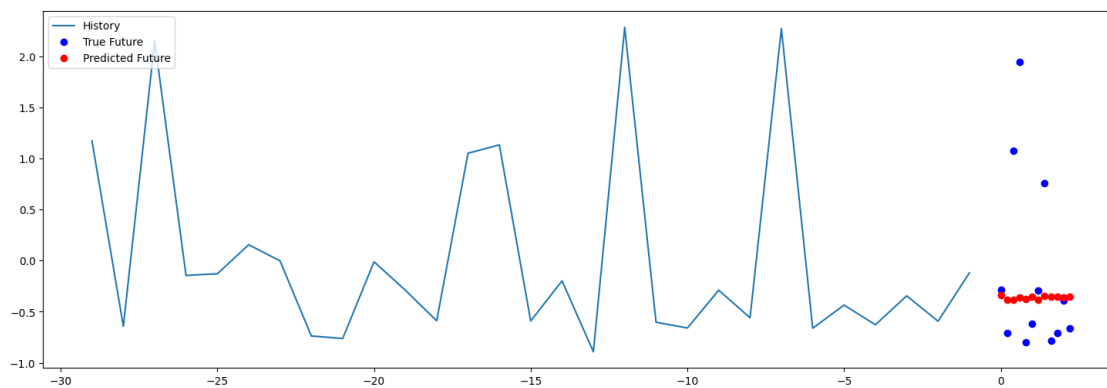


(128, 29, 1)

4/4 [=====] - 0s 3ms/step

(128, 12)

4/4 [=====] - 0s 6ms/step

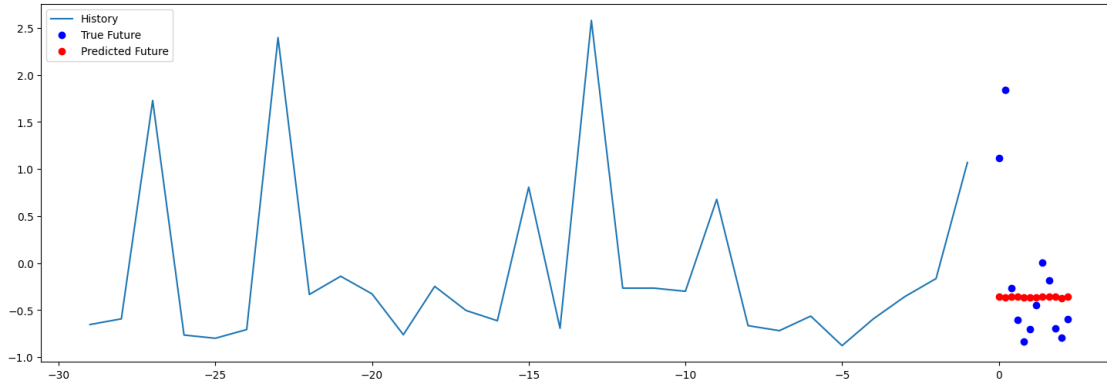


(128, 29, 1)

4/4 [=====] - 0s 4ms/step

(128, 12)

4/4 [=====] - 0s 3ms/step



```
[19]: import tensorflow as tf
train_data_multi = tf.data.Dataset.from_tensor_slices((x_train_multi,
↳ y_train_multi))
train_data_multi = train_data_multi.cache().batch(BATCH_SIZE)
val_data_multi = tf.data.Dataset.from_tensor_slices((x_val_multi, y_val_multi))
val_data_multi = val_data_multi.batch(BATCH_SIZE)

predicted_cpus = []
original_cpus = []
history_cpus = []

for x, y in train_data_multi:
    hx_cpu = np.squeeze(x[0])
    history_cpus.append(hx_cpu)

for x, y in val_data_multi:
    prediction = multi_step_model.predict(x, verbose = 0)[0]
    ori_cpus = np.squeeze(y[0])

    predicted_cpus.append(prediction)
    original_cpus.append(ori_cpus)

predicted_cpu_usage = np.concatenate(predicted_cpus, axis=0)
original_cpu_usage = np.concatenate(original_cpus, axis=0)
history_cpu_usage = np.concatenate(history_cpus, axis=0)
```

```
2023-05-29 18:07:16.003221: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [2842,12,1]
[[[{{node Placeholder/_1}}]]]
```

```

2023-05-29 18:07:16.016829: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]
[[{{node Placeholder/_1}}]]
2023-05-29 18:07:16.358147: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
2023-05-29 18:07:16.358899: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
[[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 18:07:16.359522: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

