Jupyter_main

March 2, 2021

[1]:
```
# ELEC0088 SNS
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# SN: 15105271

# This is the main file for the assignment.
# It only prints out the results.
# Please see the function files for each section for details.


#import function files
import Jcommon_model_functions as comm_func

#import Section 1: daily new cases
import Jsec1_dailycases as sec1
#import Section 2: daily new hospital admissions
import Jsec2_dailyhealthcare as sec2

import time
import sys
import itertools
import warnings
import os
import pandas as pd
import numpy as np
from matplotlib import pyplot as plt
import tensorflow as tf
import sklearn.metrics as metrics
from math import sqrt
from itertools import cycle

from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, BatchNormalization, Dropout,␣
↪Activation
from tensorflow.keras.layers import LSTM, GRU
from tensorflow.keras.optimizers import Adam, SGD, RMSprop

from sklearn.metrics import mean_squared_error
```

```
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import StandardScaler
from sklearn.svm import SVR

from pandas.plotting import autocorrelation_plot
from pandas.tseries.offsets import DateOffset

from statsmodels.tsa.stattools import adfuller
from statsmodels.tsa.seasonal import seasonal_decompose
from statsmodels.tsa.arima_model import ARIMA
from statsmodels.graphics import tsaplots
import statsmodels.api as sm
from statsmodels.tsa.holtwinters import ExponentialSmoothing as HWES
from statsmodels.tsa.holtwinters import SimpleExpSmoothing as SES
from statsmodels.tsa.statespace.sarimax import SARIMAX




def main():

    print('------------------------------Print package versions:
↪--------------------------------\n')
    print_module_version()

    #print section 1 results: predicting daily new confirmed cases in England␣
↪from 24-Nov-2020 to 27-Dec-2020
    start = time.time()
    sec1.print_sec1_dailycases_results()
    sec1_runtime = time.time() - start

    #print section 2 results: predicting daily new hospital admissions in␣
↪England from 30-Nov-2020 to 28-Dec-2020
    start = time.time()
    sec2.print_sec2_dailyhealthcare_results()
    sec2_runtime = time.time() - start

    print('Sec 1 runtime: {}, Sec 2 runtime: {} '.format(sec1_runtime,␣
↪sec2_runtime))


def print_module_version():
    for module in sys.modules:
        try:
            print(module,sys.modules[module].__version__)
        except:
```

```
            try:
                if  type(sys.modules[module].version) is str:
                    print(module,sys.modules[module].version)
                else:
                    print(module,sys.modules[module].version())
            except:
                try:
                    print(module,sys.modules[module].VERSION)
                except:
                    pass



if __name__ == '__main__':
    main()
```

```
------------------------------Print package
versions:--------------------------------

sys 3.6.7 |Anaconda, Inc.| (default, Oct 23 2018, 14:01:38)
[GCC 4.2.1 Compatible Clang 4.0.1 (tags/RELEASE_401/final)]
re 2.2.1
ipykernel 5.3.4
ipykernel._version 5.3.4
json 2.0.9
IPython 7.16.1
IPython.core.release 7.16.1
logging 0.5.1.2
zlib 1.0
traitlets 4.3.3
six 1.15.0
ipython_genutils 0.2.0
ipython_genutils._version 0.2.0
platform 1.0.8
traitlets._version 4.3.3
decorator 4.4.2
argparse 1.1
IPython.core.crashhandler 7.16.1
pygments 2.7.3
pexpect 4.8.0
ptyprocess 0.6.0
pickleshare 0.7.5
backcall 0.2.0
sqlite3 2.6.0
sqlite3.dbapi2 2.6.0
_sqlite3 2.6.0
ipaddress 1.0
```

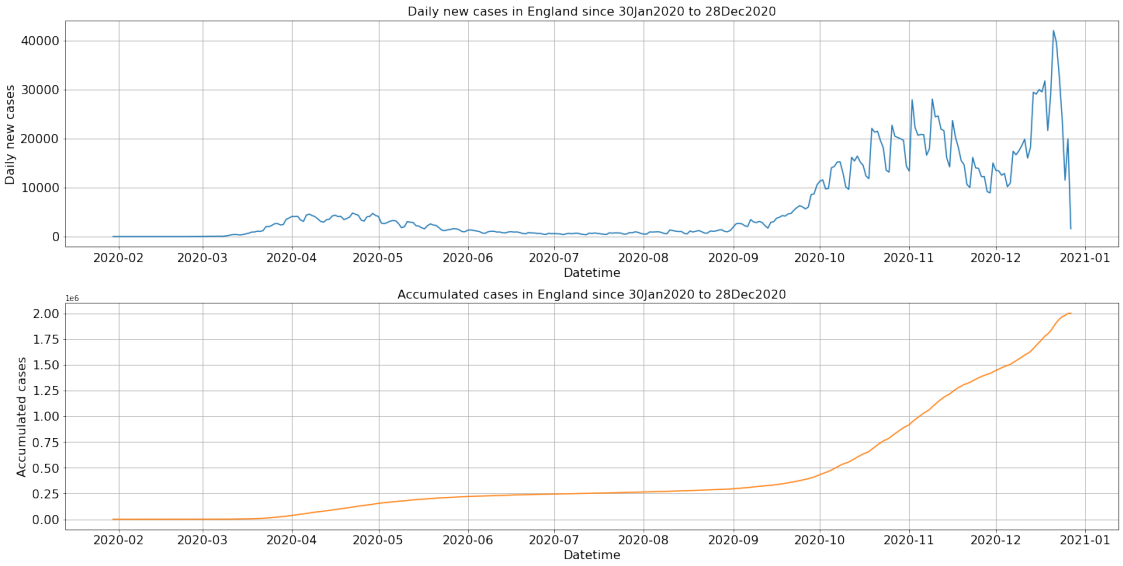
```
prompt_toolkit 3.0.8
wcwidth 0.2.5
jedi 0.18.0
parso 0.7.0
urllib.request 3.6
optparse 1.5.3
jupyter_client 6.1.7
jupyter_client._version 6.1.7
zmq 20.0.0
ctypes 1.1.0
_ctypes 1.1.0
zmq.backend.cython 40303
zmq.backend.cython.constants 40303
zmq.sugar 20.0.0
zmq.sugar.constants 40303
zmq.sugar.version 20.0.0
jupyter_core 4.7.0
jupyter_core.version 4.7.0
ctypes.macholib 1.0
tornado 6.1
_curses b'2.2'
dateutil 2.8.1
dateutil._version 2.8.1
decimal 1.70
_decimal 1.70
distutils 3.6.7
appnope 0.1.2
pandas 1.1.4
numpy 1.18.5
numpy.version 1.18.5
numpy.core 1.18.5
numpy.core._multiarray_umath 3.1
numpy.lib 1.18.5
numpy.linalg._umath_linalg b'0.1.5'
pytz 2020.4
csv 1.0
_csv 1.0
matplotlib 3.3.2
pyparsing 2.4.7
cycler 0.10.0
kiwisolver 1.3.1
PIL 8.0.1
PIL._version 8.0.1
PIL.Image 8.0.1
xml.etree.ElementTree 1.3.0
cffi 1.14.0
tensorflow 2.3.1
google.protobuf 3.14.0
```

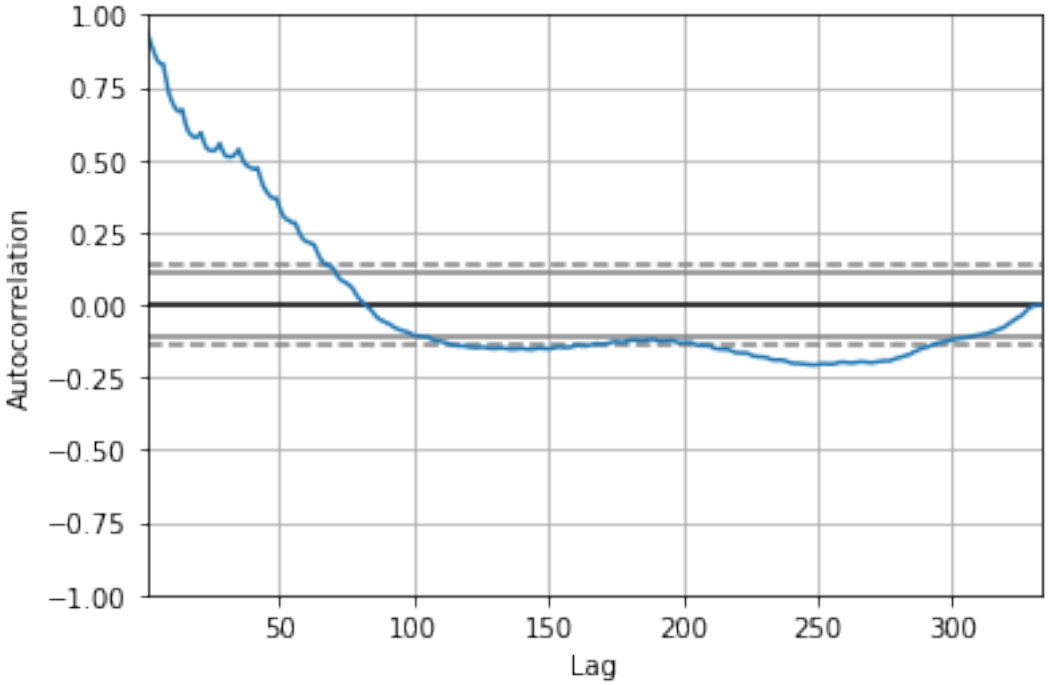
```
tensorflow.python.client.pywrap_tf_session 2.3.1
wrapt 1.12.1
tensorflow.python.framework.versions 2.3.1
opt_einsum v3.3.0
astunparse 1.6.3
termcolor (1, 1, 0)
tensorflow.python.keras 2.4.0
h5py 2.10.0
h5py.version 2.10.0
tarfile 0.9.0
requests 2.25.1
urllib3 1.26.2
urllib3.packages.six 1.12.0
urllib3._version 1.26.2
urllib3.connection 1.26.2
chardet 4.0.0
chardet.version 4.0.0
requests.__version__ 2.25.1
requests.utils 2.25.1
certifi 2020.12.05
requests.packages.urllib3 1.26.2
requests.packages.urllib3.packages.six 1.12.0
requests.packages.urllib3._version 1.26.2
requests.packages.urllib3.connection 1.26.2
idna 2.10
idna.package_data 2.10
idna.idnadata 13.0.0
requests.packages.idna 2.10
requests.packages.idna.package_data 2.10
requests.packages.idna.idnadata 13.0.0
requests.packages.chardet 4.0.0
requests.packages.chardet.version 4.0.0
scipy 1.5.4
scipy.version 1.5.4
scipy._lib._uarray 0.5.1+49.g4c3f1d7.scipy
yaml 5.3.1
xml.sax.handler 2.0beta
unittest.mock 1.0
tensorflow._api.v2.compat.v1 2.3.1
tensorflow._api.v2.compat.v1.compat.v1 2.3.1
tensorflow._api.v2.compat.v1.version 2.3.1
tensorflow.python.keras.api.keras 2.4.0
keras_preprocessing 1.1.2
scipy.ndimage 2.0
scipy.special.specfun b'$Revision: $'
scipy.linalg._fblas b'$Revision: $'
scipy.linalg._flapack b'$Revision: $'
scipy.linalg._flinalg b'$Revision: $'
```

```
tensorflow.python.keras.api._v1.keras 2.4.0
tensorflow._api.v2.compat.v1.compat.v2 2.3.1
tensorflow._api.v2.compat.v2 2.3.1
tensorflow._api.v2.compat.v2.compat.v1 2.3.1
tensorflow._api.v2.compat.v2.compat.v2 2.3.1
tensorflow._api.v2.compat.v2.version 2.3.1
tensorboard 2.4.0
tensorboard.version 2.4.0
tensorboard.compat.tensorflow_stub stub
tensorflow.python.keras.api._v2.keras 2.4.0
tensorflow._api.v2.version 2.3.1
tensorflow.keras 2.4.0
sklearn 0.21.2
sklearn.base 0.21.2
sklearn.utils._joblib 1.0.0
joblib 1.0.0
joblib.externals.loky 2.9.0
joblib.externals.cloudpickle 1.6.0
scipy.sparse.linalg.isolve._iterative b'$Revision: $'
scipy._lib.decorator 4.0.5
scipy.sparse.linalg.eigen.arpack._arpack b'$Revision: $'
scipy.optimize.minpack2 b'$Revision: $'
scipy.optimize._lbfgsb b'$Revision: $'
scipy.optimize._cobyla b'$Revision: $'
scipy.optimize._slsqp b'$Revision: $'
scipy.optimize._minpack  1.10
scipy.optimize.__nnls b'$Revision: $'
scipy.integrate._odepack  1.9
scipy.integrate._quadpack  1.13
scipy.integrate._ode $Id$
scipy.integrate.vode b'$Revision: $'
scipy.integrate._dop b'$Revision: $'
scipy.integrate.lsoda b'$Revision: $'
scipy.interpolate._fitpack  1.7
scipy.interpolate.dfitpack b'$Revision: $'
scipy.stats.statlib b'$Revision: $'
scipy.stats.mvn b'$Revision: $'
statsmodels 0.12.1
patsy 0.5.1
patsy.version 0.5.1
scipy.signal.spline 0.2
statsmodels.api 0.12.1
statsmodels.__init__ 0.12.1
statsmodels.tools.web 0.12.1

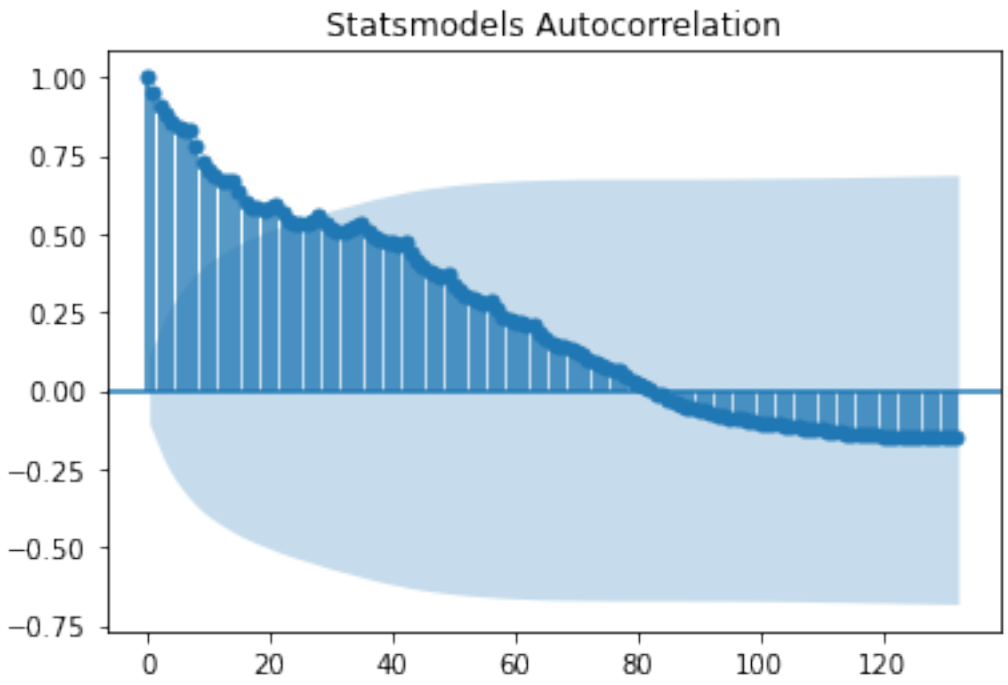
----------------------Print section 1: daily new cases
results:----------------------
```

