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August 9, 2024

[90]:
```
import tensorflow as tf
from scipy.io import loadmat
import matplotlib.pyplot as plt
import numpy as np
from tensorflow.keras.preprocessing.image import load_img, img_to_array
from tensorflow.keras.models import Sequential, load_model
from tensorflow.keras.layers import Dense, Flatten, Conv1D, MaxPooling1D,␣
↪Dropout, BatchNormalization, LSTM, Reshape
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping
import os
import pandas as pd
from tensorflow.keras.optimizers import Adam
from tensorflow.keras import regularizers
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_squared_error
from tensorflow.keras.losses import Huber
from tensorflow.keras.regularizers import l2
from tensorflow.keras.initializers import HeNormal
```

[91]:
```
# Run this cell to connect to your Drive folder

from google.colab import drive
drive.mount('/content/gdrive')
```

```
Drive already mounted at /content/gdrive; to attempt to forcibly remount, call
drive.mount("/content/gdrive", force_remount=True).
```

[92]:
```
df_forFCST = pd.read_csv(  r'/content/gdrive/MyDrive/DataStore/salesD_smoothed.
↪csv' )
df_forFCST.set_index( 'ds', inplace = True )
df_forFCST.index = pd.to_datetime( df_forFCST.index )
df_forFCST.index
```

[92]:
```
DatetimeIndex(['2019-01-01', '2019-01-02', '2019-01-03', '2019-01-04',
               '2019-01-05', '2019-01-06', '2019-01-07', '2019-01-08',
               '2019-01-09', '2019-01-10',
               …
```

```
               '2024-06-21', '2024-06-22', '2024-06-23', '2024-06-24',
               '2024-06-25', '2024-06-26', '2024-06-27', '2024-06-28',
               '2024-06-29', '2024-06-30'],
              dtype='datetime64[ns]', name='ds', length=2008, freq=None)
```

[93]:
```
def get_model(input_shape, wd = 3e-3, dp = 0.5):
    model = Sequential([
        tf.keras.layers.Conv1D(filters=64, kernel_size=3,
                    activation="relu",
                    input_shape=input_shape, kernel_initializer=HeNormal()),
  tf.keras.layers.LSTM(64, return_sequences=True, kernel_regularizer=l2(wd)),
        Dropout(dp),
  tf.keras.layers.LSTM(64, return_sequences=True, kernel_regularizer=l2(wd)),
        Dropout(dp),
  tf.keras.layers.LSTM(64, return_sequences=True, kernel_regularizer=l2(wd)),
  tf.keras.layers.LSTM(64, kernel_regularizer=l2(wd)),
  tf.keras.layers.Dense(1)
    ])
    return model
```

[94]:
```
def get_compile(model, lrate = 6e-4):
    optimizer = tf.keras.optimizers.SGD(momentum=0.9, learning_rate=lrate)

    model.compile(optimizer=optimizer,
              loss='mae',
                #loss = 'mae',
                  metrics = ['mae', 'mse'])

def get_checkpoint_every_epoch():
    return ModelCheckpoint(
        filepath='/content/gdrive/MyDrive/var/FTryModel/checkpoints_every_epoch/
 ↪checkpoint_{epoch:03d}.weights.h5',
        save_weights_only=True,
        save_freq='epoch',
    )

def get_checkpoint_best_only():
    return ModelCheckpoint(
        filepath='/content/gdrive/MyDrive/var/FTryModel/checkpoints_best_only/
 ↪checkpoint.weights.h5',
        save_weights_only=True,
        monitor='loss',
        save_best_only=True,
        mode='min',
    )

def get_early_stopping():
```

```
    return EarlyStopping(monitor='loss', patience=100, mode='min', min_delta=0.
 ↪005)
def get_lr_schedule():
    lr_schedule = tf.keras.callbacks.LearningRateScheduler(
    lambda epoch: 2e-9 * 10**(epoch / 20))
    return lr_schedule

def get_test_accuracy(model, x_test, y_test):
    test_loss, test_mse, test_mae = model.evaluate(x=x_test, y=y_test,␣
 ↪verbose=0)
    print('losses: {acc:0.3f}'.format(acc=test_loss))
    print('mse: {acc:0.3f}'.format(acc=test_mse))
    print('mae: {acc:0.3f}'.format(acc=test_mae))
    predictions = model.predict(x_test)
    print('deviation:', abs((sum(predictions) - sum(y_test))) / sum(y_test),␣
 ↪'%')
    plt.plot(y_test, label='           ')
    plt.plot(predictions, label='            ')
    #plt.plot(val_loss, label='     ')
    plt.legend()
    plt.show()
def get_test_results(model, x_test, y_test):
    test_loss, test_mse, test_mae = model.evaluate(x=x_test, y=y_test,␣
 ↪verbose=0)
    predictions = model.predict(x_test, verbose = 0)
    return test_loss, test_mse, test_mae, (abs((sum(predictions) -␣
 ↪sum(y_test))) / sum(y_test))
```