```

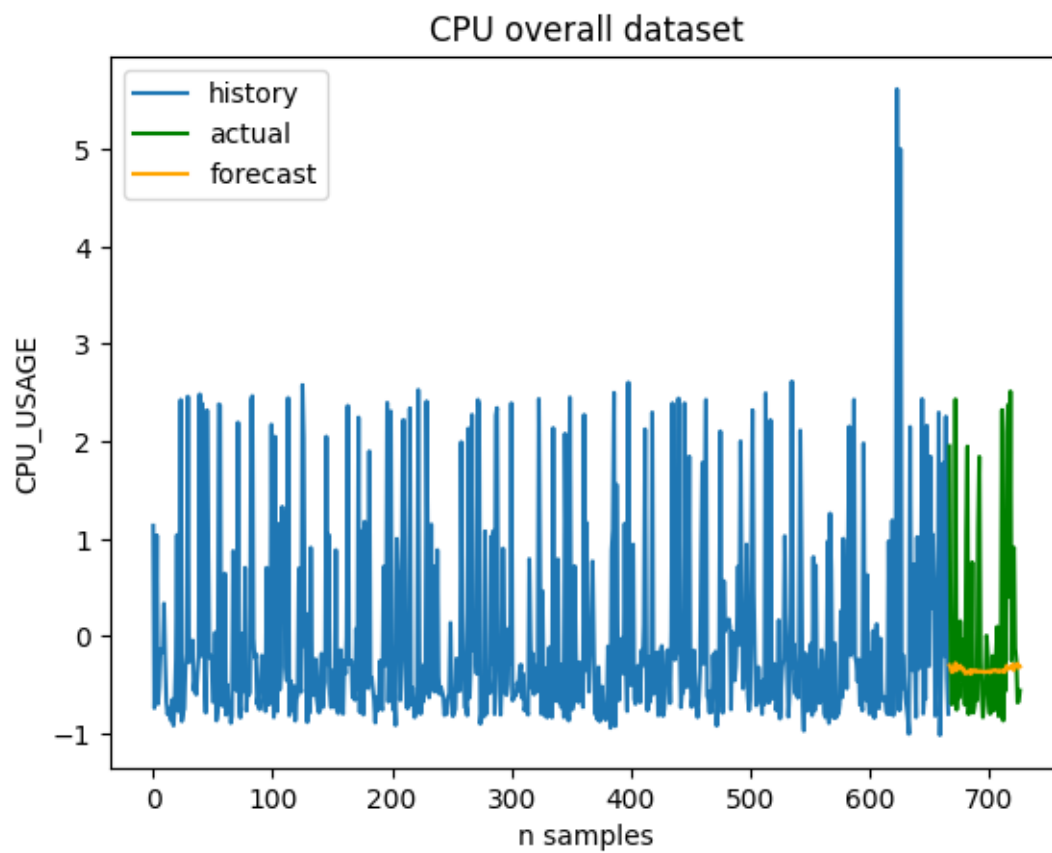
```

[20]: plt.title("CPU overall dataset")
plt.xlabel("n samples")
plt.ylabel("CPU_USAGE")
plt.plot(range(len(history_cpu_usage)),history_cpu_usage, label="history")
plt.plot(range(len(history_cpu_usage), len(history_cpu_usage) +
↳len(predicted_cpu_usage)),original_cpu_usage, label="actual", color="green")
plt.plot(range(len(history_cpu_usage), len(history_cpu_usage) +
↳len(predicted_cpu_usage)),predicted_cpu_usage, label="forecast" ,
↳color="orange")

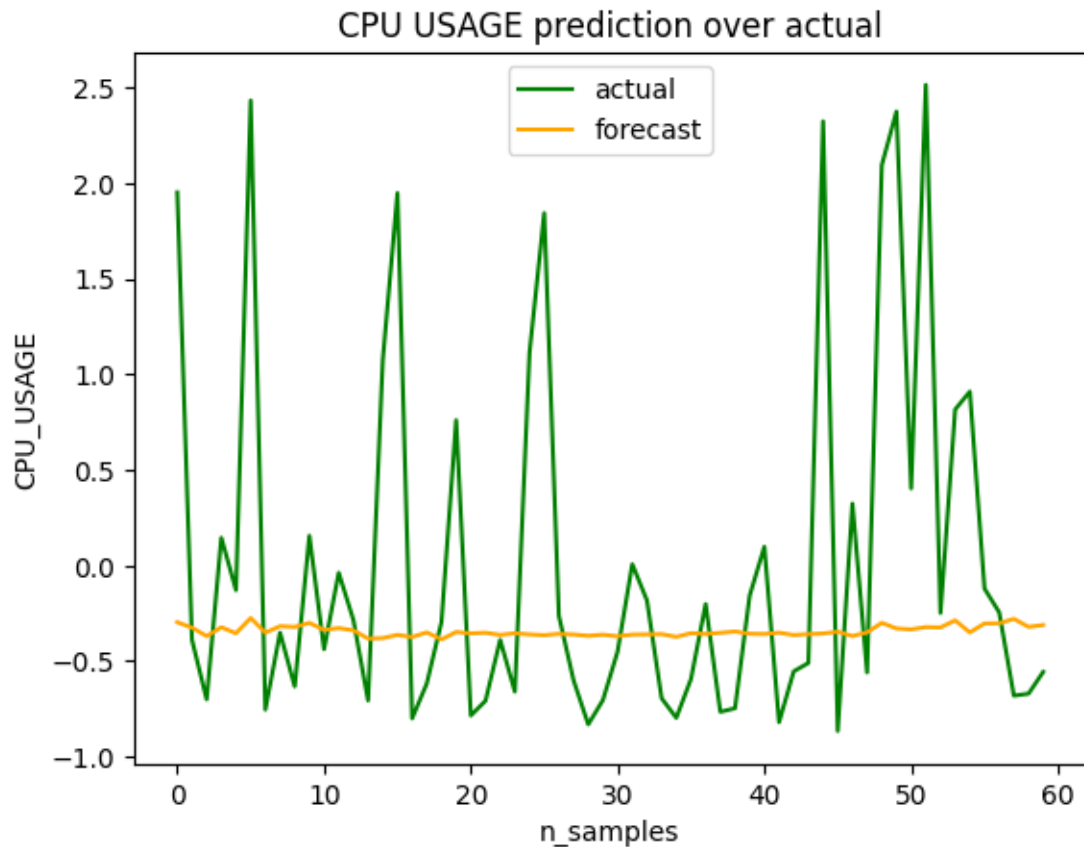
plt.legend()
plt.show()

x = range(len(predicted_cpu_usage))
plt.title("CPU USAGE prediction over actual")
plt.xlabel("n_samples")
plt.ylabel("CPU_USAGE")
plt.plot(x,original_cpu_usage, label="actual", color="green")
plt.plot(x,predicted_cpu_usage, label="forecast", color="orange")
plt.legend()

```



[20]: <matplotlib.legend.Legend at 0x7f7b0428cd90>



```
[23]: my_mean_absolute_percentage_error(original_cpu_usage, predicted_cpu_usage)
```

```
[23]: 189.3778756600039
```

3 SINGLE FEATURE RAM

```
[24]: x_train_multi, y_train_multi = multivariate_data(scaled_df[:, 0], scaled_df[:, 0], 0, 0,
                                                    training_size, PAST_WINDOW_SIZE,
                                                    FUTURE_WINDOW_SIZE, STEP)
x_val_multi, y_val_multi = multivariate_data(scaled_df[:, 0], scaled_df[:, 0], 0, 0,
                                              training_size, None, PAST_WINDOW_SIZE,
                                              FUTURE_WINDOW_SIZE, STEP)

train_data_multi = tf.data.Dataset.from_tensor_slices((x_train_multi, y_train_multi))
```



```

train_data_multi = train_data_multi.cache().shuffle(BUFFER_SIZE).
    ↪batch(BATCH_SIZE).repeat()

val_data_multi = tf.data.Dataset.from_tensor_slices((x_val_multi, y_val_multi))
val_data_multi = val_data_multi.batch(BATCH_SIZE).repeat()

multi_step_model = tf.keras.models.Sequential()
multi_step_model.add(tf.keras.layers.LSTM(32,
                                          return_sequences=True,
                                          input_shape=x_train_multi.shape[-2:]))
multi_step_model.add(tf.keras.layers.LSTM(16, activation='relu'))
multi_step_model.add(tf.keras.layers.Dense(FUTURE_WINDOW_SIZE))

multi_step_model.compile(optimizer=tf.keras.optimizers.RMSprop(clipvalue=1.0), ↪
    ↪loss='mae')
print(multi_step_model.summary())

EPOCHS = 10

early_stopping = EarlyStopping(monitor='val_loss', patience = EPOCHS, ↪
    ↪restore_best_weights=True)
multi_step_history = multi_step_model.fit(train_data_multi,
                                          epochs=EPOCHS,
                                          steps_per_epoch=EVALUATION_INTERVAL,
                                          validation_data=val_data_multi,
                                          validation_steps=EVALUATION_INTERVAL,
                                          callbacks=[early_stopping])

```

WARNING:tensorflow:Layer lstm_3 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as fallback when running on GPU.
Model: "sequential_1"

Layer (type)	Output Shape	Param #
lstm_2 (LSTM)	(None, 29, 32)	4352
lstm_3 (LSTM)	(None, 16)	3136
dense_1 (Dense)	(None, 12)	204