----------1.1 Data source inspection----------

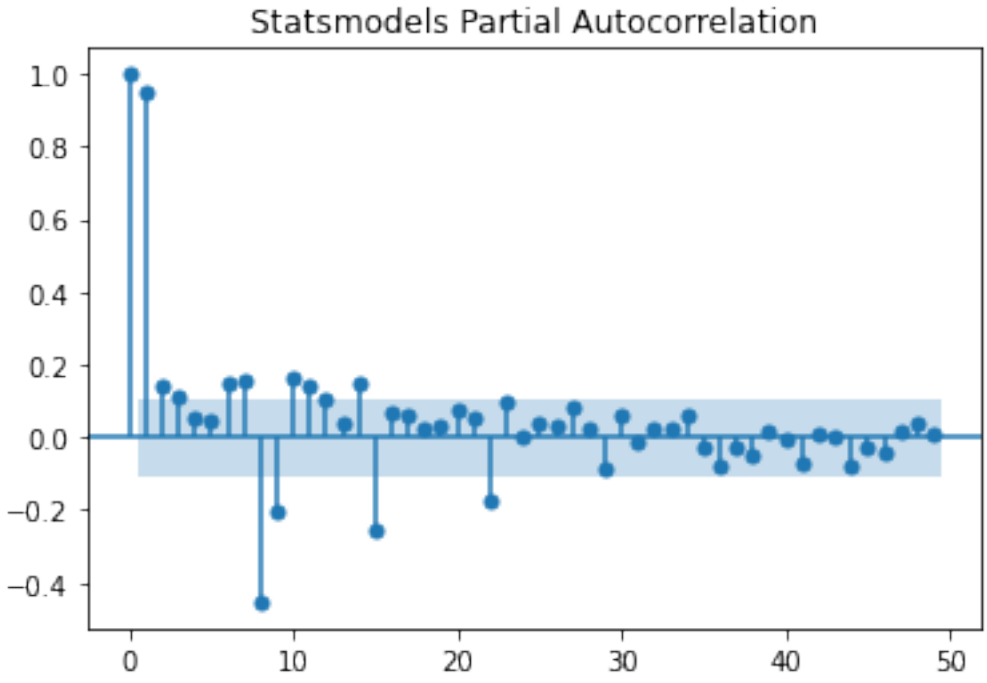


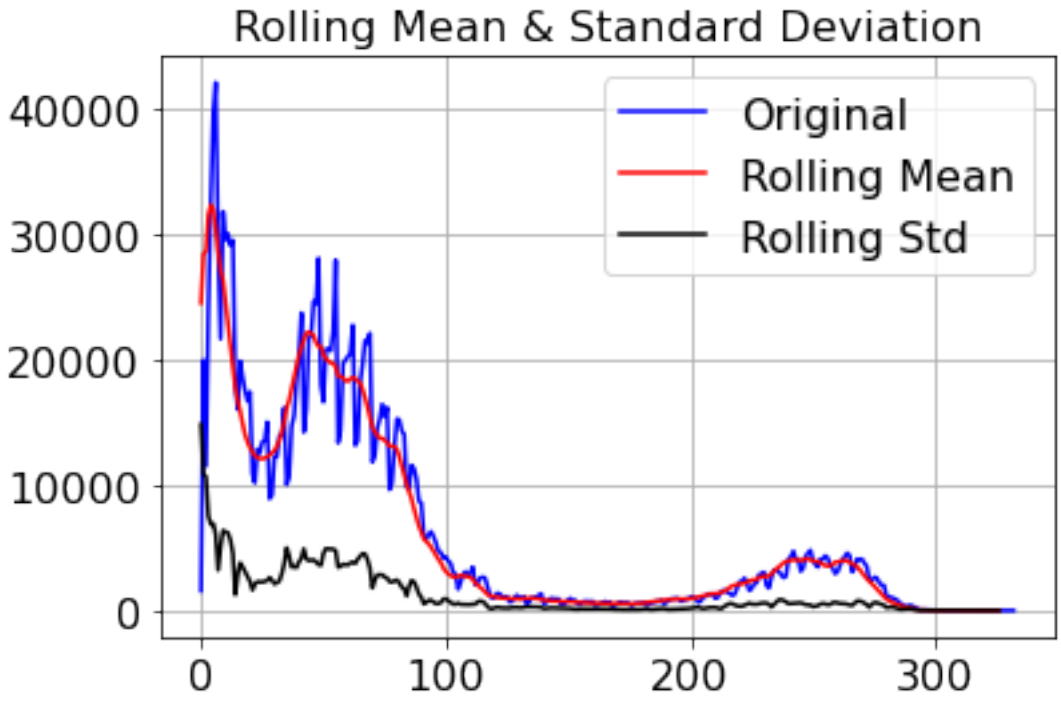


<Figure size 432x288 with 0 Axes>




```
<Figure size 432x288 with 0 Axes>
```






```
ADF Statistic: -0.8535326445806586
p-value: 0.8028895835381825
Critical Values:
        1%: -3.451148243362826
        5%: -2.8707010565250752
        10%: -2.571650950153748


-----------------------1.2 train-test split-----------------------


Raw Train length: 249
Raw Val length: 50
Raw Test length: 34


-----------------------1.3 prediction on each model-----------------------

------------1.3.1 LSTM prediction on daily new cases------------


----------------------Printing new LSTM model in para
grid-------------------------
```

```
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}
Train history feature shape: (242, 1, 7), Train label shape: 242
Val history feature shape: (36, 1, 7), Val label shape: 36
Test history feature shape: (34, 1, 7), Test label shape: 34
Adding last hidden LSTM layer 0:
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru (GRU)                    (None, 1, 112)            40656
_________________________________________________________________
dropout (Dropout)            (None, 1, 112)            0
_________________________________________________________________
lstm (LSTM)                  (None, 112)               100800
_________________________________________________________________
dropout_1 (Dropout)          (None, 112)               0
_________________________________________________________________
dense (Dense)                (None, 28)                3164
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 29
=================================================================
Total params: 144,649
Trainable params: 144,649
Non-trainable params: 0
_________________________________________________________________
Epoch 1/40
8/8 [==============================] - 1s 74ms/step - loss: 0.0481 -
mean_squared_error: 0.0481 - val_loss: 1.8564 - val_mean_squared_error: 1.8564
Epoch 2/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0228 -
mean_squared_error: 0.0228 - val_loss: 0.6674 - val_mean_squared_error: 0.6674
Epoch 3/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0125 -
mean_squared_error: 0.0125 - val_loss: 0.1952 - val_mean_squared_error: 0.1952
Epoch 4/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0090 -
mean_squared_error: 0.0090 - val_loss: 0.1410 - val_mean_squared_error: 0.1410
Epoch 5/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0048 -
mean_squared_error: 0.0048 - val_loss: 0.1226 - val_mean_squared_error: 0.1226
Epoch 6/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.4516 - val_mean_squared_error: 0.4516
Epoch 7/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.3490 - val_mean_squared_error: 0.3490
```

```
Epoch 8/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.4294 - val_mean_squared_error: 0.4294
Epoch 9/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0039 -
mean_squared_error: 0.0039 - val_loss: 0.2977 - val_mean_squared_error: 0.2977
Epoch 10/40
8/8 [==============================] - 0s 6ms/step - loss: 0.0039 -
mean_squared_error: 0.0039 - val_loss: 0.1270 - val_mean_squared_error: 0.1270
Epoch 11/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.2521 - val_mean_squared_error: 0.2521
Epoch 12/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.2513 - val_mean_squared_error: 0.2513
Epoch 13/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.2203 - val_mean_squared_error: 0.2203
Epoch 14/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.2272 - val_mean_squared_error: 0.2272
Epoch 15/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.2798 - val_mean_squared_error: 0.2798
Epoch 16/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.2847 - val_mean_squared_error: 0.2847
Epoch 17/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.2144 - val_mean_squared_error: 0.2144
Epoch 18/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.2376 - val_mean_squared_error: 0.2376
Epoch 19/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.2888 - val_mean_squared_error: 0.2888
Epoch 20/40
8/8 [==============================] - 0s 6ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.2701 - val_mean_squared_error: 0.2701
Epoch 21/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.3064 - val_mean_squared_error: 0.3064
Epoch 22/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.2161 - val_mean_squared_error: 0.2161
Epoch 23/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.2513 - val_mean_squared_error: 0.2513
```

```
Epoch 24/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.1843 - val_mean_squared_error: 0.1843
Epoch 25/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.2776 - val_mean_squared_error: 0.2776
Epoch 26/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.3128 - val_mean_squared_error: 0.3128
Epoch 27/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.3093 - val_mean_squared_error: 0.3093
Epoch 28/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.2223 - val_mean_squared_error: 0.2223
Epoch 29/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.2634 - val_mean_squared_error: 0.2634
Epoch 30/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.2379 - val_mean_squared_error: 0.2379
Epoch 31/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.2060 - val_mean_squared_error: 0.2060
Epoch 32/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.2120 - val_mean_squared_error: 0.2120
Epoch 33/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.1552 - val_mean_squared_error: 0.1552
Epoch 34/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1758 - val_mean_squared_error: 0.1758
Epoch 35/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.2659 - val_mean_squared_error: 0.2659
Epoch 36/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.2486 - val_mean_squared_error: 0.2486
Epoch 37/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.1915 - val_mean_squared_error: 0.1915
Epoch 38/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1486 - val_mean_squared_error: 0.1486
Epoch 39/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.1779 - val_mean_squared_error: 0.1779
```

```
Epoch 40/40
8/8 [==============================] - 0s 4ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.1830 - val_mean_squared_error: 0.1830

------------------------------------------------
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}, RMSE=8183.025489257138
------------------------------------------------


----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}
Train history feature shape: (242, 1, 7), Train label shape: 242
Val history feature shape: (36, 1, 7), Val label shape: 36
Test history feature shape: (34, 1, 7), Test label shape: 34
Adding hidden LSTM layer 0:
Adding last hidden LSTM layer 1:
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_1 (GRU)                  (None, 1, 896)            2432640
_________________________________________________________________
dropout_2 (Dropout)          (None, 1, 896)            0
_________________________________________________________________
lstm_1 (LSTM)                (None, 1, 896)            6426112
_________________________________________________________________
dropout_3 (Dropout)          (None, 1, 896)            0
_________________________________________________________________
dense_2 (Dense)              (None, 1, 56)             50232
_________________________________________________________________
dropout_4 (Dropout)          (None, 1, 56)             0
_________________________________________________________________
lstm_2 (LSTM)                (None, 448)               904960
_________________________________________________________________
dropout_5 (Dropout)          (None, 448)               0
_________________________________________________________________
dense_3 (Dense)              (None, 28)                12572
_________________________________________________________________
dense_4 (Dense)              (None, 1)                 29
=================================================================
Total params: 9,826,545
Trainable params: 9,826,545
Non-trainable params: 0
```

```
----------------------------------------------------------------
Epoch 1/40
8/8 [==============================] - 1s 134ms/step - loss: 0.0409 -
mean_squared_error: 0.0409 - val_loss: 0.5258 - val_mean_squared_error: 0.5258
Epoch 2/40
8/8 [==============================] - 0s 38ms/step - loss: 0.0168 -
mean_squared_error: 0.0168 - val_loss: 0.6732 - val_mean_squared_error: 0.6732
Epoch 3/40
8/8 [==============================] - 0s 39ms/step - loss: 0.0071 -
mean_squared_error: 0.0071 - val_loss: 0.3373 - val_mean_squared_error: 0.3373
Epoch 4/40
8/8 [==============================] - 0s 38ms/step - loss: 0.0053 -
mean_squared_error: 0.0053 - val_loss: 0.1352 - val_mean_squared_error: 0.1352
Epoch 5/40
8/8 [==============================] - 0s 38ms/step - loss: 0.0035 -
mean_squared_error: 0.0035 - val_loss: 0.1595 - val_mean_squared_error: 0.1595
Epoch 6/40
8/8 [==============================] - 0s 39ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.1073 - val_mean_squared_error: 0.1073
Epoch 7/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0037 -
mean_squared_error: 0.0037 - val_loss: 0.1561 - val_mean_squared_error: 0.1561
Epoch 8/40
8/8 [==============================] - 0s 38ms/step - loss: 0.0031 -
mean_squared_error: 0.0031 - val_loss: 0.1050 - val_mean_squared_error: 0.1050
Epoch 9/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.2111 - val_mean_squared_error: 0.2111
Epoch 10/40
8/8 [==============================] - 0s 38ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.1461 - val_mean_squared_error: 0.1461
Epoch 11/40
8/8 [==============================] - 0s 38ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.1485 - val_mean_squared_error: 0.1485
Epoch 12/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1062 - val_mean_squared_error: 0.1062
Epoch 13/40
8/8 [==============================] - 0s 38ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.1383 - val_mean_squared_error: 0.1383
Epoch 14/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.2915 - val_mean_squared_error: 0.2915
Epoch 15/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0033 -
mean_squared_error: 0.0033 - val_loss: 0.1117 - val_mean_squared_error: 0.1117
Epoch 16/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0043 -
```

```
mean_squared_error: 0.0043 - val_loss: 0.1093 - val_mean_squared_error: 0.1093
Epoch 17/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0040 -
mean_squared_error: 0.0040 - val_loss: 0.1356 - val_mean_squared_error: 0.1356
Epoch 18/40
8/8 [==============================] - 0s 34ms/step - loss: 0.0040 -
mean_squared_error: 0.0040 - val_loss: 0.1562 - val_mean_squared_error: 0.1562
Epoch 19/40
8/8 [==============================] - 0s 39ms/step - loss: 0.0035 -
mean_squared_error: 0.0035 - val_loss: 0.3195 - val_mean_squared_error: 0.3195
Epoch 20/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0045 -
mean_squared_error: 0.0045 - val_loss: 0.1586 - val_mean_squared_error: 0.1586
Epoch 21/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0039 -
mean_squared_error: 0.0039 - val_loss: 0.1441 - val_mean_squared_error: 0.1441
Epoch 22/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.1039 - val_mean_squared_error: 0.1039
Epoch 23/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.1764 - val_mean_squared_error: 0.1764
Epoch 24/40
8/8 [==============================] - 0s 35ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.1122 - val_mean_squared_error: 0.1122
Epoch 25/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.1529 - val_mean_squared_error: 0.1529
Epoch 26/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1239 - val_mean_squared_error: 0.1239
Epoch 27/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.1313 - val_mean_squared_error: 0.1313
Epoch 28/40
8/8 [==============================] - 0s 35ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1552 - val_mean_squared_error: 0.1552
Epoch 29/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.2076 - val_mean_squared_error: 0.2076
Epoch 30/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.2853 - val_mean_squared_error: 0.2853
Epoch 31/40
8/8 [==============================] - 0s 35ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.2044 - val_mean_squared_error: 0.2044
Epoch 32/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0023 -
```

```
mean_squared_error: 0.0023 - val_loss: 0.1767 - val_mean_squared_error: 0.1767
Epoch 33/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1741 - val_mean_squared_error: 0.1741
Epoch 34/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1942 - val_mean_squared_error: 0.1942
Epoch 35/40
8/8 [==============================] - 0s 36ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1899 - val_mean_squared_error: 0.1899
Epoch 36/40
8/8 [==============================] - 0s 37ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.1575 - val_mean_squared_error: 0.1575
Epoch 37/40
8/8 [==============================] - 0s 35ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.1795 - val_mean_squared_error: 0.1795
Epoch 38/40
8/8 [==============================] - 0s 35ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1669 - val_mean_squared_error: 0.1669
Epoch 39/40
8/8 [==============================] - 0s 35ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1569 - val_mean_squared_error: 0.1569
Epoch 40/40
8/8 [==============================] - 0s 35ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.1823 - val_mean_squared_error: 0.1823

--------------------------------------------------
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}, RMSE=8800.734541388361
--------------------------------------------------


----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}
Train history feature shape: (235, 1, 14), Train label shape: 235
Val history feature shape: (22, 1, 14), Val label shape: 22
Test history feature shape: (34, 1, 14), Test label shape: 34
Adding last hidden LSTM layer 0:
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_2 (GRU)                  (None, 1, 224)            161280
_________________________________________________________________
```

```
dropout_6 (Dropout)          (None, 1, 224)            0
_________________________________________________________________
lstm_3 (LSTM)                (None, 224)               402304
_________________________________________________________________
dropout_7 (Dropout)          (None, 224)               0
_________________________________________________________________
dense_5 (Dense)              (None, 56)                12600
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 57
=================================================================
Total params: 576,241
Trainable params: 576,241
Non-trainable params: 0
_________________________________________________________________
Epoch 1/40
8/8 [==============================] - 0s 62ms/step - loss: 0.0357 -
mean_squared_error: 0.0357 - val_loss: 0.4340 - val_mean_squared_error: 0.4340
Epoch 2/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0139 -
mean_squared_error: 0.0139 - val_loss: 0.1422 - val_mean_squared_error: 0.1422
Epoch 3/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0090 -
mean_squared_error: 0.0090 - val_loss: 0.2667 - val_mean_squared_error: 0.2667
Epoch 4/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0053 -
mean_squared_error: 0.0053 - val_loss: 0.3237 - val_mean_squared_error: 0.3237
Epoch 5/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.2792 - val_mean_squared_error: 0.2792
Epoch 6/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.2880 - val_mean_squared_error: 0.2880
Epoch 7/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0037 -
mean_squared_error: 0.0037 - val_loss: 0.3110 - val_mean_squared_error: 0.3110
Epoch 8/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.1915 - val_mean_squared_error: 0.1915
Epoch 9/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.2946 - val_mean_squared_error: 0.2946
Epoch 10/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.1542 - val_mean_squared_error: 0.1542
Epoch 11/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.3176 - val_mean_squared_error: 0.3176
Epoch 12/40
```

```
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1585 - val_mean_squared_error: 0.1585
Epoch 13/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.2247 - val_mean_squared_error: 0.2247
Epoch 14/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1561 - val_mean_squared_error: 0.1561
Epoch 15/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1959 - val_mean_squared_error: 0.1959
Epoch 16/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1602 - val_mean_squared_error: 0.1602
Epoch 17/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.1682 - val_mean_squared_error: 0.1682
Epoch 18/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1696 - val_mean_squared_error: 0.1696
Epoch 19/40
8/8 [==============================] - 0s 6ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1317 - val_mean_squared_error: 0.1317
Epoch 20/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.2119 - val_mean_squared_error: 0.2119
Epoch 21/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1401 - val_mean_squared_error: 0.1401
Epoch 22/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1426 - val_mean_squared_error: 0.1426
Epoch 23/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.1328 - val_mean_squared_error: 0.1328
Epoch 24/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.1564 - val_mean_squared_error: 0.1564
Epoch 25/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.1361 - val_mean_squared_error: 0.1361
Epoch 26/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.1249 - val_mean_squared_error: 0.1249
Epoch 27/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1216 - val_mean_squared_error: 0.1216
Epoch 28/40
```

```
8/8 [==============================] - 0s 5ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.1304 - val_mean_squared_error: 0.1304
Epoch 29/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1368 - val_mean_squared_error: 0.1368
Epoch 30/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.1254 - val_mean_squared_error: 0.1254
Epoch 31/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1316 - val_mean_squared_error: 0.1316
Epoch 32/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1251 - val_mean_squared_error: 0.1251
Epoch 33/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.1364 - val_mean_squared_error: 0.1364
Epoch 34/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1349 - val_mean_squared_error: 0.1349
Epoch 35/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1508 - val_mean_squared_error: 0.1508
Epoch 36/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.1360 - val_mean_squared_error: 0.1360
Epoch 37/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.1282 - val_mean_squared_error: 0.1282
Epoch 38/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.1346 - val_mean_squared_error: 0.1346
Epoch 39/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.1282 - val_mean_squared_error: 0.1282
Epoch 40/40
8/8 [==============================] - 0s 5ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.1295 - val_mean_squared_error: 0.1295

--------------------------------------------------
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}, RMSE=7206.426670614559
--------------------------------------------------


----------------------Printing new LSTM model in para
grid-------------------------
```

```
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}
Train history feature shape: (235, 1, 14), Train label shape: 235
Val history feature shape: (22, 1, 14), Val label shape: 22
Test history feature shape: (34, 1, 14), Test label shape: 34
Adding hidden LSTM layer 0:
Adding last hidden LSTM layer 1:
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_3 (GRU)                  (None, 1, 1792)           9719808
_________________________________________________________________
dropout_8 (Dropout)          (None, 1, 1792)           0
_________________________________________________________________
lstm_4 (LSTM)                (None, 1, 1792)           25697280
_________________________________________________________________
dropout_9 (Dropout)          (None, 1, 1792)           0
_________________________________________________________________
dense_7 (Dense)              (None, 1, 112)            200816
_________________________________________________________________
dropout_10 (Dropout)         (None, 1, 112)            0
_________________________________________________________________
lstm_5 (LSTM)                (None, 896)               3616256
_________________________________________________________________
dropout_11 (Dropout)         (None, 896)               0
_________________________________________________________________
dense_8 (Dense)              (None, 56)                50232
_________________________________________________________________
dense_9 (Dense)              (None, 1)                 57
=================================================================
Total params: 39,284,449
Trainable params: 39,284,449
Non-trainable params: 0
_________________________________________________________________
Epoch 1/40
8/8 [==============================] - 2s 209ms/step - loss: 0.0418 -
mean_squared_error: 0.0418 - val_loss: 0.5911 - val_mean_squared_error: 0.5911
Epoch 2/40
8/8 [==============================] - 1s 122ms/step - loss: 0.0097 -
mean_squared_error: 0.0097 - val_loss: 0.1480 - val_mean_squared_error: 0.1480
Epoch 3/40
8/8 [==============================] - 1s 120ms/step - loss: 0.0046 -
mean_squared_error: 0.0046 - val_loss: 0.5827 - val_mean_squared_error: 0.5827
Epoch 4/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0047 -
mean_squared_error: 0.0047 - val_loss: 0.7506 - val_mean_squared_error: 0.7506
```

```
Epoch 5/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0058 -
mean_squared_error: 0.0058 - val_loss: 0.1723 - val_mean_squared_error: 0.1723
Epoch 6/40
8/8 [==============================] - 1s 114ms/step - loss: 0.0046 -
mean_squared_error: 0.0046 - val_loss: 0.4512 - val_mean_squared_error: 0.4512
Epoch 7/40
8/8 [==============================] - 1s 118ms/step - loss: 0.0074 -
mean_squared_error: 0.0074 - val_loss: 0.3440 - val_mean_squared_error: 0.3440
Epoch 8/40
8/8 [==============================] - 1s 118ms/step - loss: 0.0045 -
mean_squared_error: 0.0045 - val_loss: 0.1736 - val_mean_squared_error: 0.1736
Epoch 9/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.1404 - val_mean_squared_error: 0.1404
Epoch 10/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.2206 - val_mean_squared_error: 0.2206
Epoch 11/40
8/8 [==============================] - 1s 114ms/step - loss: 0.0048 -
mean_squared_error: 0.0048 - val_loss: 0.2617 - val_mean_squared_error: 0.2617
Epoch 12/40
8/8 [==============================] - 1s 116ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.2051 - val_mean_squared_error: 0.2051
Epoch 13/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1277 - val_mean_squared_error: 0.1277
Epoch 14/40
8/8 [==============================] - 1s 113ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.2279 - val_mean_squared_error: 0.2279
Epoch 15/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1857 - val_mean_squared_error: 0.1857
Epoch 16/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0036 -
mean_squared_error: 0.0036 - val_loss: 0.1200 - val_mean_squared_error: 0.1200
Epoch 17/40
8/8 [==============================] - 1s 116ms/step - loss: 0.0035 -
mean_squared_error: 0.0035 - val_loss: 0.2335 - val_mean_squared_error: 0.2335
Epoch 18/40
8/8 [==============================] - 1s 116ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.2001 - val_mean_squared_error: 0.2001
Epoch 19/40
8/8 [==============================] - 1s 115ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.2220 - val_mean_squared_error: 0.2220
Epoch 20/40
8/8 [==============================] - 1s 120ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.1788 - val_mean_squared_error: 0.1788
```

```
Epoch 21/40
8/8 [==============================] - 1s 118ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.2217 - val_mean_squared_error: 0.2217
Epoch 22/40
8/8 [==============================] - 1s 119ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.2176 - val_mean_squared_error: 0.2176
Epoch 23/40
8/8 [==============================] - 1s 122ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.4631 - val_mean_squared_error: 0.4631
Epoch 24/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0031 -
mean_squared_error: 0.0031 - val_loss: 0.2961 - val_mean_squared_error: 0.2961
Epoch 25/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.2442 - val_mean_squared_error: 0.2442
Epoch 26/40
8/8 [==============================] - 1s 120ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.2411 - val_mean_squared_error: 0.2411
Epoch 27/40
8/8 [==============================] - 1s 119ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.3554 - val_mean_squared_error: 0.3554
Epoch 28/40
8/8 [==============================] - 1s 116ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.2413 - val_mean_squared_error: 0.2413
Epoch 29/40
8/8 [==============================] - 1s 118ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.1877 - val_mean_squared_error: 0.1877
Epoch 30/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.2737 - val_mean_squared_error: 0.2737
Epoch 31/40
8/8 [==============================] - 1s 116ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.3677 - val_mean_squared_error: 0.3677
Epoch 32/40
8/8 [==============================] - 1s 117ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.2709 - val_mean_squared_error: 0.2709
Epoch 33/40
8/8 [==============================] - 1s 118ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.2102 - val_mean_squared_error: 0.2102
Epoch 34/40
8/8 [==============================] - 1s 119ms/step - loss: 0.0033 -
mean_squared_error: 0.0033 - val_loss: 0.3610 - val_mean_squared_error: 0.3610
Epoch 35/40
8/8 [==============================] - 1s 120ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.4197 - val_mean_squared_error: 0.4197
Epoch 36/40
8/8 [==============================] - 1s 119ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.3085 - val_mean_squared_error: 0.3085
```

```
Epoch 37/40
8/8 [==============================] - 1s 121ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.3758 - val_mean_squared_error: 0.3758
Epoch 38/40
8/8 [==============================] - 1s 118ms/step - loss: 0.0057 -
mean_squared_error: 0.0057 - val_loss: 0.3422 - val_mean_squared_error: 0.3422
Epoch 39/40
8/8 [==============================] - 1s 116ms/step - loss: 0.0044 -
mean_squared_error: 0.0044 - val_loss: 0.4735 - val_mean_squared_error: 0.4735
Epoch 40/40
8/8 [==============================] - 1s 116ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.4227 - val_mean_squared_error: 0.4227

------------------------------------------------
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}, RMSE=10810.59553211179
------------------------------------------------


----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}
Train history feature shape: (228, 1, 21), Train label shape: 228
Val history feature shape: (8, 1, 21), Val label shape: 8
Test history feature shape: (34, 1, 21), Test label shape: 34
Adding last hidden LSTM layer 0:
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_4 (GRU)                  (None, 1, 336)            361872
_________________________________________________________________
dropout_12 (Dropout)         (None, 1, 336)            0
_________________________________________________________________
lstm_6 (LSTM)                (None, 336)               904512
_________________________________________________________________
dropout_13 (Dropout)         (None, 336)               0
_________________________________________________________________
dense_10 (Dense)             (None, 84)                28308
_________________________________________________________________
dense_11 (Dense)             (None, 1)                 85
=================================================================
Total params: 1,294,777
Trainable params: 1,294,777
Non-trainable params: 0
```

```
----------------------------------------------------------------
Epoch 1/40
8/8 [==============================] - 1s 63ms/step - loss: 0.0284 -
mean_squared_error: 0.0284 - val_loss: 0.1887 - val_mean_squared_error: 0.1887
Epoch 2/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0088 -
mean_squared_error: 0.0088 - val_loss: 0.3957 - val_mean_squared_error: 0.3957
Epoch 3/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0067 -
mean_squared_error: 0.0067 - val_loss: 0.4181 - val_mean_squared_error: 0.4181
Epoch 4/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0036 -
mean_squared_error: 0.0036 - val_loss: 0.2114 - val_mean_squared_error: 0.2114
Epoch 5/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.1981 - val_mean_squared_error: 0.1981
Epoch 6/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.1805 - val_mean_squared_error: 0.1805
Epoch 7/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.1683 - val_mean_squared_error: 0.1683
Epoch 8/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1685 - val_mean_squared_error: 0.1685
Epoch 9/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.1609 - val_mean_squared_error: 0.1609
Epoch 10/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.1628 - val_mean_squared_error: 0.1628
Epoch 11/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1597 - val_mean_squared_error: 0.1597
Epoch 12/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1531 - val_mean_squared_error: 0.1531
Epoch 13/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1630 - val_mean_squared_error: 0.1630
Epoch 14/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.1737 - val_mean_squared_error: 0.1737
Epoch 15/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.2239 - val_mean_squared_error: 0.2239
Epoch 16/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0025 -
```

```
mean_squared_error: 0.0025 - val_loss: 0.1834 - val_mean_squared_error: 0.1834
Epoch 17/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.1604 - val_mean_squared_error: 0.1604
Epoch 18/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.2033 - val_mean_squared_error: 0.2033
Epoch 19/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0031 -
mean_squared_error: 0.0031 - val_loss: 0.1697 - val_mean_squared_error: 0.1697
Epoch 20/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.2400 - val_mean_squared_error: 0.2400
Epoch 21/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.1913 - val_mean_squared_error: 0.1913
Epoch 22/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.1840 - val_mean_squared_error: 0.1840
Epoch 23/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.1517 - val_mean_squared_error: 0.1517
Epoch 24/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1557 - val_mean_squared_error: 0.1557
Epoch 25/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1990 - val_mean_squared_error: 0.1990
Epoch 26/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1628 - val_mean_squared_error: 0.1628
Epoch 27/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1626 - val_mean_squared_error: 0.1626
Epoch 28/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.1635 - val_mean_squared_error: 0.1635
Epoch 29/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1466 - val_mean_squared_error: 0.1466
Epoch 30/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1426 - val_mean_squared_error: 0.1426
Epoch 31/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.2369 - val_mean_squared_error: 0.2369
Epoch 32/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0026 -
```

```
mean_squared_error: 0.0026 - val_loss: 0.1622 - val_mean_squared_error: 0.1622
Epoch 33/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.1371 - val_mean_squared_error: 0.1371
Epoch 34/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1392 - val_mean_squared_error: 0.1392
Epoch 35/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.1400 - val_mean_squared_error: 0.1400
Epoch 36/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.1495 - val_mean_squared_error: 0.1495
Epoch 37/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.1314 - val_mean_squared_error: 0.1314
Epoch 38/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.1281 - val_mean_squared_error: 0.1281
Epoch 39/40
8/8 [==============================] - 0s 7ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.1430 - val_mean_squared_error: 0.1430
Epoch 40/40
8/8 [==============================] - 0s 8ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.1806 - val_mean_squared_error: 0.1806

--------------------------------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}, RMSE=8093.7000266583045
--------------------------------------------------


----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}
Train history feature shape: (228, 1, 21), Train label shape: 228
Val history feature shape: (8, 1, 21), Val label shape: 8
Test history feature shape: (34, 1, 21), Test label shape: 34
Adding hidden LSTM layer 0:
Adding last hidden LSTM layer 1:
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_5 (GRU)                  (None, 1, 2688)           21861504
```