[95]:
```
features = ['y_mix', 'y_wo', 'coef']

#
look_back = 10  #
df_forFCST['y_mix_lag1'] = df_forFCST['y_mix'].shift(1)
df_forFCST['y_wo_lag1'] = df_forFCST['y_wo'].shift(1)
df_forFCST['coef_lag1'] = df_forFCST['coef'].shift(1)
features.extend(['y_mix_lag1', 'y_wo_lag1', 'coef_lag1'])

#
df_forFCST.dropna(inplace=True)

scaler = MinMaxScaler()
df_forFCST[features] = scaler.fit_transform(df_forFCST[features])
print(len(df_forFCST))
#
train_size = int(len(df_forFCST) * 0.9)
train_data = df_forFCST[:train_size]
val_data = df_forFCST[train_size:train_size + int(len(df_forFCST) * 0.05)]
```

```
test_data = df_forFCST[train_size + int(len(df_forFCST) * 0.05):]



#
def create_dataset(data, look_back):
    X, Y = [], []
    for i in range(len(data) - look_back - 1):
        a = data[i:(i + look_back), :]
        X.append(a)
        Y.append(data[i + look_back, 0])
    return np.array(X), np.array(Y)

look_back = 10
X_train, y_train = create_dataset(train_data[features].values, look_back)
X_val, y_val = create_dataset(val_data[features].values, look_back)
X_test, y_test = create_dataset(test_data[features].values, look_back)
```

2007

[96]:
```
input_shape=(X_train.shape[1], X_train.shape[2])

checkpoint_every_epoch = get_checkpoint_every_epoch()
checkpoint_best_only = get_checkpoint_best_only()
early_stopping = get_early_stopping()
lr_shed = get_lr_schedule()
callbacks = [checkpoint_every_epoch, checkpoint_best_only, early_stopping]
#callbacks = [lr_shed]
```

[97]:
```
model = get_model(input_shape)
get_compile(model)
model.summary()

batchs = 50

history = model.fit(X_train, y_train, epochs = 25, verbose = 2, validation_data
 ↪= (X_val, y_val), batch_size = batchs)
```

```
/usr/local/lib/python3.10/dist-
packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning: Do not
pass an `input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in the model
instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

```
Model: "sequential_22"
```

```
Layer (type)                                Output Shape                              ␣
↪Param #

conv1d_21 (Conv1D)                          (None, 8, 64)                              ␣
↪1,216

lstm_88 (LSTM)                              (None, 8, 64)                              ␣
↪33,024

dropout_44 (Dropout)                        (None, 8, 64)                              ␣
↪  0

lstm_89 (LSTM)                              (None, 8, 64)                              ␣
↪33,024

dropout_45 (Dropout)                        (None, 8, 64)                              ␣
↪  0

lstm_90 (LSTM)                              (None, 8, 64)                              ␣
↪33,024

lstm_91 (LSTM)                              (None, 64)                                 ␣
↪33,024

dense_22 (Dense)                            (None, 1)                                  ␣
↪ 65