Total params: 7,692
Trainable params: 7,692
Non-trainable params: 0

Epoch 1/10

```
2023-05-29 18:08:32.802753: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
```

```
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
```

```
2023-05-29 18:08:32.803701: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
```

```
[[{{node gradients/split_grad/concat/split/split_dim}}]]
```

```
2023-05-29 18:08:32.804247: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
```

```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

```
2023-05-29 18:08:32.880198: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_0' with dtype double and shape [2842,29,1]
```

```
[[{{node Placeholder/_0}}]]
```

```
2023-05-29 18:08:32.980361: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
```

```
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
```

```
2023-05-29 18:08:32.981077: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
```

```
[[{{node gradients/split_grad/concat/split/split_dim}}]]
```

```
2023-05-29 18:08:32.981735: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
```

```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

```
2023-05-29 18:08:33.436621: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
```

```

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
2023-05-29 18:08:33.437555: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
[[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 18:08:33.438241: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
200/200 [=====] - ETA: 0s - loss: 0.1666
2023-05-29 18:08:37.155762: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]
[[{{node Placeholder/_1}}]]
2023-05-29 18:08:37.257472: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
2023-05-29 18:08:37.258181: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
[[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 18:08:37.258838: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
200/200 [=====] - 5s 19ms/step - loss: 0.1666 -
val_loss: 2.2841
Epoch 2/10
200/200 [=====] - 3s 17ms/step - loss: 0.0794 -
val_loss: 2.4159
Epoch 3/10
200/200 [=====] - 3s 17ms/step - loss: 0.0714 -
val_loss: 2.3641
Epoch 4/10

```

```

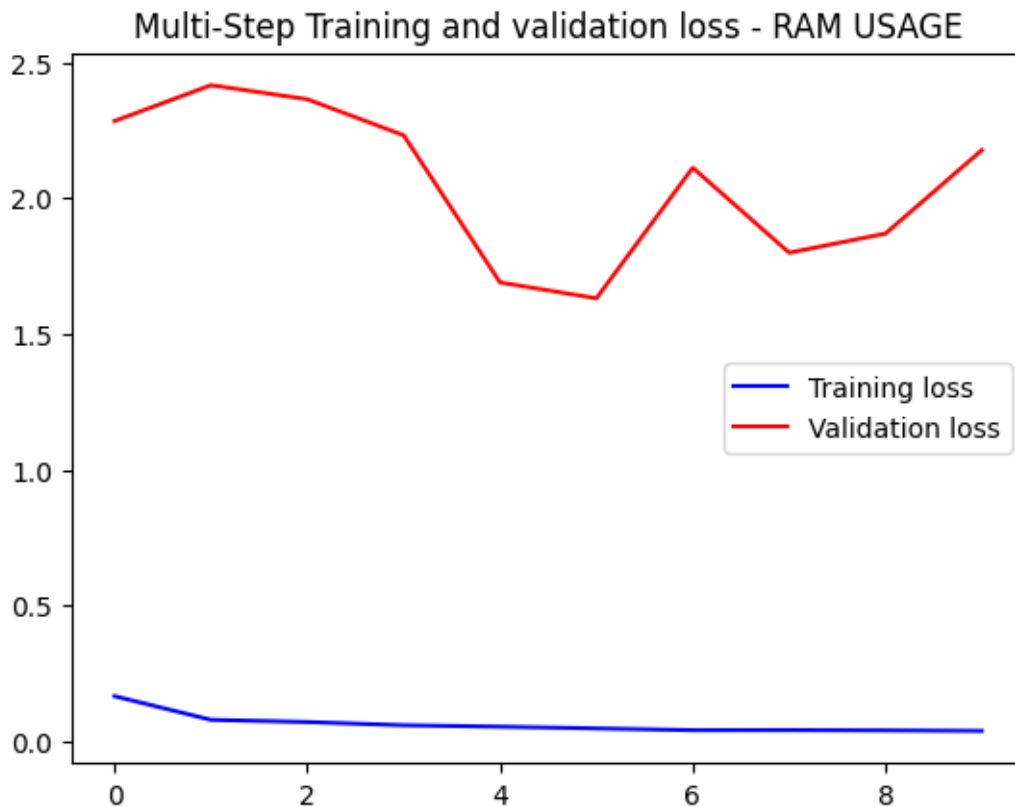
200/200 [=====] - 3s 17ms/step - loss: 0.0594 -
val_loss: 2.2314
Epoch 5/10
200/200 [=====] - 3s 17ms/step - loss: 0.0543 -
val_loss: 1.6896
Epoch 6/10
200/200 [=====] - 3s 17ms/step - loss: 0.0478 -
val_loss: 1.6314
Epoch 7/10
200/200 [=====] - 3s 17ms/step - loss: 0.0413 -
val_loss: 2.1120
Epoch 8/10
200/200 [=====] - 3s 17ms/step - loss: 0.0417 -
val_loss: 1.7991
Epoch 9/10
200/200 [=====] - 3s 17ms/step - loss: 0.0407 -
val_loss: 1.8696
Epoch 10/10
200/200 [=====] - 3s 17ms/step - loss: 0.0387 -
val_loss: 2.1768

```

```

[25]: plot_train_history(multi_step_history, 'Multi-Step Training and validation loss_
      ↪- RAM USAGE')

```



```
[27]: multi_step_model.save('best_single_feature_mem.h5')
```

```
[28]: from tensorflow import keras
multi_step_model = keras.models.load_model("./best_single_feature_mem.h5")
```

WARNING:tensorflow:Layer lstm_3 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as fallback when running on GPU.

2023-05-29 18:09:41.886176: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 18:09:41.886904: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

[[{{node gradients/split_grad/concat/split/split_dim}}]]

2023-05-29 18:09:41.887579: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

```
[44]: for x, y in val_data_multi.take(3):
      multi_step_plot(x[0], y[0], multi_step_model.predict(x)[0])
```

2023-05-29 14:44:05.883235: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]

[[{{node Placeholder/_1}}]]