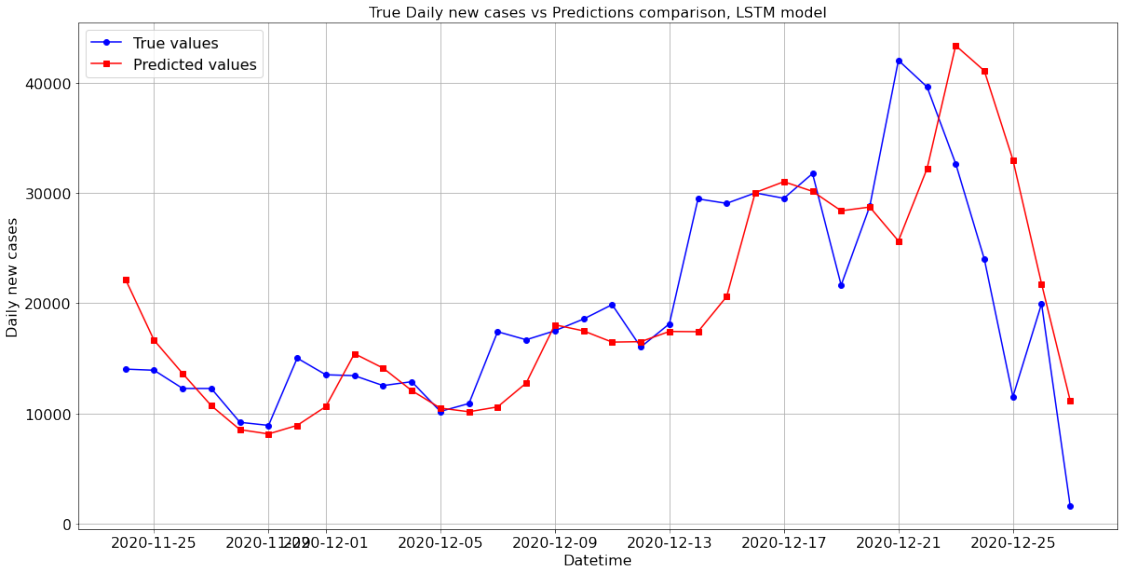
```
_________________________________________________________________
dropout_14 (Dropout)         (None, 1, 2688)           0
_________________________________________________________________
lstm_7 (LSTM)                (None, 1, 2688)           57813504
_________________________________________________________________
dropout_15 (Dropout)         (None, 1, 2688)           0
_________________________________________________________________
dense_12 (Dense)             (None, 1, 168)            451752
_________________________________________________________________
dropout_16 (Dropout)         (None, 1, 168)            0
_________________________________________________________________
lstm_8 (LSTM)                (None, 1344)              8133888
_________________________________________________________________
dropout_17 (Dropout)         (None, 1344)              0
_________________________________________________________________
dense_13 (Dense)             (None, 84)                112980
_________________________________________________________________
dense_14 (Dense)             (None, 1)                 85
=================================================================
Total params: 88,373,713
Trainable params: 88,373,713
Non-trainable params: 0
_________________________________________________________________
Epoch 1/40
8/8 [==============================] - 3s 334ms/step - loss: 0.0424 -
mean_squared_error: 0.0424 - val_loss: 1.5175 - val_mean_squared_error: 1.5175
Epoch 2/40
8/8 [==============================] - 2s 246ms/step - loss: 0.0170 -
mean_squared_error: 0.0170 - val_loss: 0.2241 - val_mean_squared_error: 0.2241
Epoch 3/40
8/8 [==============================] - 2s 247ms/step - loss: 0.0069 -
mean_squared_error: 0.0069 - val_loss: 0.2030 - val_mean_squared_error: 0.2030
Epoch 4/40
8/8 [==============================] - 2s 255ms/step - loss: 0.0038 -
mean_squared_error: 0.0038 - val_loss: 0.2963 - val_mean_squared_error: 0.2963
Epoch 5/40
8/8 [==============================] - 2s 242ms/step - loss: 0.0045 -
mean_squared_error: 0.0045 - val_loss: 0.1846 - val_mean_squared_error: 0.1846
Epoch 6/40
8/8 [==============================] - 2s 254ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.1726 - val_mean_squared_error: 0.1726
Epoch 7/40
8/8 [==============================] - 2s 252ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.1968 - val_mean_squared_error: 0.1968
Epoch 8/40
8/8 [==============================] - 2s 253ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.2596 - val_mean_squared_error: 0.2596
Epoch 9/40
```

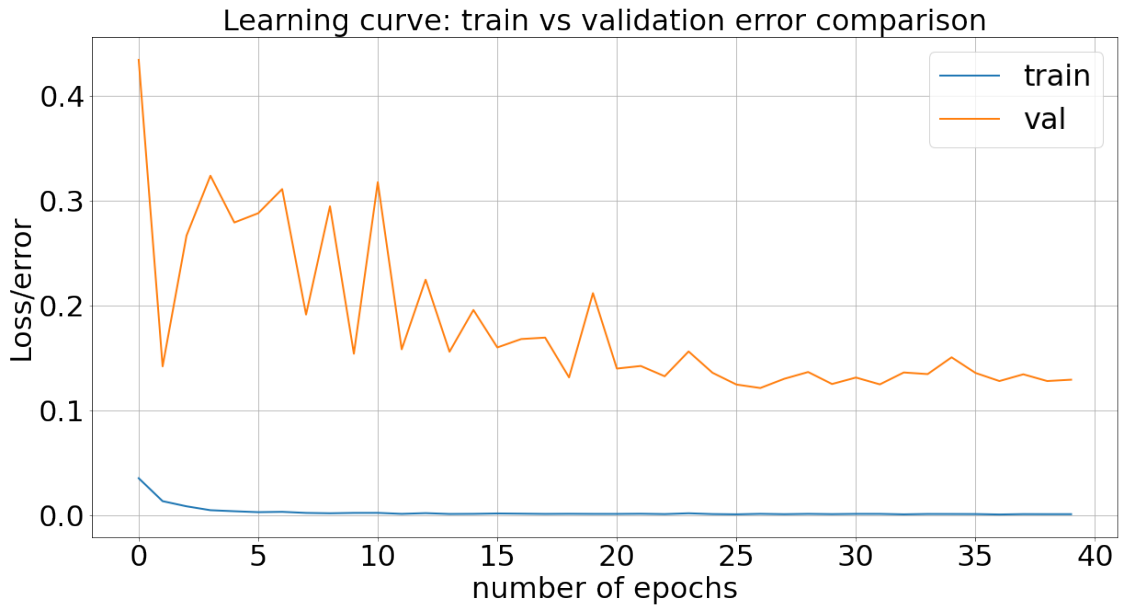
```
8/8 [==============================] - 2s 248ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.1853 - val_mean_squared_error: 0.1853
Epoch 10/40
8/8 [==============================] - 2s 249ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.4157 - val_mean_squared_error: 0.4157
Epoch 11/40
8/8 [==============================] - 2s 242ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.1351 - val_mean_squared_error: 0.1351
Epoch 12/40
8/8 [==============================] - 2s 251ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.1398 - val_mean_squared_error: 0.1398
Epoch 13/40
8/8 [==============================] - 2s 256ms/step - loss: 0.0031 -
mean_squared_error: 0.0031 - val_loss: 0.2262 - val_mean_squared_error: 0.2262
Epoch 14/40
8/8 [==============================] - 2s 247ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.2103 - val_mean_squared_error: 0.2103
Epoch 15/40
8/8 [==============================] - 2s 260ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.1381 - val_mean_squared_error: 0.1381
Epoch 16/40
8/8 [==============================] - 2s 248ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.2008 - val_mean_squared_error: 0.2008
Epoch 17/40
8/8 [==============================] - 2s 252ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.2801 - val_mean_squared_error: 0.2801
Epoch 18/40
8/8 [==============================] - 2s 253ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.4760 - val_mean_squared_error: 0.4760
Epoch 19/40
8/8 [==============================] - 2s 248ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.5962 - val_mean_squared_error: 0.5962
Epoch 20/40
8/8 [==============================] - 2s 254ms/step - loss: 0.0039 -
mean_squared_error: 0.0039 - val_loss: 0.2140 - val_mean_squared_error: 0.2140
Epoch 21/40
8/8 [==============================] - 2s 252ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.1647 - val_mean_squared_error: 0.1647
Epoch 22/40
8/8 [==============================] - 2s 252ms/step - loss: 0.0031 -
mean_squared_error: 0.0031 - val_loss: 0.1429 - val_mean_squared_error: 0.1429
Epoch 23/40
8/8 [==============================] - 2s 256ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.1529 - val_mean_squared_error: 0.1529
Epoch 24/40
8/8 [==============================] - 2s 253ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.2050 - val_mean_squared_error: 0.2050
Epoch 25/40
```

```
8/8 [==============================] - 2s 250ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.1204 - val_mean_squared_error: 0.1204
Epoch 26/40
8/8 [==============================] - 2s 252ms/step - loss: 0.0035 -
mean_squared_error: 0.0035 - val_loss: 0.1961 - val_mean_squared_error: 0.1961
Epoch 27/40
8/8 [==============================] - 2s 255ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.3050 - val_mean_squared_error: 0.3050
Epoch 28/40
8/8 [==============================] - 2s 250ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.2625 - val_mean_squared_error: 0.2625
Epoch 29/40
8/8 [==============================] - 2s 248ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.3606 - val_mean_squared_error: 0.3606
Epoch 30/40
8/8 [==============================] - 2s 250ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.2898 - val_mean_squared_error: 0.2898
Epoch 31/40
8/8 [==============================] - 2s 251ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.1409 - val_mean_squared_error: 0.1409
Epoch 32/40
8/8 [==============================] - 2s 253ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.2482 - val_mean_squared_error: 0.2482
Epoch 33/40
8/8 [==============================] - 2s 250ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.3122 - val_mean_squared_error: 0.3122
Epoch 34/40
8/8 [==============================] - 2s 257ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.2404 - val_mean_squared_error: 0.2404
Epoch 35/40
8/8 [==============================] - 2s 249ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.3747 - val_mean_squared_error: 0.3747
Epoch 36/40
8/8 [==============================] - 2s 250ms/step - loss: 0.0045 -
mean_squared_error: 0.0045 - val_loss: 0.1865 - val_mean_squared_error: 0.1865
Epoch 37/40
8/8 [==============================] - 2s 248ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.1782 - val_mean_squared_error: 0.1782
Epoch 38/40
8/8 [==============================] - 2s 257ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.1111 - val_mean_squared_error: 0.1111
Epoch 39/40
8/8 [==============================] - 2s 246ms/step - loss: 0.0041 -
mean_squared_error: 0.0041 - val_loss: 0.2585 - val_mean_squared_error: 0.2585
Epoch 40/40
8/8 [==============================] - 2s 252ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.2139 - val_mean_squared_error: 0.2139
```

```
-------------------------------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}, RMSE=8521.085295350176
-------------------------------------------------


------------------------***--------------------------
Best LSTM model:{'time_lag': 14, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 40, 'num_batch':
32}, RMSE=7206.426670614559
```





******
LSTM test rmse: 7206.426670614559 with optimal parameter set: {'time_lag': 14,
'num_LSTM_layer': 1, 'learning_rate': 0.001, 'beta_1': 0.9, 'beta_2': 0.999,
'epsilon': 1e-07, 'num_epochs': 40, 'num_batch': 32}