Total params: 133,377 (521.00 KB)

Trainable params: 133,377 (521.00 KB)

Non-trainable params: 0 (0.00 B)
```

```
Epoch 1/25
36/36 - 11s - 299ms/step - loss: 1.4867 - mae: 0.2544 - mse: 0.0921 - val_loss:
1.4173 - val_mae: 0.1863 - val_mse: 0.0439
Epoch 2/25
36/36 - 3s - 90ms/step - loss: 1.3843 - mae: 0.1549 - mse: 0.0354 - val_loss:
1.4080 - val_mae: 0.1802 - val_mse: 0.0444
Epoch 3/25
36/36 - 1s - 25ms/step - loss: 1.3788 - mae: 0.1526 - mse: 0.0356 - val_loss:
1.4038 - val_mae: 0.1792 - val_mse: 0.0432
Epoch 4/25
```

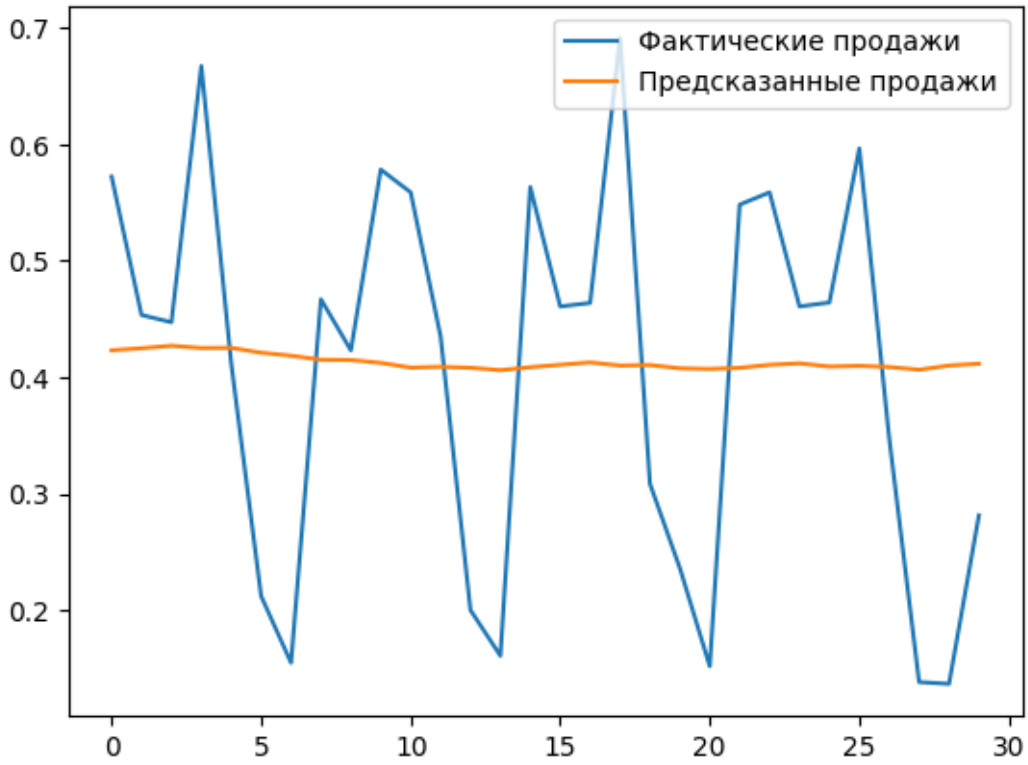
```
36/36 - 1s - 35ms/step - loss: 1.3749 - mae: 0.1518 - mse: 0.0350 - val_loss:
1.4007 - val_mae: 0.1792 - val_mse: 0.0434
Epoch 5/25
36/36 - 1s - 35ms/step - loss: 1.3721 - mae: 0.1522 - mse: 0.0353 - val_loss:
1.3973 - val_mae: 0.1790 - val_mse: 0.0431
Epoch 6/25
36/36 - 1s - 35ms/step - loss: 1.3686 - mae: 0.1518 - mse: 0.0355 - val_loss:
1.3942 - val_mae: 0.1790 - val_mse: 0.0433
Epoch 7/25
36/36 - 1s - 25ms/step - loss: 1.3655 - mae: 0.1519 - mse: 0.0352 - val_loss:
1.3906 - val_mae: 0.1786 - val_mse: 0.0426
Epoch 8/25
36/36 - 1s - 26ms/step - loss: 1.3619 - mae: 0.1514 - mse: 0.0346 - val_loss:
1.3879 - val_mae: 0.1790 - val_mse: 0.0434
Epoch 9/25
36/36 - 2s - 45ms/step - loss: 1.3588 - mae: 0.1514 - mse: 0.0355 - val_loss:
1.3847 - val_mae: 0.1790 - val_mse: 0.0434
Epoch 10/25
36/36 - 3s - 78ms/step - loss: 1.3561 - mae: 0.1518 - mse: 0.0349 - val_loss:
1.3816 - val_mae: 0.1789 - val_mse: 0.0434
Epoch 11/25
36/36 - 1s - 31ms/step - loss: 1.3532 - mae: 0.1521 - mse: 0.0357 - val_loss:
1.3778 - val_mae: 0.1783 - val_mse: 0.0425
Epoch 12/25
36/36 - 1s - 25ms/step - loss: 1.3492 - mae: 0.1511 - mse: 0.0350 - val_loss:
1.3751 - val_mae: 0.1786 - val_mse: 0.0432
Epoch 13/25
36/36 - 1s - 35ms/step - loss: 1.3468 - mae: 0.1518 - mse: 0.0351 - val_loss:
1.3718 - val_mae: 0.1784 - val_mse: 0.0430
Epoch 14/25
36/36 - 1s - 25ms/step - loss: 1.3435 - mae: 0.1516 - mse: 0.0354 - val_loss:
1.3690 - val_mae: 0.1787 - val_mse: 0.0434
Epoch 15/25
36/36 - 1s - 35ms/step - loss: 1.3400 - mae: 0.1512 - mse: 0.0352 - val_loss:
1.3653 - val_mae: 0.1781 - val_mse: 0.0426
Epoch 16/25
36/36 - 1s - 25ms/step - loss: 1.3373 - mae: 0.1516 - mse: 0.0347 - val_loss:
1.3623 - val_mae: 0.1782 - val_mse: 0.0428
Epoch 17/25
36/36 - 1s - 25ms/step - loss: 1.3337 - mae: 0.1510 - mse: 0.0351 - val_loss:
1.3592 - val_mae: 0.1781 - val_mse: 0.0428
Epoch 18/25
36/36 - 1s - 35ms/step - loss: 1.3304 - mae: 0.1508 - mse: 0.0344 - val_loss:
1.3560 - val_mae: 0.1779 - val_mse: 0.0426
Epoch 19/25
36/36 - 1s - 25ms/step - loss: 1.3273 - mae: 0.1508 - mse: 0.0351 - val_loss:
1.3530 - val_mae: 0.1780 - val_mse: 0.0429
Epoch 20/25
```