2023-05-29 14:44:06.007200: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 14:44:06.007902: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

```

[[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 14:44:06.008509: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32

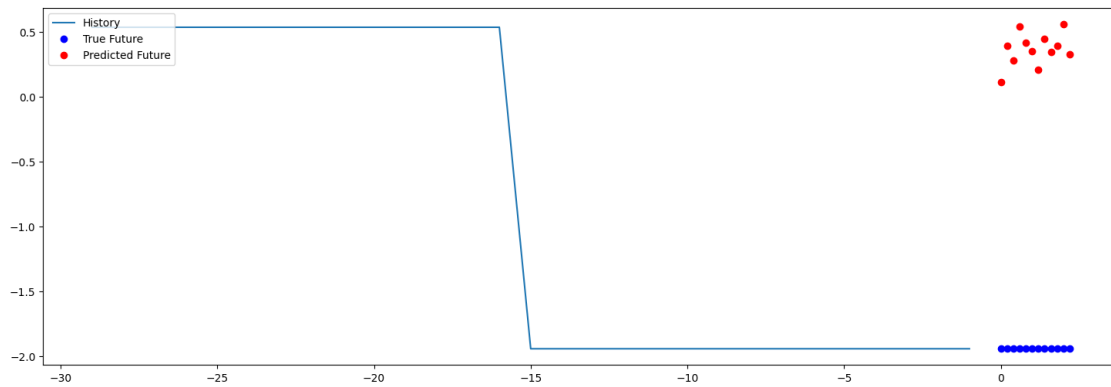
```

```

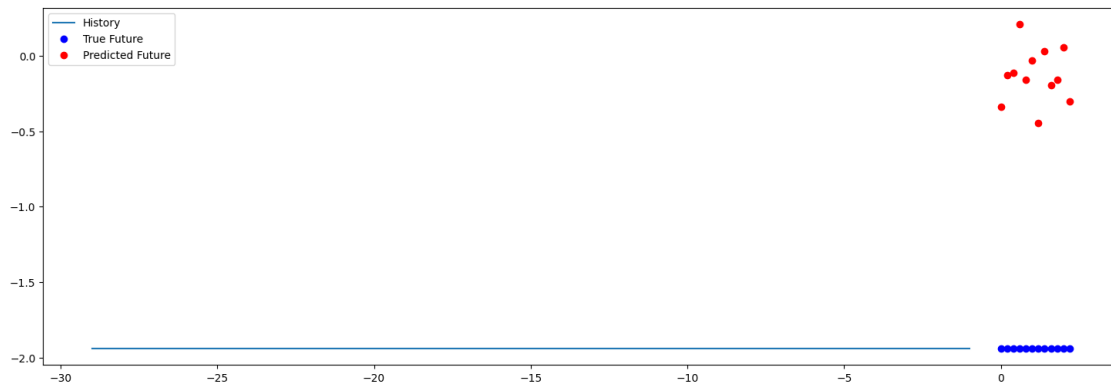
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

```

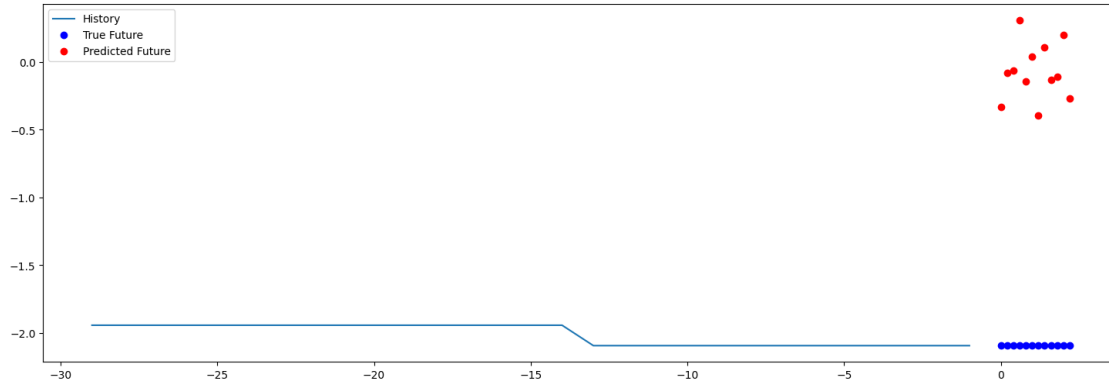
4/4 [=====] - 0s 3ms/step



4/4 [=====] - 0s 3ms/step



4/4 [=====] - 0s 3ms/step



```
[34]: import tensorflow as tf
train_data_multi = tf.data.Dataset.from_tensor_slices((x_train_multi,
↳ y_train_multi))
train_data_multi = train_data_multi.cache().batch(BATCH_SIZE)
val_data_multi = tf.data.Dataset.from_tensor_slices((x_val_multi, y_val_multi))
val_data_multi = val_data_multi.batch(BATCH_SIZE)

predicted_mems = []
original_mems = []
history_mems = []

for x, y in train_data_multi:
    hx_mem = np.squeeze(x[0])
    history_mems.append(hx_mem)

for x, y in val_data_multi:
    prediction = multi_step_model.predict(x, verbose = 0)[0]
    ori_mems = np.squeeze(y[0])

    predicted_mems.append(prediction)
    original_mems.append(ori_mems)

prediction_mem_usage = np.concatenate(predicted_mems, axis=0)
original_mem_usage = np.concatenate(original_mems, axis=0)
history_mem_usage = np.concatenate(history_mems, axis=0)
```

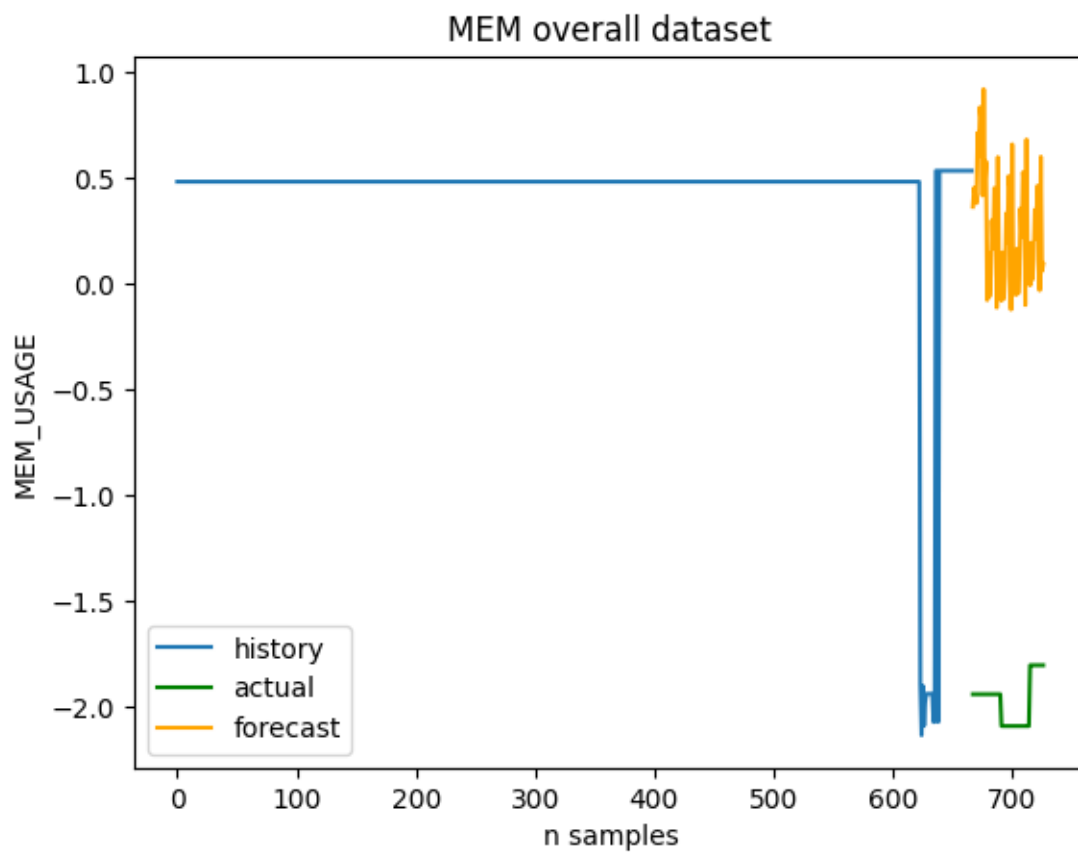
```
2023-05-29 18:11:09.852141: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [2842,12,1]
[[{{node Placeholder/_1}}]]
```

```
2023-05-29 18:11:09.867255: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]
[[{{node Placeholder/_1}}]]
```