----------1.3.2 ARIMA prediction on daily new cases----------

---
ARIMA model: (0, 0, 0), RMSE=15096.944649832025

ARIMA model: (0, 0, 1), RMSE=8438.01970596336

ARIMA model: (0, 1, 0), RMSE=4329.934935092469

ARIMA model: (0, 1, 1), RMSE=4317.139159339464

ARIMA model: (0, 1, 2), RMSE=4038.750060288262

ARIMA model: (1, 0, 0), RMSE=4318.439669541648

ARIMA model: (1, 1, 0), RMSE=4314.622835282712

```
ARIMA model: (1, 1, 1), RMSE=4054.921126593159
--------------------------------------------------

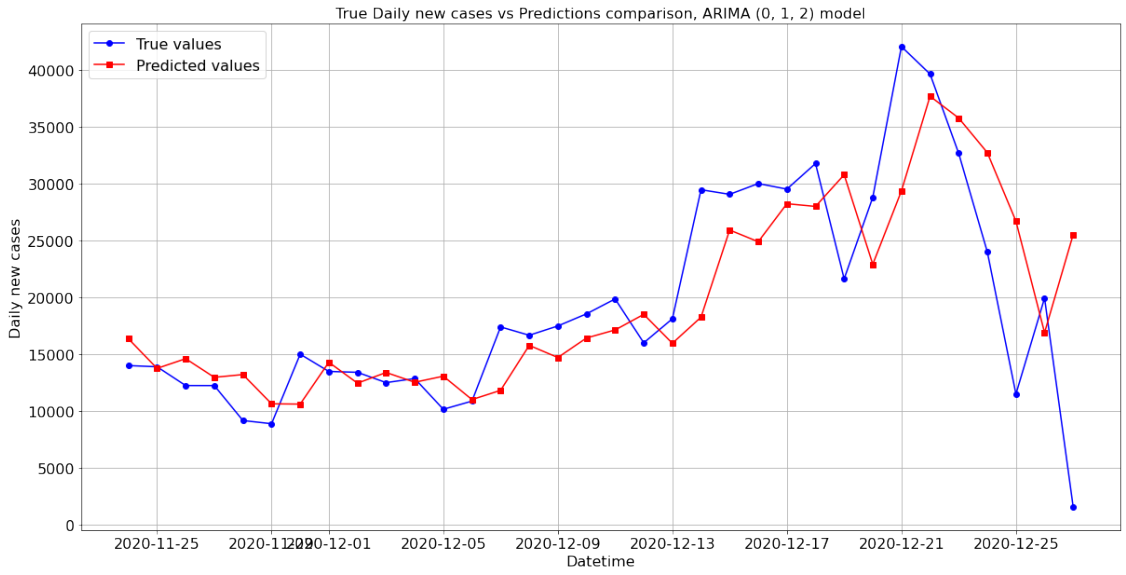

--------------------------------------------------
ARIMA model: (1, 1, 2), RMSE=4090.7672026725636
--------------------------------------------------


--------------------------------------------------
ARIMA model: (2, 0, 0), RMSE=4429.232508315501
--------------------------------------------------


--------------------------------------------------
ARIMA model: (2, 1, 0), RMSE=4242.395327150119
--------------------------------------------------


--------------------------------------------------
ARIMA model: (2, 1, 1), RMSE=4080.5382655812937
--------------------------------------------------


------------------------***-------------------------
Best ARIMA model:(0, 1, 2), RMSE=4038.750060288262
```




```
******
ARIMA test rmse: 6609.297565465731 with optimal parameter set: (0, 1, 2)
```

```
------------1.3.3 SARIMAX prediction on daily new cases------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 7), 'n'], RMSE=4045.8733698722704
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 7), 'c'], RMSE=4036.983065510987
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 7), 't'], RMSE=4060.0651804816175
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 7), 'ct'], RMSE=4064.3023726200327
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 14), 'n'], RMSE=4045.8733698722704
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 14), 'c'], RMSE=4036.983065510987
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 14), 't'], RMSE=4060.0651804816175
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 0, 14), 'ct'], RMSE=4064.3023726200327
-------------------------------------------------


-------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 7), 'n'], RMSE=2906.0301870301405
-------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 7), 'c'], RMSE=2918.0946845975927
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 7), 't'], RMSE=2942.9285439143973
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 7), 'ct'], RMSE=2963.352385284484
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 14), 'n'], RMSE=2830.7689055058986
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 14), 'c'], RMSE=2841.7531637062366
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 14), 't'], RMSE=2854.882551151053
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 1, 14), 'ct'], RMSE=2870.9824713583016
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 2, 7), 'n'], RMSE=2441.825272013032
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 2, 7), 'c'], RMSE=2453.5142644614143
------------------------------------------------


------------------------------------------------
```

```
SARIMAX model: [(0, 1, 2), (0, 0, 2, 7), 't'], RMSE=2463.5111044954806
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 2, 7), 'ct'], RMSE=2472.0929438219246
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 2, 14), 'n'], RMSE=2442.1586580104467
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 2, 14), 'c'], RMSE=2460.3545180203946
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 2, 14), 't'], RMSE=2461.6007501540103
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 0, 2, 14), 'ct'], RMSE=2471.5477538912246
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 1, 0, 7), 'n'], RMSE=1830.5192436624804
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 1, 0, 7), 'c'], RMSE=1833.4208052844556
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 1, 0, 7), 't'], RMSE=1837.2315591074403
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (0, 1, 0, 7), 'ct'], RMSE=1838.863022100786
--------------------------------------------------
```

```
--------------------------------------------------
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------------------------------------------------
```

```
SARIMAX model: [(0, 1, 2), (2, 2, 2, 7), 't'], RMSE=2067.053034020203
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (2, 2, 2, 7), 'ct'], RMSE=2070.178441614686
--------------------------------------------------

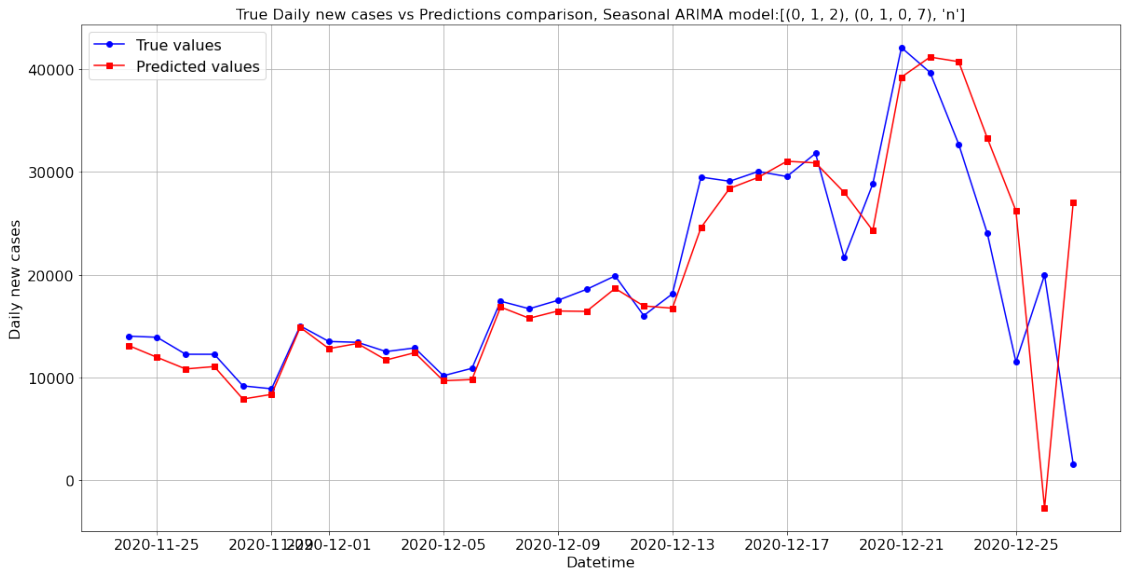

--------------------------------------------------
SARIMAX model: [(0, 1, 2), (2, 2, 2, 14), 'n'], RMSE=2447.1067250250962
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (2, 2, 2, 14), 'c'], RMSE=2462.39695355531
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (2, 2, 2, 14), 't'], RMSE=2434.8186865827656
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 2), (2, 2, 2, 14), 'ct'], RMSE=2453.4533159615653
--------------------------------------------------


-------------------------***---------------------------
Best SARIMAX model:[(0, 1, 2), (0, 1, 0, 7), 'n'], RMSE=1830.5192436624804
```



```
******
SARIMAX test rmse: 6961.286714204105 with optimal parameter set: [(0, 1, 2), (0,
1, 0, 7), 'n']


----------1.3.4 SES prediction on daily new cases----------------

4278.495537542442

--------------------------------------------------
SES model: {'initialization_method': None}, RMSE=4278.495537542442
--------------------------------------------------

4278.6226423514045

--------------------------------------------------
SES model: {'initialization_method': 'estimated'}, RMSE=4278.6226423514045
--------------------------------------------------

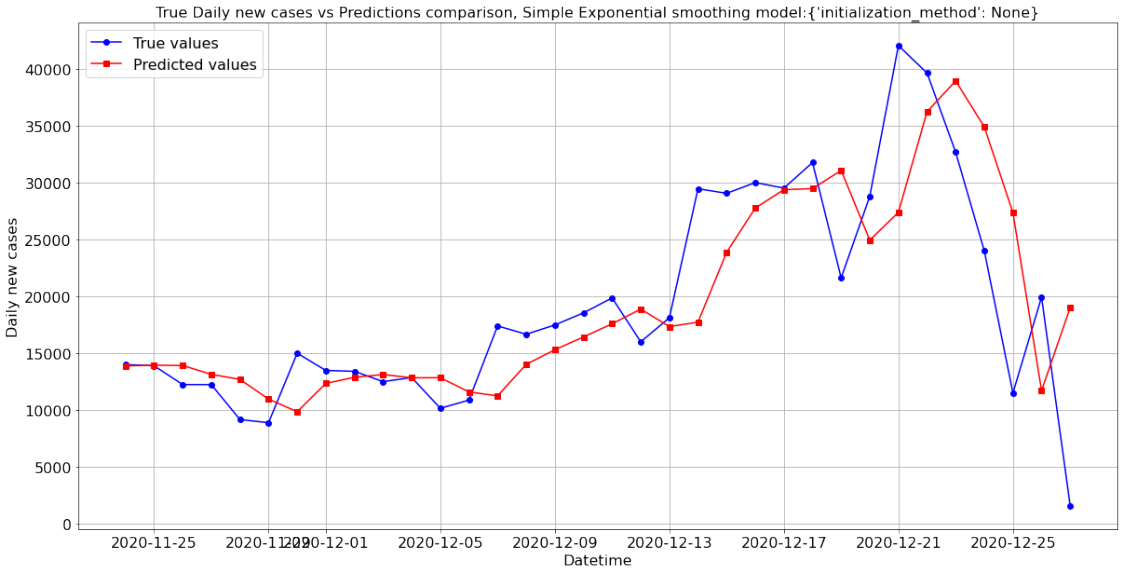
4278.6226423514045

--------------------------------------------------
SES model: {'initialization_method': 'heuristic'}, RMSE=4278.6226423514045
--------------------------------------------------

4278.495537542442

--------------------------------------------------
SES model: {'initialization_method': 'legacy-heuristic'}, RMSE=4278.495537542442
--------------------------------------------------


------------------------***--------------------------
Best SES model:{'initialization_method': None}, RMSE=4278.495537542442
```



******
SES test rmse: 6444.35055972175 with optimal parameter set:
{'initialization_method': None}

----------1.3.5 HWES predictions on daily new cases----------

1990.0737638516475

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'additive'}, RMSE=1990.0737638516475

1844.8865329777698

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'multiplicative'}, RMSE=1844.8865329777698

2037.0716577131648

HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'additive'}, RMSE=2037.0716577131648

1884.753007941981

```
--------------------------------------------------
HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'multiplicative'}, RMSE=1884.753007941981
--------------------------------------------------

2699.4498090197326

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'additive'}, RMSE=2699.4498090197326
--------------------------------------------------

2602.3659701753095

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'multiplicative'}, RMSE=2602.3659701753095
--------------------------------------------------

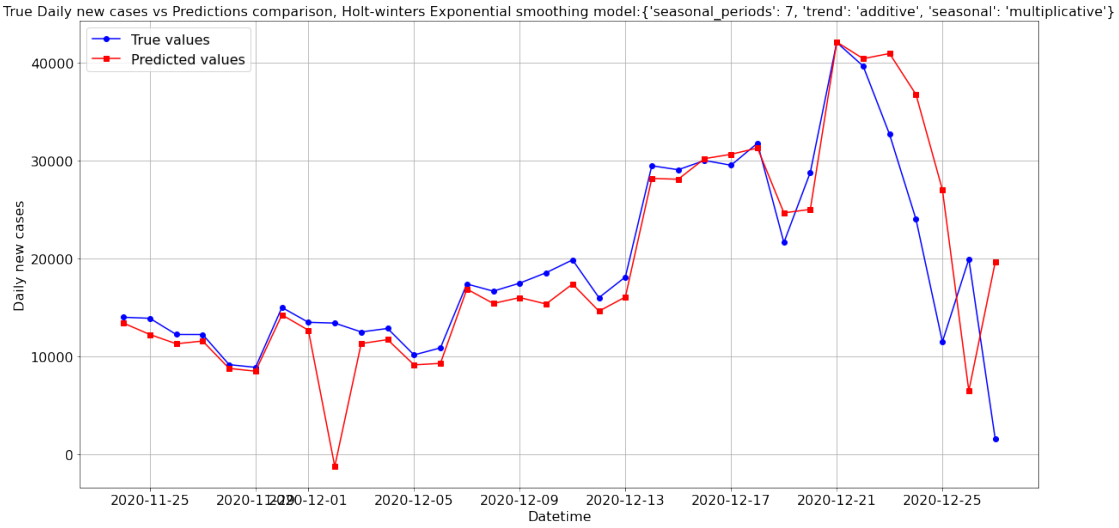
2747.5269992026524

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'additive'}, RMSE=2747.5269992026524
--------------------------------------------------

3279.5565020530967

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'multiplicative'}, RMSE=3279.5565020530967
--------------------------------------------------


------------------------***--------------------------
Best HWES model:{'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'multiplicative'}, RMSE=1844.8865329777698
```



******
HWES test rmse: 6085.357692082483 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'multiplicative'}

----------1.3.6 HWES with damping predictions on daily new cases----------

1982.4571789670413

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'additive',
'damped_trend': 'True'}, RMSE=1982.4571789670413

43547142.1509519

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=43547142.1509519

2015.048167016344

HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=2015.048167016344

2113.631774404283

```
HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=2113.631774404283
--------------------------------------------------

2682.240620567824

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=2682.240620567824
--------------------------------------------------

2716.2823520361767

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=2716.2823520361767
--------------------------------------------------

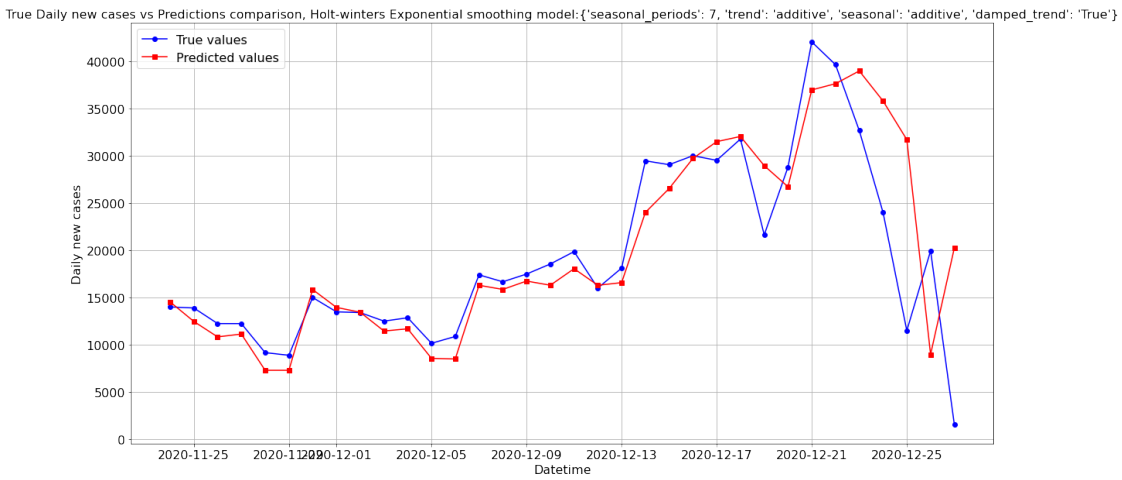
2683.9057294959275

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=2683.9057294959275
--------------------------------------------------

3133.5809452188246

--------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=3133.5809452188246
--------------------------------------------------


------------------------***--------------------------
Best HWES model:{'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=1982.4571789670413
```



******
HWES_damped test rmse: 5993.211743562428 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'additive',
'damped_trend': 'True'}

****
----------Summary of Section 1: Daily New cases test results:----------
LSTM test rmse: 7206.426670614559 with optimal parameter set: {'time_lag': 14,
'num_LSTM_layer': 1, 'learning_rate': 0.001, 'beta_1': 0.9, 'beta_2': 0.999,
'epsilon': 1e-07, 'num_epochs': 40, 'num_batch': 32}

ARIMA test rmse: 6609.297565465731 with optimal parameter set: (0, 1, 2)

SARIMAX test rmse: 6961.286714204105 with optimal parameter set: [(0, 1, 2), (0,
1, 0, 7), 'n']

SES test rmse: 6444.35055972175 with optimal parameter set:
{'initialization_method': None}

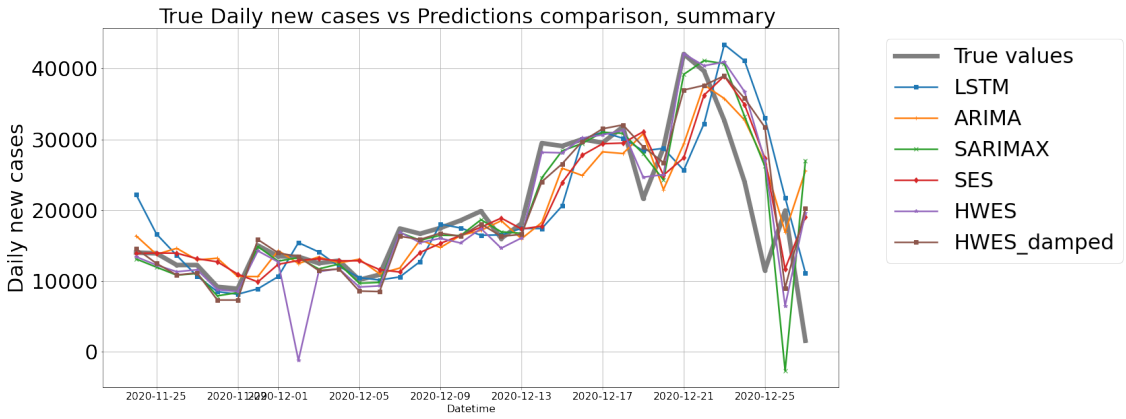
HWES test rmse: 6085.357692082483 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'multiplicative'}

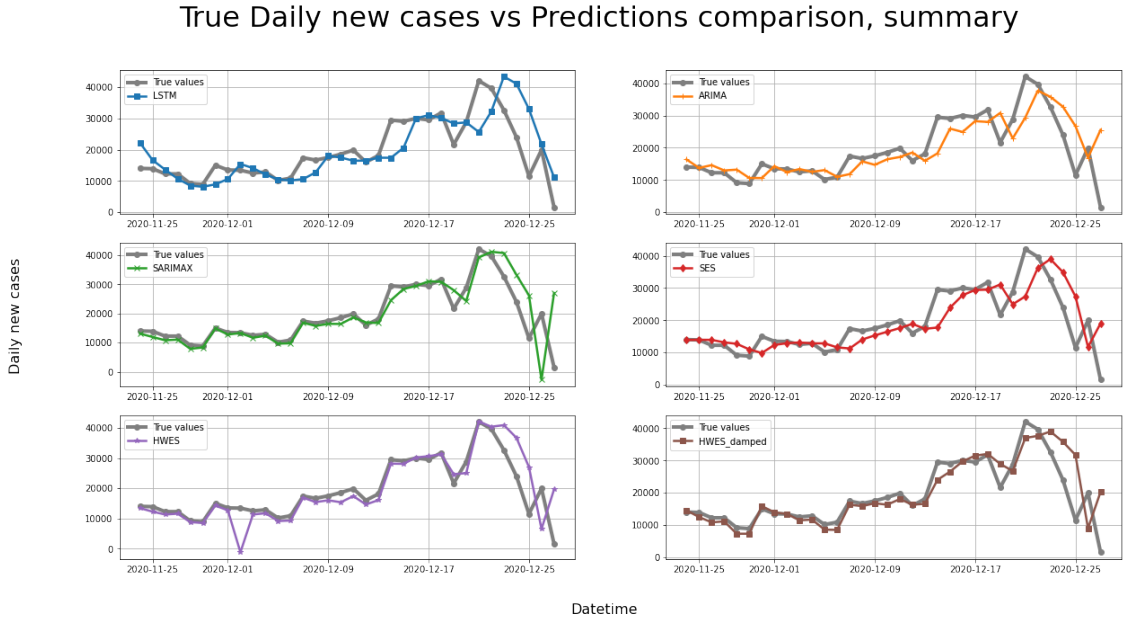
HWES_damped test rmse: 5993.211743562428 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'additive',
'damped_trend': 'True'}

----print accuracy matrices:------

LSTM ARIMA SARIMAX SES HWES

```
HWES_damped
MAE   4757.276498  4375.583231  3622.410510  4408.181834  3463.815515
3499.748582
RMSE  7206.426671  6609.297565  6961.286714  6444.350560  6085.357692
5993.211744
R2       0.391071     0.487803     0.431794     0.513049     0.565791
0.578841
```