```
36/36 - 1s - 25ms/step - loss: 1.3247 - mae: 0.1512 - mse: 0.0349 - val_loss:
1.3498 - val_mae: 0.1778 - val_mse: 0.0426
Epoch 21/25
36/36 - 1s - 39ms/step - loss: 1.3210 - mae: 0.1505 - mse: 0.0351 - val_loss:
1.3468 - val_mae: 0.1778 - val_mse: 0.0427
Epoch 22/25
36/36 - 2s - 43ms/step - loss: 1.3183 - mae: 0.1509 - mse: 0.0349 - val_loss:
1.3438 - val_mae: 0.1779 - val_mse: 0.0429
Epoch 23/25
36/36 - 2s - 44ms/step - loss: 1.3153 - mae: 0.1508 - mse: 0.0348 - val_loss:
1.3406 - val_mae: 0.1777 - val_mse: 0.0427
Epoch 24/25
36/36 - 1s - 34ms/step - loss: 1.3122 - mae: 0.1508 - mse: 0.0351 - val_loss:
1.3375 - val_mae: 0.1776 - val_mse: 0.0426
Epoch 25/25
36/36 - 1s - 26ms/step - loss: 1.3096 - mae: 0.1511 - mse: 0.0346 - val_loss:
1.3344 - val_mae: 0.1775 - val_mse: 0.0425
```

[98]:
```
get_test_accuracy(model, X_test, y_test)
#get_test_accuracy(model, X_test[-31: -1], y_test[-31:-1])
#get_test_accuracy(model, X_test[-61: -31], y_test[-61:-31])
#get_test_accuracy(model, X_test[-91: -61], y_test[-91:-61])
#get_test_accuracy(model, X_test[-121: -91], y_test[-121:-91])
get_test_accuracy(model, X_test[0: 30], y_test[0: 30])
get_test_accuracy(model, X_test[30: 60], y_test[30: 60])
get_test_accuracy(model, X_test[60: 90], y_test[60: 90])
```