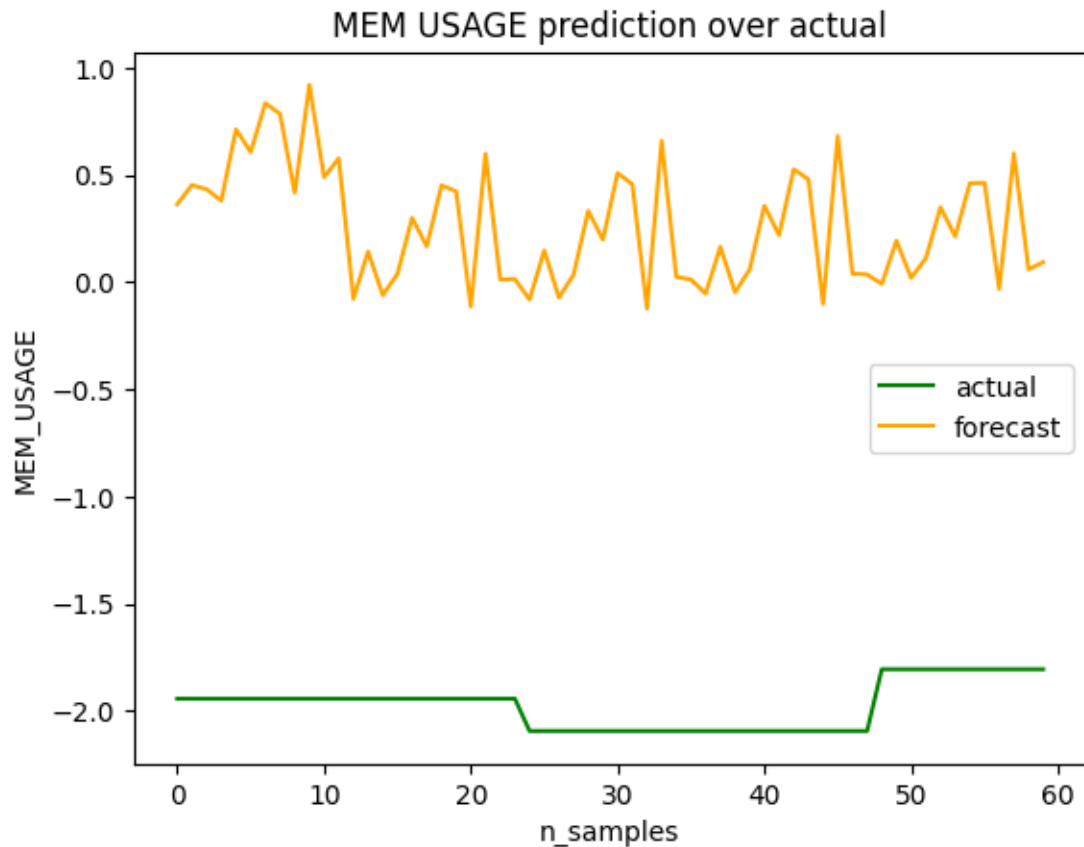
```
[35]: plt.title("MEM overall dataset")
plt.xlabel("n samples")
plt.ylabel("MEM_USAGE")
plt.plot(range(len(history_mem_usage)), history_mem_usage, label="history")
plt.plot(range(len(history_mem_usage), len(history_mem_usage) +
    ↳ len(prediction_mem_usage)), original_mem_usage, label="actual", color="green")
plt.plot(range(len(history_mem_usage), len(history_mem_usage) +
    ↳ len(prediction_mem_usage)), prediction_mem_usage, label="forecast",
    ↳ color="orange")

plt.legend()
plt.show()

x = range(len(prediction_mem_usage))
plt.title("MEM USAGE prediction over actual")
plt.xlabel("n_samples")
plt.ylabel("MEM_USAGE")
plt.plot(x, original_mem_usage, label="actual", color="green")
plt.plot(x, prediction_mem_usage, label="forecast", color="orange")
plt.legend()
```

[35]: <matplotlib.legend.Legend at 0x7f7ae44f4d90>



```
[36]: my_mean_absolute_percentage_error(original_mem_usage, prediction_mem_usage)
```

```
[36]: 113.45539445207558
```

4 SINGLE FEATURE TEMP

```
[37]: x_train_multi, y_train_multi = multivariate_data(scaled_df[:, 2], scaled_df[:, 2], 0,
                                                    training_size, PAST_WINDOW_SIZE,
                                                    FUTURE_WINDOW_SIZE, STEP)
x_val_multi, y_val_multi = multivariate_data(scaled_df[:, 2], scaled_df[:, 2],
                                              training_size, None, PAST_WINDOW_SIZE,
                                              FUTURE_WINDOW_SIZE, STEP)

train_data_multi = tf.data.Dataset.from_tensor_slices((x_train_multi, y_train_multi))
```

```

train_data_multi = train_data_multi.cache().shuffle(BUFFER_SIZE).
    ↪batch(BATCH_SIZE).repeat()

val_data_multi = tf.data.Dataset.from_tensor_slices((x_val_multi, y_val_multi))
val_data_multi = val_data_multi.batch(BATCH_SIZE).repeat()

multi_step_model = tf.keras.models.Sequential()
multi_step_model.add(tf.keras.layers.LSTM(32,
                                          return_sequences=True,
                                          input_shape=x_train_multi.shape[-2:]))
multi_step_model.add(tf.keras.layers.LSTM(16, activation='relu'))
multi_step_model.add(tf.keras.layers.Dense(FUTURE_WINDOW_SIZE))

multi_step_model.compile(optimizer=tf.keras.optimizers.RMSprop(clipvalue=1.0),
    ↪loss='mae')
print(multi_step_model.summary())

early_stopping = EarlyStopping(monitor='val_loss', patience = 3,
    ↪restore_best_weights=True)
multi_step_history = multi_step_model.fit(train_data_multi,
                                          epochs=EPOCHS,
                                          steps_per_epoch=EVALUATION_INTERVAL,
                                          validation_data=val_data_multi,
                                          validation_steps=EVALUATION_INTERVAL,
                                          callbacks=[early_stopping])

```

WARNING:tensorflow:Layer lstm_5 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as fallback when running on GPU.
Model: "sequential_2"

Layer (type)	Output Shape	Param #
lstm_4 (LSTM)	(None, 29, 32)	4352
lstm_5 (LSTM)	(None, 16)	3136
dense_2 (Dense)	(None, 12)	204

```

=====
Total params: 7,692
Trainable params: 7,692
Non-trainable params: 0