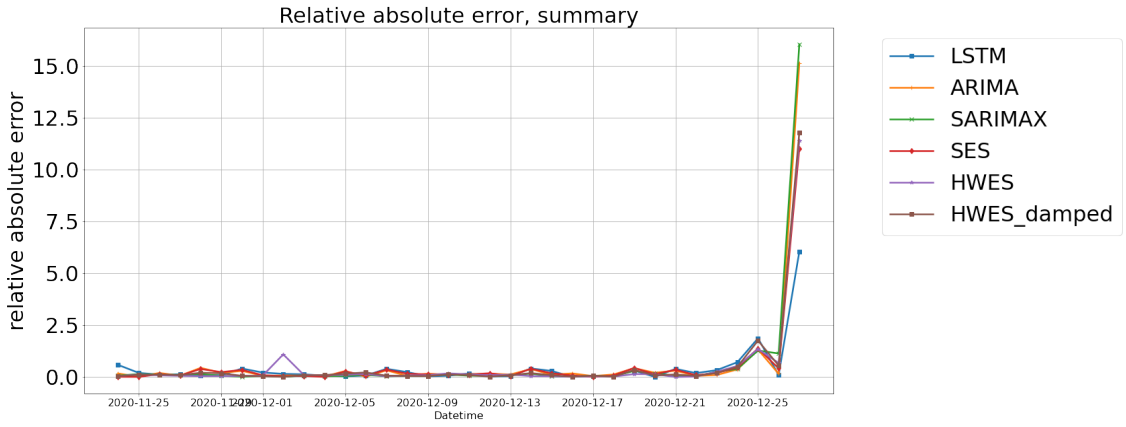





```
----print relative absolute error table----

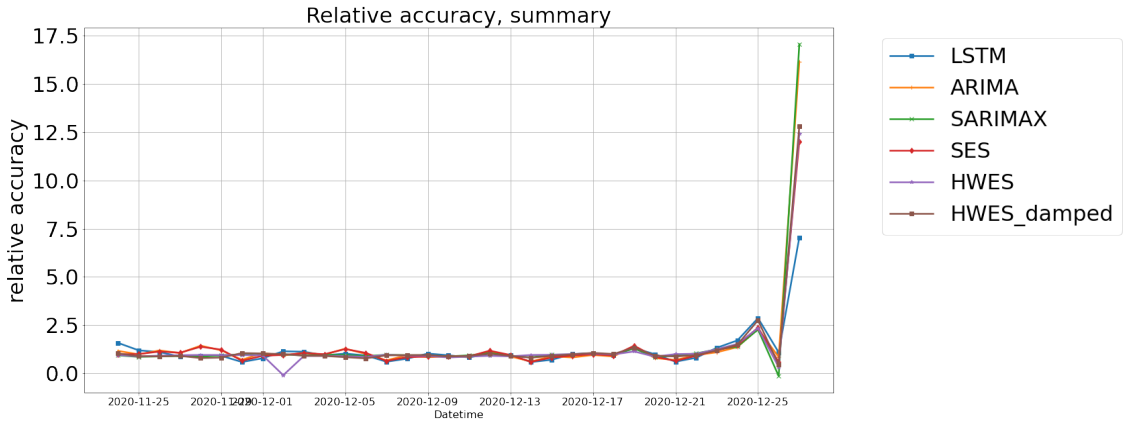
    Test Date      LSTM      ARIMA    SARIMAX       SES      HWES  HWES_damped
0  2020-11-24  0.582461   0.168037   0.064391  0.008238  0.042351     0.038329
```

1	2020-11-25	0.196169	0.010133	0.140182	0.003299	0.118786	0.102495
2	2020-11-26	0.110450	0.192549	0.116464	0.136571	0.077106	0.114937
3	2020-11-27	0.127470	0.059151	0.097243	0.073265	0.054361	0.090261
4	2020-11-28	0.072792	0.439705	0.139111	0.384284	0.042088	0.203183
5	2020-11-29	0.087065	0.196324	0.060995	0.233038	0.044091	0.178320
6	2020-11-30	0.406839	0.292072	0.009658	0.342545	0.050274	0.056019
7	2020-12-01	0.213693	0.059821	0.051317	0.084464	0.059660	0.034655
8	2020-12-02	0.148534	0.070923	0.008902	0.038871	1.088968	0.002661
9	2020-12-03	0.127019	0.071043	0.065261	0.049742	0.094768	0.083436
10	2020-12-04	0.062709	0.025076	0.035958	0.001706	0.088410	0.090943
11	2020-12-05	0.029686	0.285719	0.047957	0.264072	0.099934	0.156568
12	2020-12-06	0.068806	0.012356	0.099972	0.065875	0.144836	0.218326
13	2020-12-07	0.392130	0.320073	0.032555	0.352743	0.029900	0.063379
14	2020-12-08	0.235404	0.053293	0.055293	0.158682	0.075262	0.048426
15	2020-12-09	0.031184	0.158417	0.059157	0.124522	0.084222	0.042279
16	2020-12-10	0.057904	0.114269	0.114957	0.114078	0.171763	0.121052
17	2020-12-11	0.171259	0.137041	0.061270	0.114295	0.123949	0.091005
18	2020-12-12	0.030646	0.155987	0.058291	0.179379	0.085983	0.018279
19	2020-12-13	0.038348	0.118707	0.076883	0.042805	0.112767	0.084919
20	2020-12-14	0.409126	0.380164	0.166514	0.397755	0.043880	0.185133
21	2020-12-15	0.291320	0.107917	0.023786	0.178311	0.033294	0.086778
22	2020-12-16	0.001185	0.170354	0.019017	0.074639	0.006179	0.009650
23	2020-12-17	0.051040	0.043423	0.050302	0.004671	0.037795	0.066869
24	2020-12-18	0.050945	0.118725	0.029003	0.072186	0.015592	0.008643
25	2020-12-19	0.312146	0.423003	0.293423	0.436347	0.139951	0.338382
26	2020-12-20	0.002561	0.204337	0.157282	0.133724	0.131218	0.071903
27	2020-12-21	0.389930	0.301788	0.068317	0.348463	0.001047	0.120826
28	2020-12-22	0.187272	0.049272	0.037525	0.085644	0.019127	0.050714
29	2020-12-23	0.328100	0.094948	0.245275	0.192115	0.252484	0.193081
30	2020-12-24	0.711927	0.363321	0.385019	0.453646	0.530101	0.490993
31	2020-12-25	1.867090	1.319867	1.275882	1.377570	1.347911	1.754811
32	2020-12-26	0.090745	0.152480	1.134330	0.412201	0.673731	0.549096
33	2020-12-27	6.049669	15.140489	16.056210	11.025272	11.414180	11.807373



----print relative accuracy table----

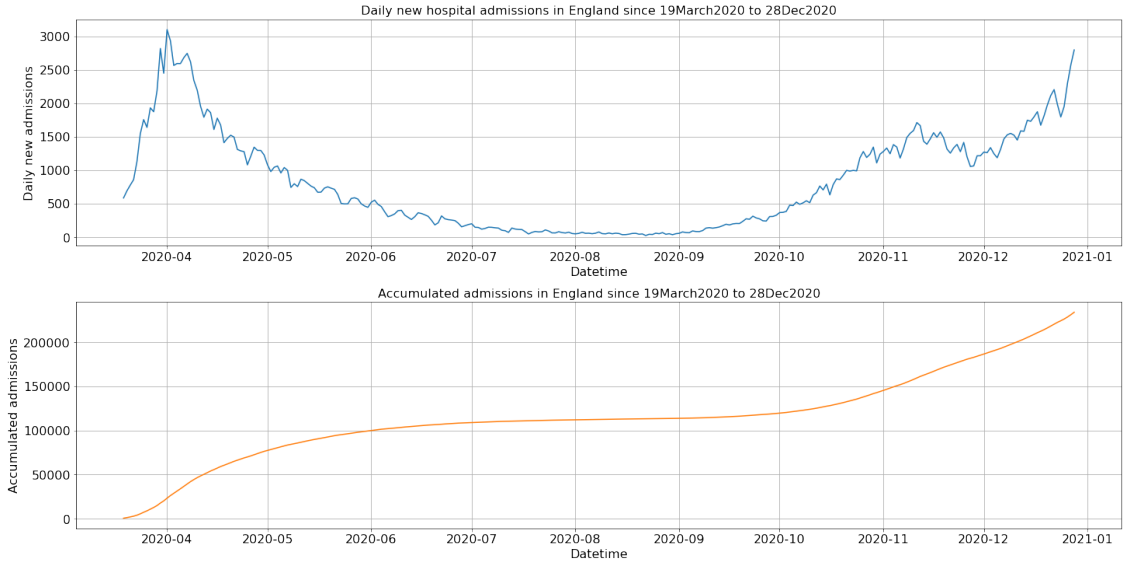
	Test Date	LSTM	ARIMA	SARIMAX	SES	HWES	HWES_damped
0	2020-11-24	1.582461	1.168037	0.935609	0.991762	0.957649	1.038329
1	2020-11-25	1.196169	0.989867	0.859818	1.003299	0.881214	0.897505
2	2020-11-26	1.110450	1.192549	0.883536	1.136571	0.922894	0.885063
3	2020-11-27	0.872530	1.059151	0.902757	1.073265	0.945639	0.909739
4	2020-11-28	0.927208	1.439705	0.860889	1.384284	0.957912	0.796817
5	2020-11-29	0.912935	1.196324	0.939005	1.233038	0.955909	0.821680
6	2020-11-30	0.593161	0.707928	0.990342	0.657455	0.949726	1.056019
7	2020-12-01	0.786307	1.059821	0.948683	0.915536	0.940340	1.034655
8	2020-12-02	1.148534	0.929077	0.991098	0.961129	-0.088968	1.002661
9	2020-12-03	1.127019	1.071043	0.934739	1.049742	0.905232	0.916564
10	2020-12-04	0.937291	0.974924	0.964042	0.998294	0.911590	0.909057
11	2020-12-05	1.029686	1.285719	0.952043	1.264072	0.900066	0.843432
12	2020-12-06	0.931194	1.012356	0.900028	1.065875	0.855164	0.781674
13	2020-12-07	0.607870	0.679927	0.967445	0.647257	0.970100	0.936621
14	2020-12-08	0.764596	0.946707	0.944707	0.841318	0.924738	0.951574
15	2020-12-09	1.031184	0.841583	0.940843	0.875478	0.915778	0.957721
16	2020-12-10	0.942096	0.885731	0.885043	0.885922	0.828237	0.878948
17	2020-12-11	0.828741	0.862959	0.938730	0.885705	0.876051	0.908995
18	2020-12-12	1.030646	1.155987	1.058291	1.179379	0.914017	1.018279
19	2020-12-13	0.961652	0.881293	0.923117	0.957195	0.887233	0.915081
20	2020-12-14	0.590874	0.619836	0.833486	0.602245	0.956120	0.814867
21	2020-12-15	0.708680	0.892083	0.976214	0.821689	0.966706	0.913222
22	2020-12-16	1.001185	0.829646	0.980983	0.925361	1.006179	0.990350
23	2020-12-17	1.051040	0.956577	1.050302	0.995329	1.037795	1.066869
24	2020-12-18	0.949055	0.881275	0.970997	0.927814	0.984408	1.008643
25	2020-12-19	1.312146	1.423003	1.293423	1.436347	1.139951	1.338382
26	2020-12-20	0.997439	0.795663	0.842718	0.866276	0.868782	0.928097
27	2020-12-21	0.610070	0.698212	0.931683	0.651537	1.001047	0.879174
28	2020-12-22	0.812728	0.950728	1.037525	0.914356	1.019127	0.949286
29	2020-12-23	1.328100	1.094948	1.245275	1.192115	1.252484	1.193081
30	2020-12-24	1.711927	1.363321	1.385019	1.453646	1.530101	1.490993
31	2020-12-25	2.867090	2.319867	2.275882	2.377570	2.347911	2.754811
32	2020-12-26	1.090745	0.847520	-0.134330	0.587799	0.326269	0.450904
33	2020-12-27	7.049669	16.140489	17.056210	12.025272	12.414180	12.807373

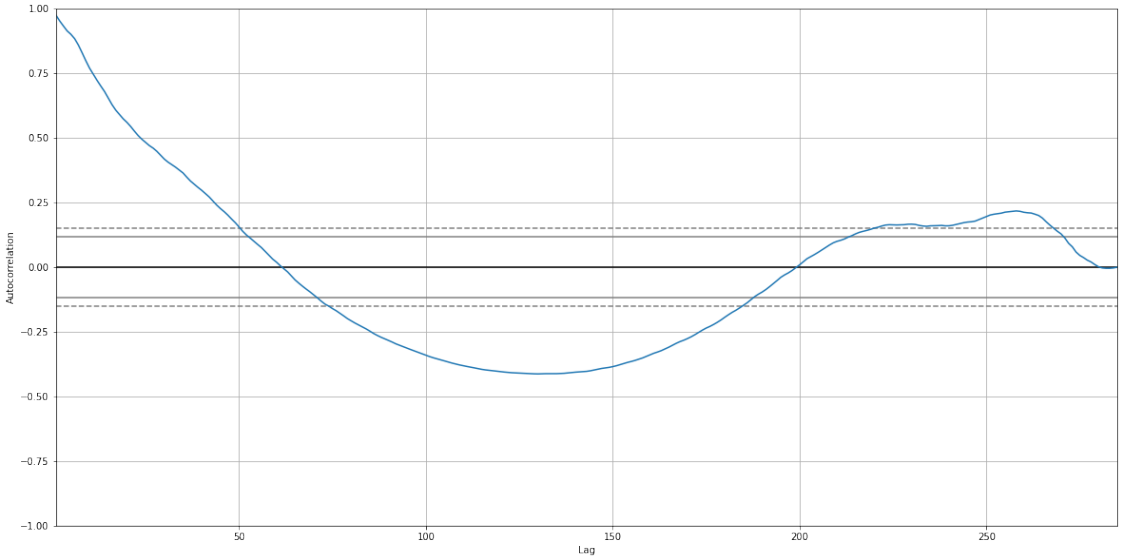


----End of Section 1: Daily new cases ----

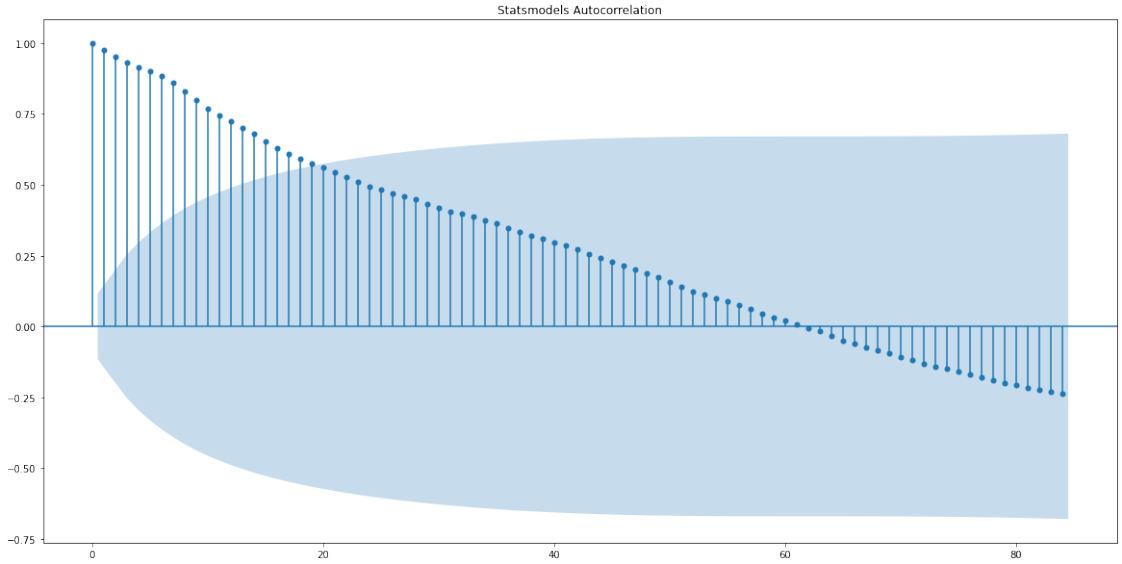
----------Print section 2: daily patients admitted to hospital:----------

----------2.1 Data source inspection----------

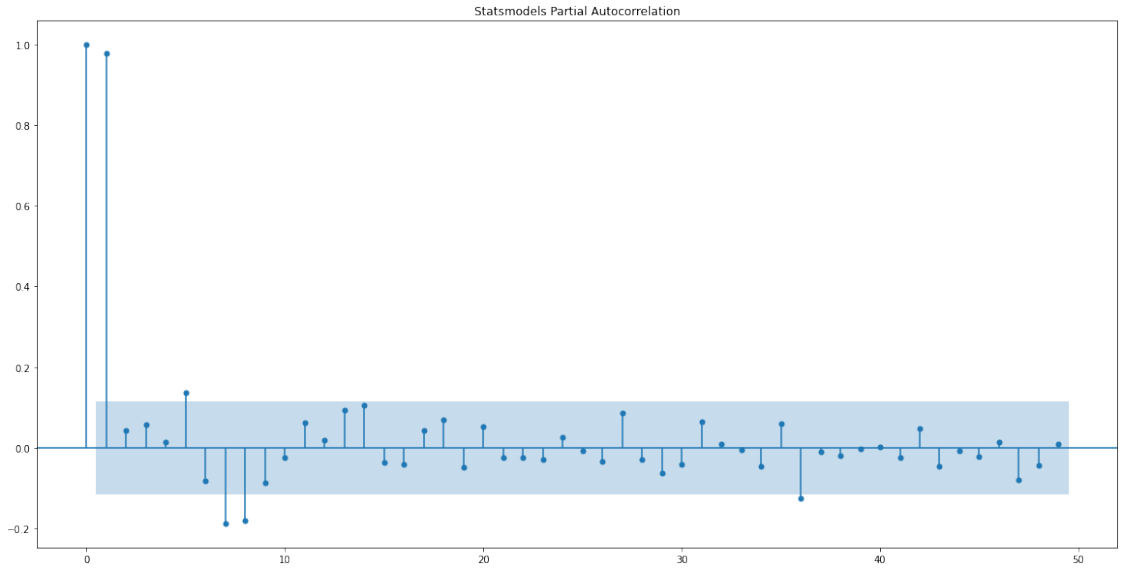


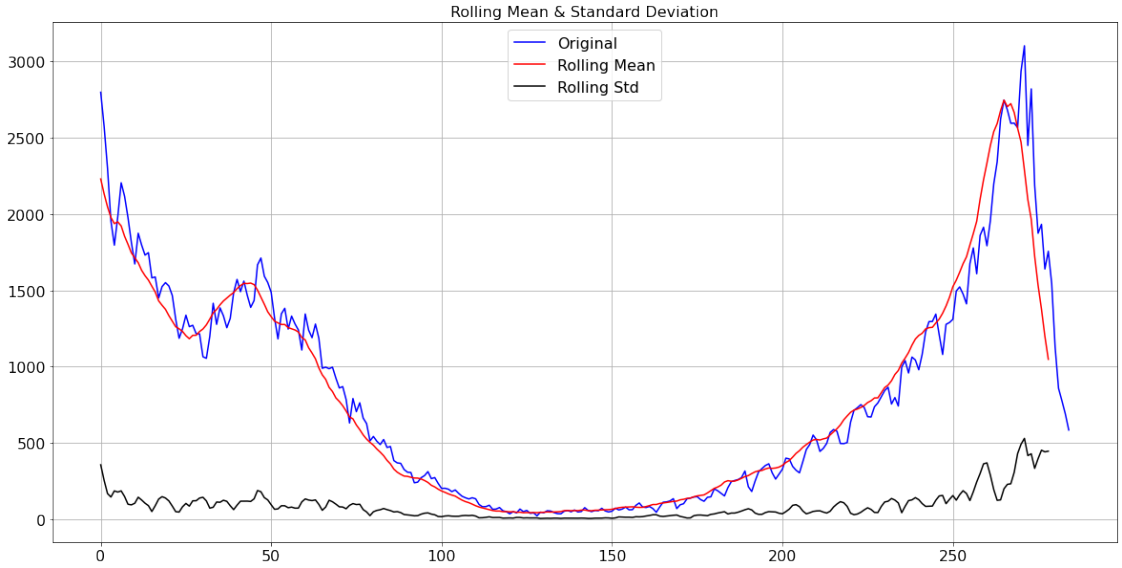


<Figure size 1440x720 with 0 Axes>



<Figure size 1440x720 with 0 Axes>






```
ADF Statistic: -0.26263993167365085
p-value: 0.930631496211892
Critical Values:
        1%: -3.454988209954765
        5%: -2.8723857312734613
        10%: -2.572549407997327
```