```
losses: 1.332
mse: 0.175
mae: 0.043
3/3             1s 301ms/step
deviation: [0.0168781] %
```


```
losses: 1.296
mse: 0.139
mae: 0.027
1/1             0s 26ms/step
deviation: [0.01996112] %
```

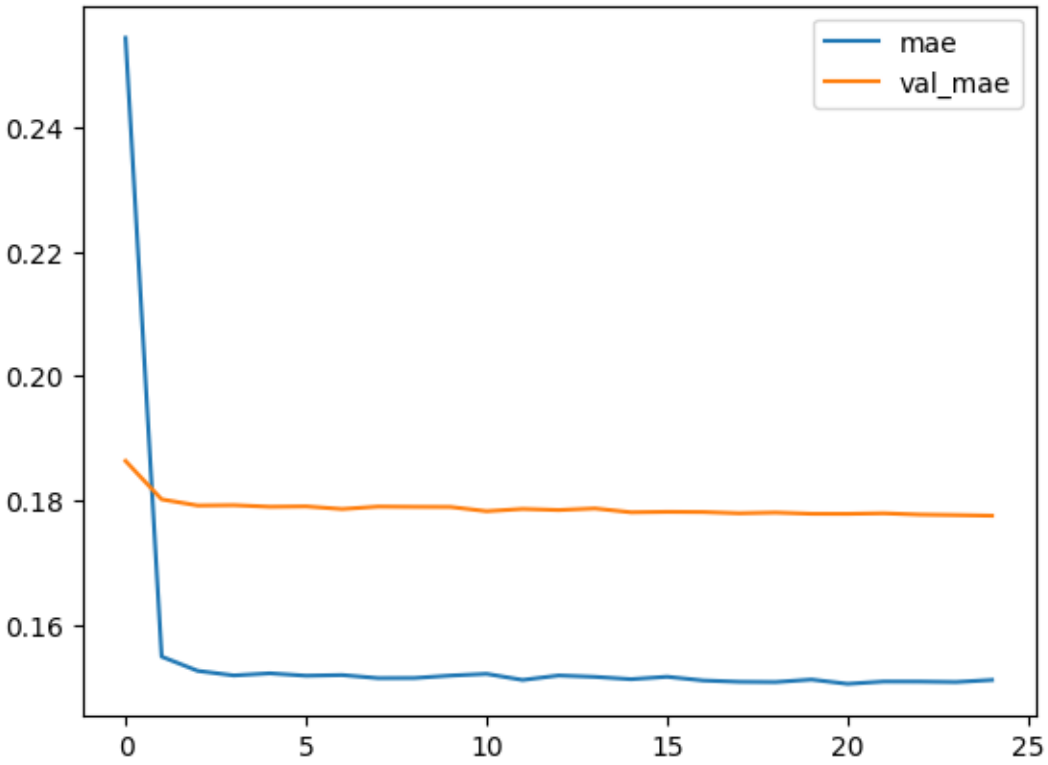