```

```

-----
None
Epoch 1/10

```

```

2023-05-29 18:11:36.104044: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an

```

error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 18:11:36.104934: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

[[{{node gradients/split_grad/concat/split/split_dim}}]]

2023-05-29 18:11:36.105494: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

2023-05-29 18:11:36.155555: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'Placeholder/_0' with dtype double and shape [2842,29,1]

[[{{node Placeholder/_0}}]]

2023-05-29 18:11:36.260044: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 18:11:36.260786: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

[[{{node gradients/split_grad/concat/split/split_dim}}]]

2023-05-29 18:11:36.261426: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

2023-05-29 18:11:36.909145: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 18:11:36.910195: I tensorflow/core/common_runtime/executor.cc:1197 [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value

```

for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
    [[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 18:11:36.910878: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
    [[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
197/200 [=====>.] - ETA: 0s - loss: 0.4125

2023-05-29 18:11:40.608153: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]
    [[{{node Placeholder/_1}}]]
2023-05-29 18:11:40.708139: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
    [[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
2023-05-29 18:11:40.708971: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
    [[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 18:11:40.709603: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
    [[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
200/200 [=====] - 5s 19ms/step - loss: 0.4124 -
val_loss: 0.3323
Epoch 2/10
200/200 [=====] - 3s 17ms/step - loss: 0.2458 -
val_loss: 0.1728
Epoch 3/10
200/200 [=====] - 3s 17ms/step - loss: 0.1979 -
val_loss: 0.1455
Epoch 4/10
200/200 [=====] - 3s 17ms/step - loss: 0.1647 -
val_loss: 0.1351
Epoch 5/10
200/200 [=====] - 3s 17ms/step - loss: 0.1450 -

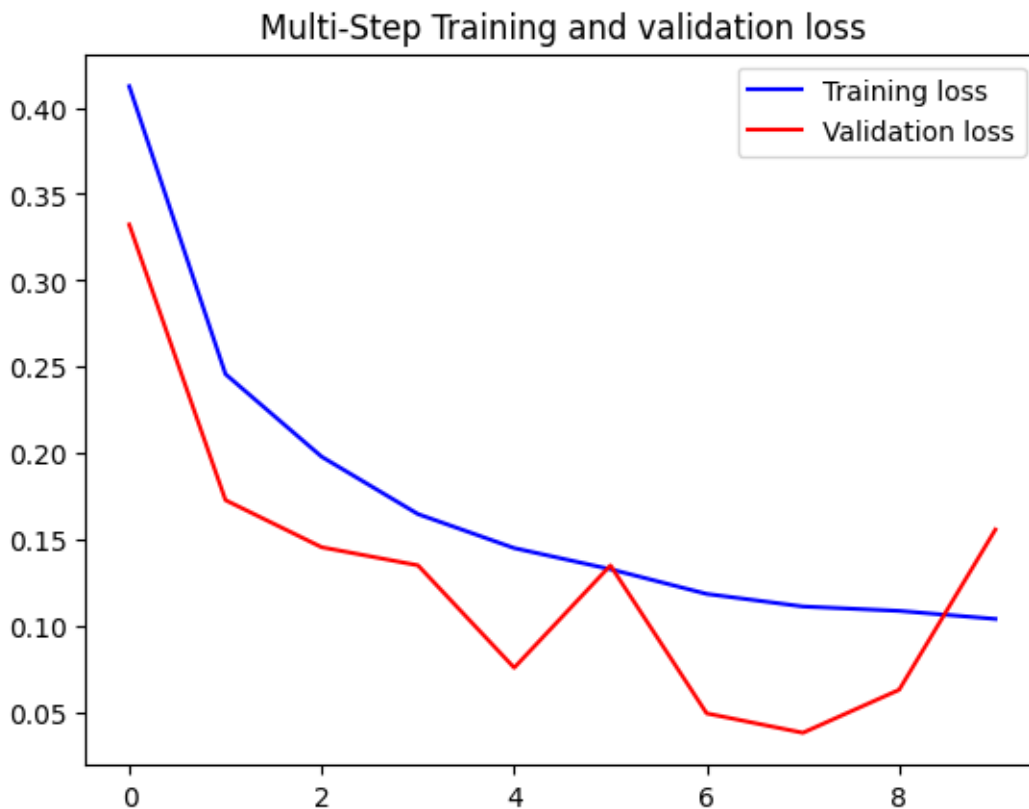
```

```

val_loss: 0.0758
Epoch 6/10
200/200 [=====] - 3s 17ms/step - loss: 0.1328 -
val_loss: 0.1350
Epoch 7/10
200/200 [=====] - 3s 17ms/step - loss: 0.1185 -
val_loss: 0.0494
Epoch 8/10
200/200 [=====] - 3s 17ms/step - loss: 0.1112 -
val_loss: 0.0381
Epoch 9/10
200/200 [=====] - 3s 17ms/step - loss: 0.1087 -
val_loss: 0.0630
Epoch 10/10
200/200 [=====] - 3s 17ms/step - loss: 0.1040 -
val_loss: 0.1558

```

```
[38]: plot_train_history(multi_step_history, 'Multi-Step Training and validation_
      ↪loss')
```



```
[39]: multi_step_model.save('best_single_feature_temp.h5')
```

```
[40]: from tensorflow import keras
multi_step_model = keras.models.load_model("./best_single_feature_temp.h5")
```

WARNING:tensorflow:Layer lstm_5 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as fallback when running on GPU.

2023-05-29 18:12:37.560932: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 18:12:37.561649: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

[[{{node gradients/split_grad/concat/split/split_dim}}]]

2023-05-29 18:12:37.562242: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

```
[49]: for x, y in val_data_multi.take(3):
      multi_step_plot(x[0], y[0], multi_step_model.predict(x)[0])
```

2023-05-29 14:46:50.883482: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]

[[{{node Placeholder/_1}}]]

2023-05-29 14:46:51.070465: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]

2023-05-29 14:46:51.071267: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

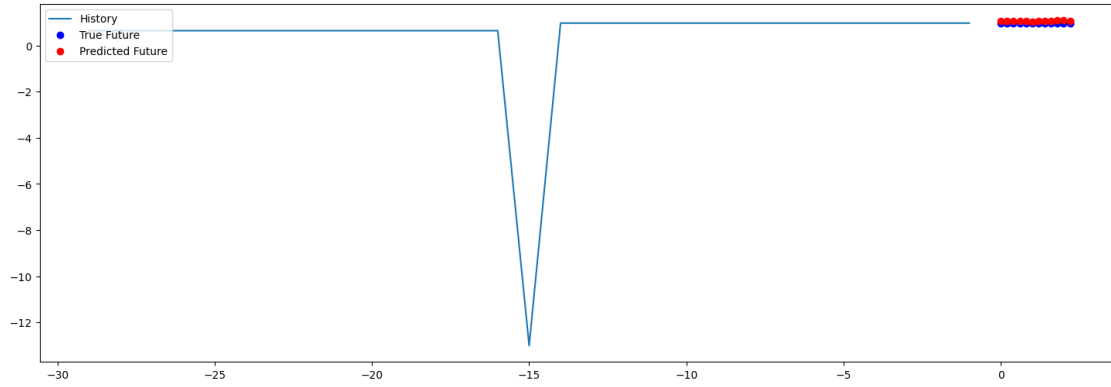
[[{{node gradients/split_grad/concat/split/split_dim}}]]