----------1.2 train-test split----------

```
Raw Train length: 213
Raw Val length: 43
Raw Test length: 29


----------------------2.3 prediction on each model----------------------

------------2.3.1 LSTM prediction on daily new healthcare------------


----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}
Train history feature shape: (206, 1, 7), Train label shape: 206
Val history feature shape: (29, 1, 7), Val label shape: 29
Test history feature shape: (29, 1, 7), Test label shape: 29
Adding last hidden LSTM layer 0:
Model: "sequential_6"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_6 (GRU)                  (None, 1, 112)            40656
_________________________________________________________________
dropout_18 (Dropout)         (None, 1, 112)            0
_________________________________________________________________
lstm_9 (LSTM)                (None, 112)               100800
_________________________________________________________________
dropout_19 (Dropout)         (None, 112)               0
_________________________________________________________________
dense_15 (Dense)             (None, 28)                3164
_________________________________________________________________
dense_16 (Dense)             (None, 1)                 29
=================================================================
Total params: 144,649
Trainable params: 144,649
Non-trainable params: 0
_________________________________________________________________
Epoch 1/80
7/7 [==============================] - 0s 66ms/step - loss: 0.0680 -
mean_squared_error: 0.0680 - val_loss: 0.0813 - val_mean_squared_error: 0.0813
Epoch 2/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0240 -
mean_squared_error: 0.0240 - val_loss: 0.0052 - val_mean_squared_error: 0.0052
Epoch 3/80
```

```
7/7 [==============================] - 0s 4ms/step - loss: 0.0155 -
mean_squared_error: 0.0155 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 4/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0097 -
mean_squared_error: 0.0097 - val_loss: 0.0054 - val_mean_squared_error: 0.0054
Epoch 5/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0078 -
mean_squared_error: 0.0078 - val_loss: 0.0089 - val_mean_squared_error: 0.0089
Epoch 6/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0053 -
mean_squared_error: 0.0053 - val_loss: 0.0028 - val_mean_squared_error: 0.0028
Epoch 7/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0049 -
mean_squared_error: 0.0049 - val_loss: 0.0031 - val_mean_squared_error: 0.0031
Epoch 8/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0046 -
mean_squared_error: 0.0046 - val_loss: 0.0039 - val_mean_squared_error: 0.0039
Epoch 9/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0045 -
mean_squared_error: 0.0045 - val_loss: 0.0063 - val_mean_squared_error: 0.0063
Epoch 10/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.0026 - val_mean_squared_error: 0.0026
Epoch 11/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 12/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0028 - val_mean_squared_error: 0.0028
Epoch 13/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0040 -
mean_squared_error: 0.0040 - val_loss: 0.0038 - val_mean_squared_error: 0.0038
Epoch 14/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0032 -
mean_squared_error: 0.0032 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 15/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 16/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.0037 - val_mean_squared_error: 0.0037
Epoch 17/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 18/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.0030 - val_mean_squared_error: 0.0030
Epoch 19/80
```

```
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0025 - val_mean_squared_error: 0.0025
Epoch 20/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.0025 - val_mean_squared_error: 0.0025
Epoch 21/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 22/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 23/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0029 - val_mean_squared_error: 0.0029
Epoch 24/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 25/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 26/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 27/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 28/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 29/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 30/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 31/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 32/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 33/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0025 - val_mean_squared_error: 0.0025
Epoch 34/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 35/80
```

```
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 36/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 37/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 38/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 39/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0025 - val_mean_squared_error: 0.0025
Epoch 40/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 41/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 42/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 43/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 44/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 45/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 46/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 47/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 48/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 49/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 50/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 51/80
```

```
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 52/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 53/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0027 - val_mean_squared_error: 0.0027
Epoch 54/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 55/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 56/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 57/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 58/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 59/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 60/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 61/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0025 - val_mean_squared_error: 0.0025
Epoch 62/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 63/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 64/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 65/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 66/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 67/80
```

```
7/7 [==============================] - 0s 4ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 68/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 69/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 70/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 71/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 72/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 73/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 74/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0017 - val_mean_squared_error: 0.0017
Epoch 75/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 76/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 77/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 78/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 79/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 80/80
7/7 [==============================] - 0s 4ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0018 - val_mean_squared_error: 0.0018

------------------------------------------------
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}, RMSE=261.5880688924358
------------------------------------------------
```

```
----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}
Train history feature shape: (206, 1, 7), Train label shape: 206
Val history feature shape: (29, 1, 7), Val label shape: 29
Test history feature shape: (29, 1, 7), Test label shape: 29
Adding hidden LSTM layer 0:
Adding last hidden LSTM layer 1:
Model: "sequential_7"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_7 (GRU)                  (None, 1, 896)            2432640
_________________________________________________________________
dropout_20 (Dropout)         (None, 1, 896)            0
_________________________________________________________________
lstm_10 (LSTM)               (None, 1, 896)            6426112
_________________________________________________________________
dropout_21 (Dropout)         (None, 1, 896)            0
_________________________________________________________________
dense_17 (Dense)             (None, 1, 56)             50232
_________________________________________________________________
dropout_22 (Dropout)         (None, 1, 56)             0
_________________________________________________________________
lstm_11 (LSTM)               (None, 448)               904960
_________________________________________________________________
dropout_23 (Dropout)         (None, 448)               0
_________________________________________________________________
dense_18 (Dense)             (None, 28)                12572
_________________________________________________________________
dense_19 (Dense)             (None, 1)                 29
=================================================================
Total params: 9,826,545
Trainable params: 9,826,545
Non-trainable params: 0
_________________________________________________________________
Epoch 1/80
7/7 [==============================] - 1s 129ms/step - loss: 0.0647 -
mean_squared_error: 0.0647 - val_loss: 0.0083 - val_mean_squared_error: 0.0083
Epoch 2/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0172 -
mean_squared_error: 0.0172 - val_loss: 0.0144 - val_mean_squared_error: 0.0144
Epoch 3/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0085 -
mean_squared_error: 0.0085 - val_loss: 0.0044 - val_mean_squared_error: 0.0044
```

```
Epoch 4/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0071 -
mean_squared_error: 0.0071 - val_loss: 0.0243 - val_mean_squared_error: 0.0243
Epoch 5/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0071 -
mean_squared_error: 0.0071 - val_loss: 0.0040 - val_mean_squared_error: 0.0040
Epoch 6/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0047 -
mean_squared_error: 0.0047 - val_loss: 0.0050 - val_mean_squared_error: 0.0050
Epoch 7/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 8/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0033 -
mean_squared_error: 0.0033 - val_loss: 0.0061 - val_mean_squared_error: 0.0061
Epoch 9/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0044 -
mean_squared_error: 0.0044 - val_loss: 0.0028 - val_mean_squared_error: 0.0028
Epoch 10/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0055 -
mean_squared_error: 0.0055 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 11/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0048 -
mean_squared_error: 0.0048 - val_loss: 0.0055 - val_mean_squared_error: 0.0055
Epoch 12/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0040 -
mean_squared_error: 0.0040 - val_loss: 0.0031 - val_mean_squared_error: 0.0031
Epoch 13/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0041 -
mean_squared_error: 0.0041 - val_loss: 0.0116 - val_mean_squared_error: 0.0116
Epoch 14/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.0027 - val_mean_squared_error: 0.0027
Epoch 15/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0029 - val_mean_squared_error: 0.0029
Epoch 16/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0040 -
mean_squared_error: 0.0040 - val_loss: 0.0050 - val_mean_squared_error: 0.0050
Epoch 17/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0034 - val_mean_squared_error: 0.0034
Epoch 18/80
7/7 [==============================] - 0s 38ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 19/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
```

```
Epoch 20/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 21/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 22/80
7/7 [==============================] - 0s 37ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0045 - val_mean_squared_error: 0.0045
Epoch 23/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 24/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0047 - val_mean_squared_error: 0.0047
Epoch 25/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 26/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 27/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 28/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 29/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 30/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0037 - val_mean_squared_error: 0.0037
Epoch 31/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 32/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0037 - val_mean_squared_error: 0.0037
Epoch 33/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 34/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 35/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
```

```
Epoch 36/80
7/7 [==============================] - 0s 34ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 37/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 38/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0033 - val_mean_squared_error: 0.0033
Epoch 39/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 40/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 41/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0056 - val_mean_squared_error: 0.0056
Epoch 42/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 43/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 44/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.0029 - val_mean_squared_error: 0.0029
Epoch 45/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0043 - val_mean_squared_error: 0.0043
Epoch 46/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0043 - val_mean_squared_error: 0.0043
Epoch 47/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0062 - val_mean_squared_error: 0.0062
Epoch 48/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.0030 - val_mean_squared_error: 0.0030
Epoch 49/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0031 - val_mean_squared_error: 0.0031
Epoch 50/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0067 - val_mean_squared_error: 0.0067
Epoch 51/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0053 - val_mean_squared_error: 0.0053
```

```
Epoch 52/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 53/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0033 - val_mean_squared_error: 0.0033
Epoch 54/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 55/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 56/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 57/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0081 - val_mean_squared_error: 0.0081
Epoch 58/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0028 - val_mean_squared_error: 0.0028
Epoch 59/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 60/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0025 - val_mean_squared_error: 0.0025
Epoch 61/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 62/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 63/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 64/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0029 - val_mean_squared_error: 0.0029
Epoch 65/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 66/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 67/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0040 - val_mean_squared_error: 0.0040
```

```
Epoch 68/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 69/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0028 - val_mean_squared_error: 0.0028
Epoch 70/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0045 - val_mean_squared_error: 0.0045
Epoch 71/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 72/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0043 - val_mean_squared_error: 0.0043
Epoch 73/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 74/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.0031 - val_mean_squared_error: 0.0031
Epoch 75/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0033 -
mean_squared_error: 0.0033 - val_loss: 0.0041 - val_mean_squared_error: 0.0041
Epoch 76/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 77/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 78/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0027 - val_mean_squared_error: 0.0027
Epoch 79/80
7/7 [==============================] - 0s 36ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 80/80
7/7 [==============================] - 0s 35ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0026 - val_mean_squared_error: 0.0026

--------------------------------------------------
LSTM model: {'time_lag': 7, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}, RMSE=286.9481353584009
--------------------------------------------------


----------------------Printing new LSTM model in para
```

```
grid-------------------------
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}
Train history feature shape: (199, 1, 14), Train label shape: 199
Val history feature shape: (15, 1, 14), Val label shape: 15
Test history feature shape: (29, 1, 14), Test label shape: 29
Adding last hidden LSTM layer 0:
Model: "sequential_8"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_8 (GRU)                  (None, 1, 224)            161280
_________________________________________________________________
dropout_24 (Dropout)         (None, 1, 224)            0
_________________________________________________________________
lstm_12 (LSTM)               (None, 224)               402304
_________________________________________________________________
dropout_25 (Dropout)         (None, 224)               0
_________________________________________________________________
dense_20 (Dense)             (None, 56)                12600
_________________________________________________________________
dense_21 (Dense)             (None, 1)                 57
=================================================================
Total params: 576,241
Trainable params: 576,241
Non-trainable params: 0
_________________________________________________________________
Epoch 1/80
7/7 [==============================] - 0s 71ms/step - loss: 0.0382 -
mean_squared_error: 0.0382 - val_loss: 0.0138 - val_mean_squared_error: 0.0138
Epoch 2/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0111 -
mean_squared_error: 0.0111 - val_loss: 0.0048 - val_mean_squared_error: 0.0048
Epoch 3/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0061 -
mean_squared_error: 0.0061 - val_loss: 0.0268 - val_mean_squared_error: 0.0268
Epoch 4/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0041 -
mean_squared_error: 0.0041 - val_loss: 0.0058 - val_mean_squared_error: 0.0058
Epoch 5/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0039 -
mean_squared_error: 0.0039 - val_loss: 0.0095 - val_mean_squared_error: 0.0095
Epoch 6/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0091 - val_mean_squared_error: 0.0091
Epoch 7/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0022 -
```

```
mean_squared_error: 0.0022 - val_loss: 0.0055 - val_mean_squared_error: 0.0055
Epoch 8/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0068 - val_mean_squared_error: 0.0068
Epoch 9/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0031 - val_mean_squared_error: 0.0031
Epoch 10/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0044 - val_mean_squared_error: 0.0044
Epoch 11/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0037 - val_mean_squared_error: 0.0037
Epoch 12/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0040 - val_mean_squared_error: 0.0040
Epoch 13/80
7/7 [==============================] - 0s 5ms/step - loss: 8.7976e-04 -
mean_squared_error: 8.7976e-04 - val_loss: 0.0031 - val_mean_squared_error:
0.0031
Epoch 14/80
7/7 [==============================] - 0s 5ms/step - loss: 9.0396e-04 -
mean_squared_error: 9.0396e-04 - val_loss: 0.0040 - val_mean_squared_error:
0.0040
Epoch 15/80
7/7 [==============================] - 0s 5ms/step - loss: 9.6417e-04 -
mean_squared_error: 9.6417e-04 - val_loss: 0.0036 - val_mean_squared_error:
0.0036
Epoch 16/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 17/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0045 - val_mean_squared_error: 0.0045
Epoch 18/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0039 - val_mean_squared_error: 0.0039
Epoch 19/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 20/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0050 - val_mean_squared_error: 0.0050
Epoch 21/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 22/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
```

```
mean_squared_error: 0.0011 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 23/80
7/7 [==============================] - 0s 5ms/step - loss: 7.2408e-04 -
mean_squared_error: 7.2408e-04 - val_loss: 0.0060 - val_mean_squared_error:
0.0060
Epoch 24/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 25/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0040 - val_mean_squared_error: 0.0040
Epoch 26/80
7/7 [==============================] - 0s 5ms/step - loss: 8.1191e-04 -
mean_squared_error: 8.1191e-04 - val_loss: 0.0020 - val_mean_squared_error:
0.0020
Epoch 27/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0062 - val_mean_squared_error: 0.0062
Epoch 28/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 29/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0042 - val_mean_squared_error: 0.0042
Epoch 30/80
7/7 [==============================] - 0s 5ms/step - loss: 8.1622e-04 -
mean_squared_error: 8.1622e-04 - val_loss: 0.0020 - val_mean_squared_error:
0.0020
Epoch 31/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0045 - val_mean_squared_error: 0.0045
Epoch 32/80
7/7 [==============================] - 0s 5ms/step - loss: 7.4758e-04 -
mean_squared_error: 7.4758e-04 - val_loss: 0.0019 - val_mean_squared_error:
0.0019
Epoch 33/80
7/7 [==============================] - 0s 5ms/step - loss: 8.4232e-04 -
mean_squared_error: 8.4232e-04 - val_loss: 0.0042 - val_mean_squared_error:
0.0042
Epoch 34/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 35/80
7/7 [==============================] - 0s 5ms/step - loss: 6.8474e-04 -
mean_squared_error: 6.8474e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 36/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
```

```
mean_squared_error: 0.0011 - val_loss: 0.0052 - val_mean_squared_error: 0.0052
Epoch 37/80
7/7 [==============================] - 0s 5ms/step - loss: 9.0772e-04 -
mean_squared_error: 9.0772e-04 - val_loss: 0.0025 - val_mean_squared_error:
0.0025
Epoch 38/80
7/7 [==============================] - 0s 5ms/step - loss: 8.2367e-04 -
mean_squared_error: 8.2367e-04 - val_loss: 0.0026 - val_mean_squared_error:
0.0026
Epoch 39/80
7/7 [==============================] - 0s 5ms/step - loss: 9.3608e-04 -
mean_squared_error: 9.3608e-04 - val_loss: 0.0029 - val_mean_squared_error:
0.0029
Epoch 40/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 41/80
7/7 [==============================] - 0s 5ms/step - loss: 6.4608e-04 -
mean_squared_error: 6.4608e-04 - val_loss: 0.0025 - val_mean_squared_error:
0.0025
Epoch 42/80
7/7 [==============================] - 0s 5ms/step - loss: 7.3853e-04 -
mean_squared_error: 7.3853e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 43/80
7/7 [==============================] - 0s 5ms/step - loss: 8.4201e-04 -
mean_squared_error: 8.4201e-04 - val_loss: 0.0040 - val_mean_squared_error:
0.0040
Epoch 44/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 45/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0029 - val_mean_squared_error: 0.0029
Epoch 46/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 47/80
7/7 [==============================] - 0s 5ms/step - loss: 7.2606e-04 -
mean_squared_error: 7.2606e-04 - val_loss: 0.0022 - val_mean_squared_error:
0.0022
Epoch 48/80
7/7 [==============================] - 0s 5ms/step - loss: 5.8225e-04 -
mean_squared_error: 5.8225e-04 - val_loss: 0.0032 - val_mean_squared_error:
0.0032
Epoch 49/80
7/7 [==============================] - 0s 5ms/step - loss: 7.3678e-04 -
mean_squared_error: 7.3678e-04 - val_loss: 0.0017 - val_mean_squared_error:
```

```
0.0017
Epoch 50/80
7/7 [==============================] - 0s 5ms/step - loss: 8.0814e-04 -
mean_squared_error: 8.0814e-04 - val_loss: 0.0029 - val_mean_squared_error:
0.0029
Epoch 51/80
7/7 [==============================] - 0s 5ms/step - loss: 6.9978e-04 -
mean_squared_error: 6.9978e-04 - val_loss: 0.0024 - val_mean_squared_error:
0.0024
Epoch 52/80
7/7 [==============================] - 0s 5ms/step - loss: 7.6266e-04 -
mean_squared_error: 7.6266e-04 - val_loss: 0.0016 - val_mean_squared_error:
0.0016
Epoch 53/80
7/7 [==============================] - 0s 5ms/step - loss: 8.1504e-04 -
mean_squared_error: 8.1504e-04 - val_loss: 0.0046 - val_mean_squared_error:
0.0046
Epoch 54/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0016 - val_mean_squared_error: 0.0016
Epoch 55/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0030 - val_mean_squared_error: 0.0030
Epoch 56/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 57/80
7/7 [==============================] - 0s 5ms/step - loss: 9.7211e-04 -
mean_squared_error: 9.7211e-04 - val_loss: 0.0018 - val_mean_squared_error:
0.0018
Epoch 58/80
7/7 [==============================] - 0s 5ms/step - loss: 7.0201e-04 -
mean_squared_error: 7.0201e-04 - val_loss: 0.0018 - val_mean_squared_error:
0.0018
Epoch 59/80
7/7 [==============================] - 0s 5ms/step - loss: 6.2968e-04 -
mean_squared_error: 6.2968e-04 - val_loss: 0.0017 - val_mean_squared_error:
0.0017
Epoch 60/80
7/7 [==============================] - 0s 5ms/step - loss: 8.3680e-04 -
mean_squared_error: 8.3680e-04 - val_loss: 0.0042 - val_mean_squared_error:
0.0042
Epoch 61/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 62/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0015 - val_mean_squared_error: 0.0015
```

```
Epoch 63/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0101 - val_mean_squared_error: 0.0101
Epoch 64/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 65/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0090 - val_mean_squared_error: 0.0090
Epoch 66/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0017 - val_mean_squared_error: 0.0017
Epoch 67/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0047 - val_mean_squared_error: 0.0047
Epoch 68/80
7/7 [==============================] - 0s 5ms/step - loss: 7.8031e-04 -
mean_squared_error: 7.8031e-04 - val_loss: 0.0016 - val_mean_squared_error:
0.0016
Epoch 69/80
7/7 [==============================] - 0s 5ms/step - loss: 8.9054e-04 -
mean_squared_error: 8.9054e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 70/80
7/7 [==============================] - 0s 5ms/step - loss: 7.2656e-04 -
mean_squared_error: 7.2656e-04 - val_loss: 0.0016 - val_mean_squared_error:
0.0016
Epoch 71/80
7/7 [==============================] - 0s 5ms/step - loss: 7.6036e-04 -
mean_squared_error: 7.6036e-04 - val_loss: 0.0021 - val_mean_squared_error:
0.0021
Epoch 72/80
7/7 [==============================] - 0s 5ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 73/80
7/7 [==============================] - 0s 5ms/step - loss: 9.6045e-04 -
mean_squared_error: 9.6045e-04 - val_loss: 0.0018 - val_mean_squared_error:
0.0018
Epoch 74/80
7/7 [==============================] - 0s 5ms/step - loss: 7.5899e-04 -
mean_squared_error: 7.5899e-04 - val_loss: 0.0027 - val_mean_squared_error:
0.0027
Epoch 75/80
7/7 [==============================] - 0s 5ms/step - loss: 5.1518e-04 -
mean_squared_error: 5.1518e-04 - val_loss: 0.0016 - val_mean_squared_error:
0.0016
Epoch 76/80
7/7 [==============================] - 0s 5ms/step - loss: 6.6646e-04 -
```

```
mean_squared_error: 6.6646e-04 - val_loss: 0.0032 - val_mean_squared_error:
0.0032
Epoch 77/80
7/7 [==============================] - 0s 5ms/step - loss: 9.5787e-04 -
mean_squared_error: 9.5787e-04 - val_loss: 0.0016 - val_mean_squared_error:
0.0016
Epoch 78/80
7/7 [==============================] - 0s 5ms/step - loss: 7.4466e-04 -
mean_squared_error: 7.4466e-04 - val_loss: 0.0030 - val_mean_squared_error:
0.0030
Epoch 79/80
7/7 [==============================] - 0s 5ms/step - loss: 7.6883e-04 -
mean_squared_error: 7.6883e-04 - val_loss: 0.0019 - val_mean_squared_error:
0.0019
Epoch 80/80
7/7 [==============================] - 0s 5ms/step - loss: 7.8972e-04 -
mean_squared_error: 7.8972e-04 - val_loss: 0.0017 - val_mean_squared_error:
0.0017

--------------------------------------------------
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}, RMSE=273.31067460383423
--------------------------------------------------


----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}
Train history feature shape: (199, 1, 14), Train label shape: 199
Val history feature shape: (15, 1, 14), Val label shape: 15
Test history feature shape: (29, 1, 14), Test label shape: 29
Adding hidden LSTM layer 0:
Adding last hidden LSTM layer 1:
Model: "sequential_9"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_9 (GRU)                  (None, 1, 1792)           9719808
_________________________________________________________________
dropout_26 (Dropout)         (None, 1, 1792)           0
_________________________________________________________________
lstm_13 (LSTM)               (None, 1, 1792)           25697280
_________________________________________________________________
dropout_27 (Dropout)         (None, 1, 1792)           0
_________________________________________________________________
```

```
dense_22 (Dense)             (None, 1, 112)            200816
_________________________________________________________________
dropout_28 (Dropout)         (None, 1, 112)            0
_________________________________________________________________
lstm_14 (LSTM)               (None, 896)               3616256
_________________________________________________________________
dropout_29 (Dropout)         (None, 896)               0
_________________________________________________________________
dense_23 (Dense)             (None, 56)                50232
_________________________________________________________________
dense_24 (Dense)             (None, 1)                 57
=================================================================
Total params: 39,284,449
Trainable params: 39,284,449
Non-trainable params: 0
_________________________________________________________________
Epoch 1/80
7/7 [==============================] - 2s 217ms/step - loss: 0.0452 -
mean_squared_error: 0.0452 - val_loss: 0.0221 - val_mean_squared_error: 0.0221
Epoch 2/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0119 -
mean_squared_error: 0.0119 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 3/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0086 -
mean_squared_error: 0.0086 - val_loss: 0.0401 - val_mean_squared_error: 0.0401
Epoch 4/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0051 -
mean_squared_error: 0.0051 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 5/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.0044 - val_mean_squared_error: 0.0044
Epoch 6/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0033 -
mean_squared_error: 0.0033 - val_loss: 0.0186 - val_mean_squared_error: 0.0186
Epoch 7/80
7/7 [==============================] - 1s 114ms/step - loss: 0.0035 -
mean_squared_error: 0.0035 - val_loss: 0.0030 - val_mean_squared_error: 0.0030
Epoch 8/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0043 - val_mean_squared_error: 0.0043
Epoch 9/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 10/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 11/80
7/7 [==============================] - 1s 114ms/step - loss: 0.0020 -
```

```
mean_squared_error: 0.0020 - val_loss: 0.0035 - val_mean_squared_error: 0.0035
Epoch 12/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 13/80
7/7 [==============================] - 1s 116ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0058 - val_mean_squared_error: 0.0058
Epoch 14/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0039 - val_mean_squared_error: 0.0039
Epoch 15/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0025 - val_mean_squared_error: 0.0025
Epoch 16/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 17/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 18/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0043 - val_mean_squared_error: 0.0043
Epoch 19/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 20/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 21/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 22/80
7/7 [==============================] - 1s 114ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 23/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 24/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0032 - val_mean_squared_error: 0.0032
Epoch 25/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 26/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0024 - val_mean_squared_error: 0.0024
Epoch 27/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0017 -
```

```
mean_squared_error: 0.0017 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 28/80
7/7 [==============================] - 1s 109ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0050 - val_mean_squared_error: 0.0050
Epoch 29/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0031 - val_mean_squared_error: 0.0031
Epoch 30/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0037 - val_mean_squared_error: 0.0037
Epoch 31/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0031 - val_mean_squared_error: 0.0031
Epoch 32/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0051 - val_mean_squared_error: 0.0051
Epoch 33/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 34/80
7/7 [==============================] - 1s 111ms/step - loss: 9.2319e-04 -
mean_squared_error: 9.2319e-04 - val_loss: 0.0037 - val_mean_squared_error:
0.0037
Epoch 35/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0034 - val_mean_squared_error: 0.0034
Epoch 36/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 37/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0020 - val_mean_squared_error: 0.0020
Epoch 38/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0013 -
mean_squared_error: 0.0013 - val_loss: 0.0019 - val_mean_squared_error: 0.0019
Epoch 39/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0029 - val_mean_squared_error: 0.0029
Epoch 40/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0021 - val_mean_squared_error: 0.0021
Epoch 41/80
7/7 [==============================] - 1s 113ms/step - loss: 9.7371e-04 -
mean_squared_error: 9.7371e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 42/80
7/7 [==============================] - 1s 113ms/step - loss: 7.8163e-04 -
mean_squared_error: 7.8163e-04 - val_loss: 0.0017 - val_mean_squared_error:
```