```
losses: 1.361
mse: 0.204
mae: 0.057
1/1             0s 25ms/step
deviation: [0.03512097] %
```


```
losses: 1.339
mse: 0.182
mae: 0.046
1/1             0s 33ms/step
deviation: [0.0037432] %
```

[101]:
```
df = pd.DataFrame(history.history)
df.plot(y=['mae', 'val_mae'])
```

[101]: <Axes: >



[100]:
```
batchsi = [32, 50]
lratesi = [6e-4, 8e-4, 1e-3, 2e-3, 3e-3, 4e-3]
weedi = [6e-4, 8e-4, 1e-3, 2e-3, 3e-3]
dpi = [0.4, 0.45, 0.5, 0.6]
bests = []
```

[ ]:
```
for batchs in batchsi:
    for lrate in lratesi:
        for weed in weedi:
            for dp in dpi:
                model = get_model(input_shape, weed, dp)
                get_compile(model, lrate)
                history = model.fit(X_train, y_train, epochs=25, verbose = 0,␣
 ↪batch_size = batchs)
                test_loss, test_mse, test_mae, dev = get_test_results(model,␣
 ↪X_test, y_test)
                test_loss1, test_mse1, test_mae1, dev1 =␣
 ↪get_test_results(model, X_test[-31: -1], y_test[-31:-1])
                test_loss2, test_mse2, test_mae2, dev2 =␣
 ↪get_test_results(model, X_test[-61: -31], y_test[-61:-31])
```

```
                test_loss3, test_mse3, test_mae3, dev3 =␣
↪get_test_results(model, X_test[-91: -61], y_test[-91:-61])
                print(batchs, lrate, weed)
                print(get_test_results(model, X_test, y_test))
                if max(dev1, dev2, dev3) < 0.05:
                    print(get_test_results(model, X_test[0: 30], y_test[0:30]))
                    print(get_test_results(model, X_test[30: 60], y_test[30:
↪60]), end = '   ')
                    print(get_test_results(model, X_test[60: 90], y_test[60:
↪90]))
                    bests.append((batchs, lrate, weed))
```

[ ]:
```
#Best models dont go above 5% bar 25-35 epochs optimal (25 - tested, many␣
↪epochs/no convolution - results worse)
#batch_size learning_rate weight_decay dropout%
#32 6e-4 6e-4 50 in 4% *
#32 6e-4 1e-3 50 in 5%
#32 8e-4 2e-3 45 in 6%
#32 1e-3 1e-3 50 in 4% **
#32 2e-3 2e-3 45 in 5% *
#50 6e-4 6e-4 50 in 4% **
#50 6e-4 8e-4 45 in 4% **
#50 6e-4 1e-3 50 in 4% **
#50 6e-4 3e-3 50 in 3% ***
#50 1e-3 1e-3 50 in 3% **
#50 1e-3 3e-3 50 in 4% **
print(bests)
```

[ ]:
```
model1 = get_model(input_shape)  # Create a new model
get_compile(model1)
model1.load_weights('/content/gdrive/MyDrive/var/FTryModel/
↪checkpoints_best_only/checkpoint.weights.h5')
get_test_accuracy(model1, X_test, y_test)
get_test_accuracy(model1, X_test[-31: -1], y_test[-31:-1])
```

[ ]:
```
# Define the learning rate array (adjust to match the number of epochs)
lrs = 2e-9 * (10 ** (np.arange(len(history.history['loss'])) / 20))

# Set the figure size
plt.figure(figsize=(10, 6))

# Set the grid
plt.grid(True)

# Plot the loss in log scale
plt.semilogx(lrs[8:], history.history["loss"][8:])
```

```
# Increase the tickmarks size
plt.tick_params('both', length=1, width=1, which='both')

# Set the plot boundaries
plt.xlabel("Learning Rate")
plt.ylabel("Loss")
plt.title("Learning Rate vs Loss")
plt.show()
```