2023-05-29 14:46:51.071875: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value

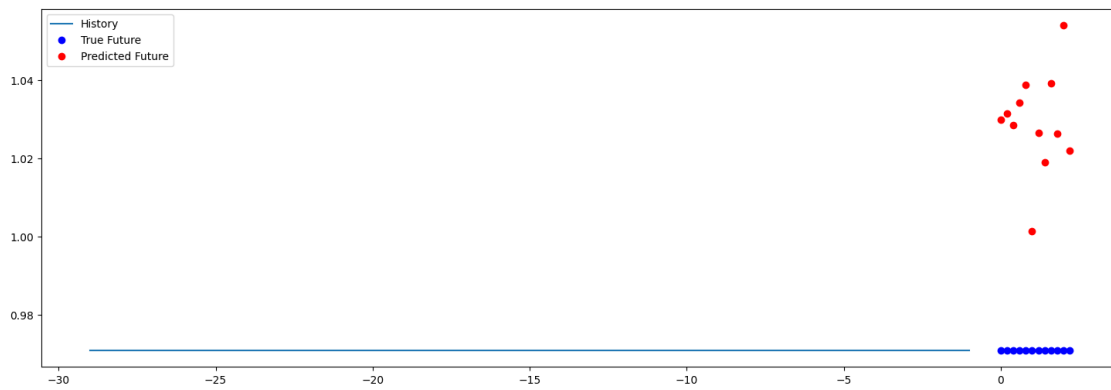
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

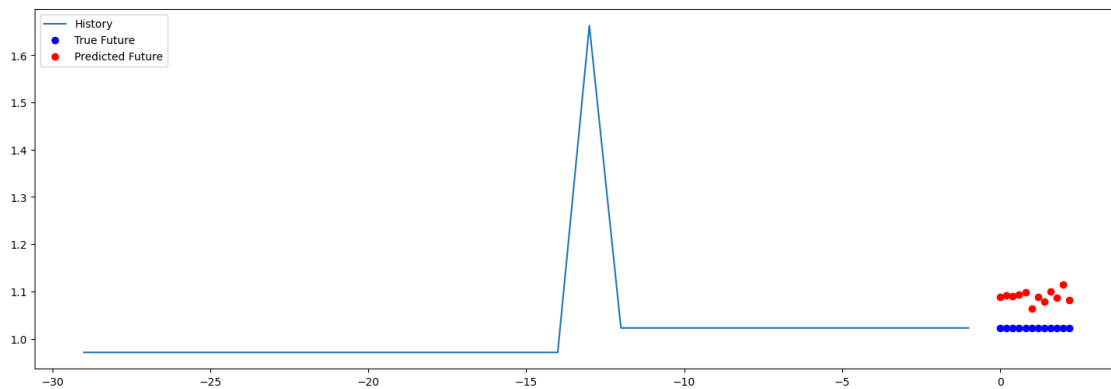
4/4 [=====] - 0s 5ms/step



4/4 [=====] - 0s 3ms/step



4/4 [=====] - 0s 3ms/step




```
[41]: import tensorflow as tf
train_data_multi = tf.data.Dataset.from_tensor_slices((x_train_multi,
    ↪y_train_multi))
train_data_multi = train_data_multi.cache().batch(BATCH_SIZE)
val_data_multi = tf.data.Dataset.from_tensor_slices((x_val_multi, y_val_multi))
val_data_multi = val_data_multi.batch(BATCH_SIZE)

predicted_temps = []
original_temps = []
history_temps = []

for x, y in train_data_multi:
    hx_temp = np.squeeze(x[0])
    history_temps.append(hx_temp)

for x, y in val_data_multi:
    prediction = multi_step_model.predict(x, verbose = 0)[0]
    ori_mems = np.squeeze(y[0])

    predicted_temps.append(prediction)
    original_temps.append(ori_mems)

predicted_temp_usage = np.concatenate(predicted_temps, axis=0)
original_temp_usage = np.concatenate(original_temps, axis=0)
history_temp_usage = np.concatenate(history_temps, axis=0)
```

```
2023-05-29 18:13:06.128408: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [2842,12,1]
[[{{node Placeholder/_1}}]]
2023-05-29 18:13:06.151074: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]
[[{{node Placeholder/_1}}]]
2023-05-29 18:13:06.265925: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
2023-05-29 18:13:06.266579: I tensorflow/core/common_runtime/executor.cc:1197]
```

[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

```
[[{{node gradients/split_grad/concat/split/split_dim}}]]
```

2023-05-29 18:13:06.267175: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

2023-05-29 18:13:06.648464: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with dtype int32

```
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
```

2023-05-29 18:13:06.649221: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype int32

```
[[{{node gradients/split_grad/concat/split/split_dim}}]]
```

2023-05-29 18:13:06.649878: I tensorflow/core/common_runtime/executor.cc:1197] [/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an error and you can ignore this message): INVALID_ARGUMENT: You must feed a value for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with dtype int32

```
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]
```

```
[50]: import tensorflow as tf
val_data_multi = tf.data.Dataset.from_tensor_slices((x_val_multi, y_val_multi))
val_data_multi = val_data_multi.batch(BATCH_SIZE)

predicted_temps = []
original_temps = []

for x, y in val_data_multi:
    prediction = multi_step_model.predict(x, verbose = 0 )[0]
    ori_temps = np.squeeze(y[0])

    predicted_temps.append(prediction)
    original_temps.append(ori_temps)

prediction_temp_usage = np.concatenate(predicted_temps, axis=0)
original_temp_usage = np.concatenate(original_temps, axis=0)
```

2023-05-29 14:47:50.797998: I tensorflow/core/common_runtime/executor.cc:1197]

```

[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'Placeholder/_1' with dtype double and shape [591,12,1]
[[{{node Placeholder/_1}}]]
2023-05-29 14:47:51.050516: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_2_grad/concat/split_2/split_dim' with
dtype int32
[[{{node gradients/split_2_grad/concat/split_2/split_dim}}]]
2023-05-29 14:47:51.051221: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_grad/concat/split/split_dim' with dtype
int32
[[{{node gradients/split_grad/concat/split/split_dim}}]]
2023-05-29 14:47:51.051857: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'gradients/split_1_grad/concat/split_1/split_dim' with
dtype int32
[[{{node gradients/split_1_grad/concat/split_1/split_dim}}]]