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0.0017
Epoch 43/80
7/7 [==============================] - 1s 109ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0035 - val_mean_squared_error: 0.0035
Epoch 44/80
7/7 [==============================] - 1s 109ms/step - loss: 9.7618e-04 -
mean_squared_error: 9.7618e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 45/80
7/7 [==============================] - 1s 113ms/step - loss: 8.8571e-04 -
mean_squared_error: 8.8571e-04 - val_loss: 0.0059 - val_mean_squared_error:
0.0059
Epoch 46/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 47/80
7/7 [==============================] - 1s 114ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0078 - val_mean_squared_error: 0.0078
Epoch 48/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 49/80
7/7 [==============================] - 1s 114ms/step - loss: 7.5999e-04 -
mean_squared_error: 7.5999e-04 - val_loss: 0.0025 - val_mean_squared_error:
0.0025
Epoch 50/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0022 - val_mean_squared_error: 0.0022
Epoch 51/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 52/80
7/7 [==============================] - 1s 115ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0073 - val_mean_squared_error: 0.0073
Epoch 53/80
7/7 [==============================] - 1s 113ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0066 - val_mean_squared_error: 0.0066
Epoch 54/80
7/7 [==============================] - 1s 114ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0058 - val_mean_squared_error: 0.0058
Epoch 55/80
7/7 [==============================] - 1s 114ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 56/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0036 - val_mean_squared_error: 0.0036
Epoch 57/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0012 -
```

```
mean_squared_error: 0.0012 - val_loss: 0.0026 - val_mean_squared_error: 0.0026
Epoch 58/80
7/7 [==============================] - 1s 112ms/step - loss: 8.8073e-04 -
mean_squared_error: 8.8073e-04 - val_loss: 0.0036 - val_mean_squared_error:
0.0036
Epoch 59/80
7/7 [==============================] - 1s 109ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 60/80
7/7 [==============================] - 1s 112ms/step - loss: 9.3266e-04 -
mean_squared_error: 9.3266e-04 - val_loss: 0.0020 - val_mean_squared_error:
0.0020
Epoch 61/80
7/7 [==============================] - 1s 112ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0033 - val_mean_squared_error: 0.0033
Epoch 62/80
7/7 [==============================] - 1s 111ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0017 - val_mean_squared_error: 0.0017
Epoch 63/80
7/7 [==============================] - 1s 115ms/step - loss: 9.6837e-04 -
mean_squared_error: 9.6837e-04 - val_loss: 0.0019 - val_mean_squared_error:
0.0019
Epoch 64/80
7/7 [==============================] - 1s 112ms/step - loss: 9.4992e-04 -
mean_squared_error: 9.4992e-04 - val_loss: 0.0024 - val_mean_squared_error:
0.0024
Epoch 65/80
7/7 [==============================] - 1s 110ms/step - loss: 7.0218e-04 -
mean_squared_error: 7.0218e-04 - val_loss: 0.0017 - val_mean_squared_error:
0.0017
Epoch 66/80
7/7 [==============================] - 1s 111ms/step - loss: 6.7358e-04 -
mean_squared_error: 6.7358e-04 - val_loss: 0.0019 - val_mean_squared_error:
0.0019
Epoch 67/80
7/7 [==============================] - 1s 110ms/step - loss: 6.6980e-04 -
mean_squared_error: 6.6980e-04 - val_loss: 0.0033 - val_mean_squared_error:
0.0033
Epoch 68/80
7/7 [==============================] - 1s 109ms/step - loss: 8.9543e-04 -
mean_squared_error: 8.9543e-04 - val_loss: 0.0020 - val_mean_squared_error:
0.0020
Epoch 69/80
7/7 [==============================] - 1s 109ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0041 - val_mean_squared_error: 0.0041
Epoch 70/80
7/7 [==============================] - 1s 110ms/step - loss: 8.6509e-04 -
mean_squared_error: 8.6509e-04 - val_loss: 0.0017 - val_mean_squared_error:
```

```
0.0017
Epoch 71/80
7/7 [==============================] - 1s 109ms/step - loss: 9.0423e-04 -
mean_squared_error: 9.0423e-04 - val_loss: 0.0017 - val_mean_squared_error:
0.0017
Epoch 72/80
7/7 [==============================] - 1s 112ms/step - loss: 8.1823e-04 -
mean_squared_error: 8.1823e-04 - val_loss: 0.0020 - val_mean_squared_error:
0.0020
Epoch 73/80
7/7 [==============================] - 1s 110ms/step - loss: 9.0591e-04 -
mean_squared_error: 9.0591e-04 - val_loss: 0.0020 - val_mean_squared_error:
0.0020
Epoch 74/80
7/7 [==============================] - 1s 110ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0030 - val_mean_squared_error: 0.0030
Epoch 75/80
7/7 [==============================] - 1s 110ms/step - loss: 8.7051e-04 -
mean_squared_error: 8.7051e-04 - val_loss: 0.0022 - val_mean_squared_error:
0.0022
Epoch 76/80
7/7 [==============================] - 1s 112ms/step - loss: 6.4774e-04 -
mean_squared_error: 6.4774e-04 - val_loss: 0.0028 - val_mean_squared_error:
0.0028
Epoch 77/80
7/7 [==============================] - 1s 111ms/step - loss: 9.2922e-04 -
mean_squared_error: 9.2922e-04 - val_loss: 0.0059 - val_mean_squared_error:
0.0059
Epoch 78/80
7/7 [==============================] - 1s 109ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0023 - val_mean_squared_error: 0.0023
Epoch 79/80
7/7 [==============================] - 1s 112ms/step - loss: 8.5865e-04 -
mean_squared_error: 8.5865e-04 - val_loss: 0.0015 - val_mean_squared_error:
0.0015
Epoch 80/80
7/7 [==============================] - 1s 112ms/step - loss: 7.9643e-04 -
mean_squared_error: 7.9643e-04 - val_loss: 0.0016 - val_mean_squared_error:
0.0016

--------------------------------------------------
LSTM model: {'time_lag': 14, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}, RMSE=275.30881124634055
--------------------------------------------------


----------------------Printing new LSTM model in para
```

```
grid-------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}
Train history feature shape: (192, 1, 21), Train label shape: 192
Val history feature shape: (1, 1, 21), Val label shape: 1
Test history feature shape: (29, 1, 21), Test label shape: 29
Adding last hidden LSTM layer 0:
Model: "sequential_10"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_10 (GRU)                 (None, 1, 336)            361872
_________________________________________________________________
dropout_30 (Dropout)         (None, 1, 336)            0
_________________________________________________________________
lstm_15 (LSTM)               (None, 336)               904512
_________________________________________________________________
dropout_31 (Dropout)         (None, 336)               0
_________________________________________________________________
dense_25 (Dense)             (None, 84)                28308
_________________________________________________________________
dense_26 (Dense)             (None, 1)                 85
=================================================================
Total params: 1,294,777
Trainable params: 1,294,777
Non-trainable params: 0
_________________________________________________________________
Epoch 1/80
6/6 [==============================] - 0s 80ms/step - loss: 0.0187 -
mean_squared_error: 0.0187 - val_loss: 0.0103 - val_mean_squared_error: 0.0103
Epoch 2/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0056 -
mean_squared_error: 0.0056 - val_loss: 0.0614 - val_mean_squared_error: 0.0614
Epoch 3/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0048 -
mean_squared_error: 0.0048 - val_loss: 0.0439 - val_mean_squared_error: 0.0439
Epoch 4/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0044 -
mean_squared_error: 0.0044 - val_loss: 0.0208 - val_mean_squared_error: 0.0208
Epoch 5/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.0509 - val_mean_squared_error: 0.0509
Epoch 6/80
6/6 [==============================] - 0s 8ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0206 - val_mean_squared_error: 0.0206
Epoch 7/80
6/6 [==============================] - 0s 8ms/step - loss: 0.0016 -
```

```
mean_squared_error: 0.0016 - val_loss: 0.0246 - val_mean_squared_error: 0.0246
Epoch 8/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0300 - val_mean_squared_error: 0.0300
Epoch 9/80
6/6 [==============================] - 0s 8ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0164 - val_mean_squared_error: 0.0164
Epoch 10/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0216 - val_mean_squared_error: 0.0216
Epoch 11/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0179 - val_mean_squared_error: 0.0179
Epoch 12/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0159 - val_mean_squared_error: 0.0159
Epoch 13/80
6/6 [==============================] - 0s 7ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0182 - val_mean_squared_error: 0.0182
Epoch 14/80
6/6 [==============================] - 0s 7ms/step - loss: 7.8105e-04 -
mean_squared_error: 7.8105e-04 - val_loss: 0.0156 - val_mean_squared_error:
0.0156
Epoch 15/80
6/6 [==============================] - 0s 7ms/step - loss: 8.6350e-04 -
mean_squared_error: 8.6350e-04 - val_loss: 0.0186 - val_mean_squared_error:
0.0186
Epoch 16/80
6/6 [==============================] - 0s 7ms/step - loss: 8.4457e-04 -
mean_squared_error: 8.4457e-04 - val_loss: 0.0149 - val_mean_squared_error:
0.0149
Epoch 17/80
6/6 [==============================] - 0s 7ms/step - loss: 9.2141e-04 -
mean_squared_error: 9.2141e-04 - val_loss: 0.0168 - val_mean_squared_error:
0.0168
Epoch 18/80
6/6 [==============================] - 0s 7ms/step - loss: 8.8470e-04 -
mean_squared_error: 8.8470e-04 - val_loss: 0.0143 - val_mean_squared_error:
0.0143
Epoch 19/80
6/6 [==============================] - 0s 7ms/step - loss: 8.6966e-04 -
mean_squared_error: 8.6966e-04 - val_loss: 0.0120 - val_mean_squared_error:
0.0120
Epoch 20/80
6/6 [==============================] - 0s 7ms/step - loss: 7.9348e-04 -
mean_squared_error: 7.9348e-04 - val_loss: 0.0144 - val_mean_squared_error:
0.0144
Epoch 21/80
```

```
6/6 [==============================] - 0s 7ms/step - loss: 9.3826e-04 -
mean_squared_error: 9.3826e-04 - val_loss: 0.0104 - val_mean_squared_error:
0.0104
Epoch 22/80
6/6 [==============================] - 0s 7ms/step - loss: 9.1116e-04 -
mean_squared_error: 9.1116e-04 - val_loss: 0.0125 - val_mean_squared_error:
0.0125
Epoch 23/80
6/6 [==============================] - 0s 7ms/step - loss: 6.8711e-04 -
mean_squared_error: 6.8711e-04 - val_loss: 0.0136 - val_mean_squared_error:
0.0136
Epoch 24/80
6/6 [==============================] - 0s 7ms/step - loss: 8.7576e-04 -
mean_squared_error: 8.7576e-04 - val_loss: 0.0105 - val_mean_squared_error:
0.0105
Epoch 25/80
6/6 [==============================] - 0s 7ms/step - loss: 7.1621e-04 -
mean_squared_error: 7.1621e-04 - val_loss: 0.0148 - val_mean_squared_error:
0.0148
Epoch 26/80
6/6 [==============================] - 0s 7ms/step - loss: 7.3851e-04 -
mean_squared_error: 7.3851e-04 - val_loss: 0.0057 - val_mean_squared_error:
0.0057
Epoch 27/80
6/6 [==============================] - 0s 7ms/step - loss: 6.2333e-04 -
mean_squared_error: 6.2333e-04 - val_loss: 0.0109 - val_mean_squared_error:
0.0109
Epoch 28/80
6/6 [==============================] - 0s 7ms/step - loss: 5.6770e-04 -
mean_squared_error: 5.6770e-04 - val_loss: 0.0091 - val_mean_squared_error:
0.0091
Epoch 29/80
6/6 [==============================] - 0s 8ms/step - loss: 6.5469e-04 -
mean_squared_error: 6.5469e-04 - val_loss: 0.0147 - val_mean_squared_error:
0.0147
Epoch 30/80
6/6 [==============================] - 0s 8ms/step - loss: 5.3434e-04 -
mean_squared_error: 5.3434e-04 - val_loss: 0.0079 - val_mean_squared_error:
0.0079
Epoch 31/80
6/6 [==============================] - 0s 7ms/step - loss: 6.2860e-04 -
mean_squared_error: 6.2860e-04 - val_loss: 0.0105 - val_mean_squared_error:
0.0105
Epoch 32/80
6/6 [==============================] - 0s 7ms/step - loss: 6.3280e-04 -
mean_squared_error: 6.3280e-04 - val_loss: 0.0090 - val_mean_squared_error:
0.0090
Epoch 33/80
```

```
6/6 [==============================] - 0s 7ms/step - loss: 4.5112e-04 -
mean_squared_error: 4.5112e-04 - val_loss: 0.0076 - val_mean_squared_error:
0.0076
Epoch 34/80
6/6 [==============================] - 0s 7ms/step - loss: 5.6469e-04 -
mean_squared_error: 5.6469e-04 - val_loss: 0.0123 - val_mean_squared_error:
0.0123
Epoch 35/80
6/6 [==============================] - 0s 7ms/step - loss: 5.0121e-04 -
mean_squared_error: 5.0121e-04 - val_loss: 0.0077 - val_mean_squared_error:
0.0077
Epoch 36/80
6/6 [==============================] - 0s 7ms/step - loss: 6.1250e-04 -
mean_squared_error: 6.1250e-04 - val_loss: 0.0059 - val_mean_squared_error:
0.0059
Epoch 37/80
6/6 [==============================] - 0s 7ms/step - loss: 5.6236e-04 -
mean_squared_error: 5.6236e-04 - val_loss: 0.0172 - val_mean_squared_error:
0.0172
Epoch 38/80
6/6 [==============================] - 0s 7ms/step - loss: 8.3891e-04 -
mean_squared_error: 8.3891e-04 - val_loss: 0.0056 - val_mean_squared_error:
0.0056
Epoch 39/80
6/6 [==============================] - 0s 7ms/step - loss: 5.4052e-04 -
mean_squared_error: 5.4052e-04 - val_loss: 0.0123 - val_mean_squared_error:
0.0123
Epoch 40/80
6/6 [==============================] - 0s 7ms/step - loss: 4.9178e-04 -
mean_squared_error: 4.9178e-04 - val_loss: 0.0127 - val_mean_squared_error:
0.0127
Epoch 41/80
6/6 [==============================] - 0s 7ms/step - loss: 5.2487e-04 -
mean_squared_error: 5.2487e-04 - val_loss: 0.0052 - val_mean_squared_error:
0.0052
Epoch 42/80
6/6 [==============================] - 0s 7ms/step - loss: 5.7812e-04 -
mean_squared_error: 5.7812e-04 - val_loss: 0.0167 - val_mean_squared_error:
0.0167
Epoch 43/80
6/6 [==============================] - 0s 7ms/step - loss: 6.8948e-04 -
mean_squared_error: 6.8948e-04 - val_loss: 0.0021 - val_mean_squared_error:
0.0021
Epoch 44/80
6/6 [==============================] - 0s 7ms/step - loss: 7.6009e-04 -
mean_squared_error: 7.6009e-04 - val_loss: 0.0169 - val_mean_squared_error:
0.0169
Epoch 45/80
```