```

[50]: 0.06582491098070845

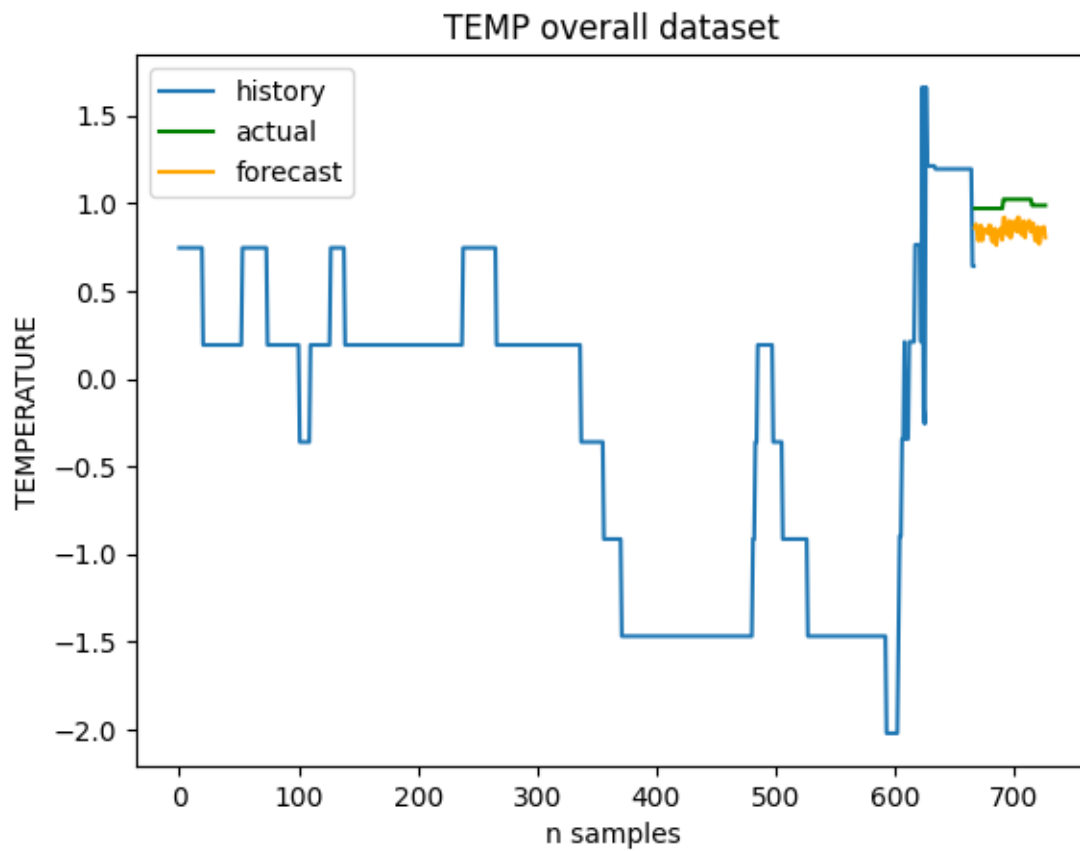
```

[42]: plt.title("TEMP overall dataset")
plt.xlabel("n samples")
plt.ylabel("TEMPERATURE")
plt.plot(range(len(history_temp_usage)), history_temp_usage, label="history")
plt.plot(range(len(history_temp_usage), len(history_temp_usage) +
↳ len(predicted_temp_usage)), original_temp_usage, label="actual",
↳ color="green")
plt.plot(range(len(history_temp_usage), len(history_temp_usage) +
↳ len(predicted_temp_usage)), predicted_temp_usage, label="forecast",
↳ color="orange")

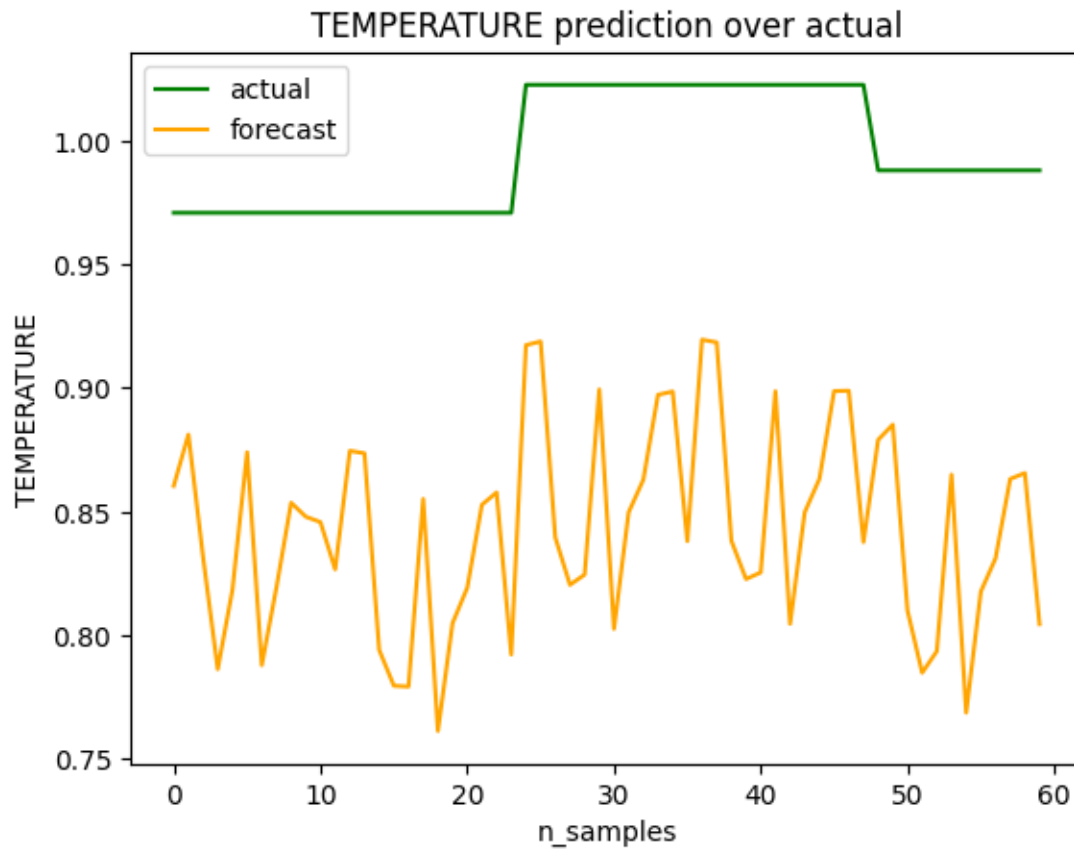
plt.legend()
plt.show()

x = range(len(predicted_temp_usage))
plt.title("TEMPERATURE prediction over actual")
plt.xlabel("n_samples")
plt.ylabel("TEMPERATURE")
plt.plot(x, original_temp_usage, label="actual", color="green")
plt.plot(x, predicted_temp_usage, label="forecast", color="orange")
plt.legend()

```



[42]: <matplotlib.legend.Legend at 0x7f7b881bcd90>



```
[43]: my_mean_absolute_percentage_error(original_temp_usage, predicted_temp_usage)
```

```
[43]: 15.249705187382014
```

Overall the only metrics which reaches a reasonable accuracy is the temperature with 84.7% of accuracy (1-MAPE)