```
6/6 [==============================] - 0s 7ms/step - loss: 6.9762e-04 -
mean_squared_error: 6.9762e-04 - val_loss: 0.0040 - val_mean_squared_error:
0.0040
Epoch 46/80
6/6 [==============================] - 0s 7ms/step - loss: 6.0115e-04 -
mean_squared_error: 6.0115e-04 - val_loss: 0.0126 - val_mean_squared_error:
0.0126
Epoch 47/80
6/6 [==============================] - 0s 7ms/step - loss: 6.6181e-04 -
mean_squared_error: 6.6181e-04 - val_loss: 0.0065 - val_mean_squared_error:
0.0065
Epoch 48/80
6/6 [==============================] - 0s 7ms/step - loss: 4.4431e-04 -
mean_squared_error: 4.4431e-04 - val_loss: 0.0104 - val_mean_squared_error:
0.0104
Epoch 49/80
6/6 [==============================] - 0s 8ms/step - loss: 5.2523e-04 -
mean_squared_error: 5.2523e-04 - val_loss: 0.0124 - val_mean_squared_error:
0.0124
Epoch 50/80
6/6 [==============================] - 0s 8ms/step - loss: 4.9085e-04 -
mean_squared_error: 4.9085e-04 - val_loss: 0.0064 - val_mean_squared_error:
0.0064
Epoch 51/80
6/6 [==============================] - 0s 7ms/step - loss: 4.2212e-04 -
mean_squared_error: 4.2212e-04 - val_loss: 0.0098 - val_mean_squared_error:
0.0098
Epoch 52/80
6/6 [==============================] - 0s 7ms/step - loss: 5.0463e-04 -
mean_squared_error: 5.0463e-04 - val_loss: 0.0086 - val_mean_squared_error:
0.0086
Epoch 53/80
6/6 [==============================] - 0s 7ms/step - loss: 4.1988e-04 -
mean_squared_error: 4.1988e-04 - val_loss: 0.0074 - val_mean_squared_error:
0.0074
Epoch 54/80
6/6 [==============================] - 0s 7ms/step - loss: 3.4528e-04 -
mean_squared_error: 3.4528e-04 - val_loss: 0.0091 - val_mean_squared_error:
0.0091
Epoch 55/80
6/6 [==============================] - 0s 7ms/step - loss: 3.3201e-04 -
mean_squared_error: 3.3201e-04 - val_loss: 0.0067 - val_mean_squared_error:
0.0067
Epoch 56/80
6/6 [==============================] - 0s 7ms/step - loss: 3.3321e-04 -
mean_squared_error: 3.3321e-04 - val_loss: 0.0108 - val_mean_squared_error:
0.0108
Epoch 57/80
```

```
6/6 [==============================] - 0s 8ms/step - loss: 4.0495e-04 -
mean_squared_error: 4.0495e-04 - val_loss: 0.0086 - val_mean_squared_error:
0.0086
Epoch 58/80
6/6 [==============================] - 0s 8ms/step - loss: 3.4213e-04 -
mean_squared_error: 3.4213e-04 - val_loss: 0.0098 - val_mean_squared_error:
0.0098
Epoch 59/80
6/6 [==============================] - 0s 7ms/step - loss: 4.8044e-04 -
mean_squared_error: 4.8044e-04 - val_loss: 0.0052 - val_mean_squared_error:
0.0052
Epoch 60/80
6/6 [==============================] - 0s 8ms/step - loss: 5.1459e-04 -
mean_squared_error: 5.1459e-04 - val_loss: 0.0081 - val_mean_squared_error:
0.0081
Epoch 61/80
6/6 [==============================] - 0s 7ms/step - loss: 6.1498e-04 -
mean_squared_error: 6.1498e-04 - val_loss: 0.0066 - val_mean_squared_error:
0.0066
Epoch 62/80
6/6 [==============================] - 0s 7ms/step - loss: 4.5284e-04 -
mean_squared_error: 4.5284e-04 - val_loss: 0.0075 - val_mean_squared_error:
0.0075
Epoch 63/80
6/6 [==============================] - 0s 7ms/step - loss: 3.7066e-04 -
mean_squared_error: 3.7066e-04 - val_loss: 0.0114 - val_mean_squared_error:
0.0114
Epoch 64/80
6/6 [==============================] - 0s 7ms/step - loss: 4.2719e-04 -
mean_squared_error: 4.2719e-04 - val_loss: 0.0067 - val_mean_squared_error:
0.0067
Epoch 65/80
6/6 [==============================] - 0s 7ms/step - loss: 3.4769e-04 -
mean_squared_error: 3.4769e-04 - val_loss: 0.0110 - val_mean_squared_error:
0.0110
Epoch 66/80
6/6 [==============================] - 0s 7ms/step - loss: 3.5056e-04 -
mean_squared_error: 3.5056e-04 - val_loss: 0.0098 - val_mean_squared_error:
0.0098
Epoch 67/80
6/6 [==============================] - 0s 7ms/step - loss: 3.3788e-04 -
mean_squared_error: 3.3788e-04 - val_loss: 0.0106 - val_mean_squared_error:
0.0106
Epoch 68/80
6/6 [==============================] - 0s 8ms/step - loss: 3.8966e-04 -
mean_squared_error: 3.8966e-04 - val_loss: 0.0084 - val_mean_squared_error:
0.0084
Epoch 69/80
```

```
6/6 [==============================] - 0s 7ms/step - loss: 4.2579e-04 -
mean_squared_error: 4.2579e-04 - val_loss: 0.0102 - val_mean_squared_error:
0.0102
Epoch 70/80
6/6 [==============================] - 0s 7ms/step - loss: 3.3828e-04 -
mean_squared_error: 3.3828e-04 - val_loss: 0.0041 - val_mean_squared_error:
0.0041
Epoch 71/80
6/6 [==============================] - 0s 7ms/step - loss: 4.6018e-04 -
mean_squared_error: 4.6018e-04 - val_loss: 0.0058 - val_mean_squared_error:
0.0058
Epoch 72/80
6/6 [==============================] - 0s 7ms/step - loss: 3.8655e-04 -
mean_squared_error: 3.8655e-04 - val_loss: 0.0084 - val_mean_squared_error:
0.0084
Epoch 73/80
6/6 [==============================] - 0s 7ms/step - loss: 2.8516e-04 -
mean_squared_error: 2.8516e-04 - val_loss: 0.0128 - val_mean_squared_error:
0.0128
Epoch 74/80
6/6 [==============================] - 0s 7ms/step - loss: 3.4913e-04 -
mean_squared_error: 3.4913e-04 - val_loss: 0.0076 - val_mean_squared_error:
0.0076
Epoch 75/80
6/6 [==============================] - 0s 7ms/step - loss: 3.9760e-04 -
mean_squared_error: 3.9760e-04 - val_loss: 0.0099 - val_mean_squared_error:
0.0099
Epoch 76/80
6/6 [==============================] - 0s 7ms/step - loss: 4.4532e-04 -
mean_squared_error: 4.4532e-04 - val_loss: 0.0045 - val_mean_squared_error:
0.0045
Epoch 77/80
6/6 [==============================] - 0s 7ms/step - loss: 4.2634e-04 -
mean_squared_error: 4.2634e-04 - val_loss: 0.0067 - val_mean_squared_error:
0.0067
Epoch 78/80
6/6 [==============================] - 0s 7ms/step - loss: 4.2349e-04 -
mean_squared_error: 4.2349e-04 - val_loss: 0.0121 - val_mean_squared_error:
0.0121
Epoch 79/80
6/6 [==============================] - 0s 8ms/step - loss: 4.1697e-04 -
mean_squared_error: 4.1697e-04 - val_loss: 0.0055 - val_mean_squared_error:
0.0055
Epoch 80/80
6/6 [==============================] - 0s 7ms/step - loss: 4.5183e-04 -
mean_squared_error: 4.5183e-04 - val_loss: 0.0088 - val_mean_squared_error:
0.0088
```

```
------------------------------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}, RMSE=432.87632369289486
------------------------------------------------


----------------------Printing new LSTM model in para
grid-------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}
Train history feature shape: (192, 1, 21), Train label shape: 192
Val history feature shape: (1, 1, 21), Val label shape: 1
Test history feature shape: (29, 1, 21), Test label shape: 29
Adding hidden LSTM layer 0:
Adding last hidden LSTM layer 1:
Model: "sequential_11"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_11 (GRU)                 (None, 1, 2688)           21861504
_________________________________________________________________
dropout_32 (Dropout)         (None, 1, 2688)           0
_________________________________________________________________
lstm_16 (LSTM)               (None, 1, 2688)           57813504
_________________________________________________________________
dropout_33 (Dropout)         (None, 1, 2688)           0
_________________________________________________________________
dense_27 (Dense)             (None, 1, 168)            451752
_________________________________________________________________
dropout_34 (Dropout)         (None, 1, 168)            0
_________________________________________________________________
lstm_17 (LSTM)               (None, 1344)              8133888
_________________________________________________________________
dropout_35 (Dropout)         (None, 1344)              0
_________________________________________________________________
dense_28 (Dense)             (None, 84)                112980
_________________________________________________________________
dense_29 (Dense)             (None, 1)                 85
=================================================================
Total params: 88,373,713
Trainable params: 88,373,713
Non-trainable params: 0
_________________________________________________________________
Epoch 1/80
6/6 [==============================] - 2s 360ms/step - loss: 0.0257 -
mean_squared_error: 0.0257 - val_loss: 0.0774 - val_mean_squared_error: 0.0774
```

```
Epoch 2/80
6/6 [==============================] - 1s 238ms/step - loss: 0.0080 -
mean_squared_error: 0.0080 - val_loss: 0.0109 - val_mean_squared_error: 0.0109
Epoch 3/80
6/6 [==============================] - 1s 241ms/step - loss: 0.0041 -
mean_squared_error: 0.0041 - val_loss: 0.0610 - val_mean_squared_error: 0.0610
Epoch 4/80
6/6 [==============================] - 1s 243ms/step - loss: 0.0040 -
mean_squared_error: 0.0040 - val_loss: 0.0337 - val_mean_squared_error: 0.0337
Epoch 5/80
6/6 [==============================] - 1s 241ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0071 - val_mean_squared_error: 0.0071
Epoch 6/80
6/6 [==============================] - 1s 242ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0273 - val_mean_squared_error: 0.0273
Epoch 7/80
6/6 [==============================] - 1s 236ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0160 - val_mean_squared_error: 0.0160
Epoch 8/80
6/6 [==============================] - 1s 240ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0097 - val_mean_squared_error: 0.0097
Epoch 9/80
6/6 [==============================] - 1s 234ms/step - loss: 9.5337e-04 -
mean_squared_error: 9.5337e-04 - val_loss: 0.0212 - val_mean_squared_error:
0.0212
Epoch 10/80
6/6 [==============================] - 1s 243ms/step - loss: 0.0012 -
mean_squared_error: 0.0012 - val_loss: 0.0127 - val_mean_squared_error: 0.0127
Epoch 11/80
6/6 [==============================] - 1s 237ms/step - loss: 7.8661e-04 -
mean_squared_error: 7.8661e-04 - val_loss: 0.0135 - val_mean_squared_error:
0.0135
Epoch 12/80
6/6 [==============================] - 1s 241ms/step - loss: 9.1438e-04 -
mean_squared_error: 9.1438e-04 - val_loss: 0.0046 - val_mean_squared_error:
0.0046
Epoch 13/80
6/6 [==============================] - 1s 239ms/step - loss: 6.8126e-04 -
mean_squared_error: 6.8126e-04 - val_loss: 0.0104 - val_mean_squared_error:
0.0104
Epoch 14/80
6/6 [==============================] - 1s 240ms/step - loss: 6.5225e-04 -
mean_squared_error: 6.5225e-04 - val_loss: 0.0086 - val_mean_squared_error:
0.0086
Epoch 15/80
6/6 [==============================] - 1s 239ms/step - loss: 8.3658e-04 -
mean_squared_error: 8.3658e-04 - val_loss: 0.0062 - val_mean_squared_error:
0.0062
```

```
Epoch 16/80
6/6 [==============================] - 1s 242ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0221 - val_mean_squared_error: 0.0221
Epoch 17/80
6/6 [==============================] - 1s 233ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0195 - val_mean_squared_error: 0.0195
Epoch 18/80
6/6 [==============================] - 1s 243ms/step - loss: 8.7184e-04 -
mean_squared_error: 8.7184e-04 - val_loss: 0.0097 - val_mean_squared_error:
0.0097
Epoch 19/80
6/6 [==============================] - 1s 245ms/step - loss: 6.1341e-04 -
mean_squared_error: 6.1341e-04 - val_loss: 0.0050 - val_mean_squared_error:
0.0050
Epoch 20/80
6/6 [==============================] - 1s 241ms/step - loss: 7.5277e-04 -
mean_squared_error: 7.5277e-04 - val_loss: 0.0107 - val_mean_squared_error:
0.0107
Epoch 21/80
6/6 [==============================] - 1s 240ms/step - loss: 5.9473e-04 -
mean_squared_error: 5.9473e-04 - val_loss: 0.0081 - val_mean_squared_error:
0.0081
Epoch 22/80
6/6 [==============================] - 1s 233ms/step - loss: 8.6049e-04 -
mean_squared_error: 8.6049e-04 - val_loss: 0.0141 - val_mean_squared_error:
0.0141
Epoch 23/80
6/6 [==============================] - 1s 244ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0028 - val_mean_squared_error: 0.0028
Epoch 24/80
6/6 [==============================] - 1s 243ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0012 - val_mean_squared_error: 0.0012
Epoch 25/80
6/6 [==============================] - 1s 239ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0129 - val_mean_squared_error: 0.0129
Epoch 26/80
6/6 [==============================] - 1s 233ms/step - loss: 9.0634e-04 -
mean_squared_error: 9.0634e-04 - val_loss: 0.0071 - val_mean_squared_error:
0.0071
Epoch 27/80
6/6 [==============================] - 1s 243ms/step - loss: 7.4441e-04 -
mean_squared_error: 7.4441e-04 - val_loss: 0.0094 - val_mean_squared_error:
0.0094
Epoch 28/80
6/6 [==============================] - 1s 238ms/step - loss: 7.6910e-04 -
mean_squared_error: 7.6910e-04 - val_loss: 0.0021 - val_mean_squared_error:
0.0021
Epoch 29/80
```

```
6/6 [==============================] - 1s 239ms/step - loss: 9.7212e-04 -
mean_squared_error: 9.7212e-04 - val_loss: 0.0083 - val_mean_squared_error:
0.0083
Epoch 30/80
6/6 [==============================] - 1s 242ms/step - loss: 8.9926e-04 -
mean_squared_error: 8.9926e-04 - val_loss: 0.0130 - val_mean_squared_error:
0.0130
Epoch 31/80
6/6 [==============================] - 1s 236ms/step - loss: 5.7969e-04 -
mean_squared_error: 5.7969e-04 - val_loss: 2.0267e-04 - val_mean_squared_error:
2.0267e-04
Epoch 32/80
6/6 [==============================] - 1s 239ms/step - loss: 8.6378e-04 -
mean_squared_error: 8.6378e-04 - val_loss: 0.0016 - val_mean_squared_error:
0.0016
Epoch 33/80
6/6 [==============================] - 1s 242ms/step - loss: 6.5591e-04 -
mean_squared_error: 6.5591e-04 - val_loss: 0.0081 - val_mean_squared_error:
0.0081
Epoch 34/80
6/6 [==============================] - 1s 239ms/step - loss: 7.0696e-04 -
mean_squared_error: 7.0696e-04 - val_loss: 0.0078 - val_mean_squared_error:
0.0078
Epoch 35/80
6/6 [==============================] - 1s 236ms/step - loss: 6.0298e-04 -
mean_squared_error: 6.0298e-04 - val_loss: 9.2510e-04 - val_mean_squared_error:
9.2510e-04
Epoch 36/80
6/6 [==============================] - 1s 234ms/step - loss: 6.5879e-04 -
mean_squared_error: 6.5879e-04 - val_loss: 0.0039 - val_mean_squared_error:
0.0039
Epoch 37/80
6/6 [==============================] - 1s 244ms/step - loss: 6.0147e-04 -
mean_squared_error: 6.0147e-04 - val_loss: 0.0085 - val_mean_squared_error:
0.0085
Epoch 38/80
6/6 [==============================] - 1s 244ms/step - loss: 5.7533e-04 -
mean_squared_error: 5.7533e-04 - val_loss: 0.0024 - val_mean_squared_error:
0.0024
Epoch 39/80
6/6 [==============================] - 1s 237ms/step - loss: 8.8198e-04 -
mean_squared_error: 8.8198e-04 - val_loss: 5.2688e-04 - val_mean_squared_error:
5.2688e-04
Epoch 40/80
6/6 [==============================] - 1s 245ms/step - loss: 0.0014 -
mean_squared_error: 0.0014 - val_loss: 0.0018 - val_mean_squared_error: 0.0018
Epoch 41/80
6/6 [==============================] - 1s 240ms/step - loss: 9.8566e-04 -
```

```
mean_squared_error: 9.8566e-04 - val_loss: 0.0160 - val_mean_squared_error:
0.0160
Epoch 42/80
6/6 [==============================] - 1s 238ms/step - loss: 0.0010 -
mean_squared_error: 0.0010 - val_loss: 0.0052 - val_mean_squared_error: 0.0052
Epoch 43/80
6/6 [==============================] - 1s 238ms/step - loss: 6.9772e-04 -
mean_squared_error: 6.9772e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 44/80
6/6 [==============================] - 1s 243ms/step - loss: 6.3572e-04 -
mean_squared_error: 6.3572e-04 - val_loss: 0.0051 - val_mean_squared_error:
0.0051
Epoch 45/80
6/6 [==============================] - 1s 241ms/step - loss: 5.6755e-04 -
mean_squared_error: 5.6755e-04 - val_loss: 0.0043 - val_mean_squared_error:
0.0043
Epoch 46/80
6/6 [==============================] - 1s 238ms/step - loss: 5.3621e-04 -
mean_squared_error: 5.3621e-04 - val_loss: 0.0040 - val_mean_squared_error:
0.0040
Epoch 47/80
6/6 [==============================] - 1s 244ms/step - loss: 8.7851e-04 -
mean_squared_error: 8.7851e-04 - val_loss: 0.0139 - val_mean_squared_error:
0.0139
Epoch 48/80
6/6 [==============================] - 1s 229ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0074 - val_mean_squared_error: 0.0074
Epoch 49/80
6/6 [==============================] - 1s 239ms/step - loss: 8.4468e-04 -
mean_squared_error: 8.4468e-04 - val_loss: 7.2869e-05 - val_mean_squared_error:
7.2869e-05
Epoch 50/80
6/6 [==============================] - 1s 237ms/step - loss: 9.1763e-04 -
mean_squared_error: 9.1763e-04 - val_loss: 0.0104 - val_mean_squared_error:
0.0104
Epoch 51/80
6/6 [==============================] - 1s 234ms/step - loss: 9.8808e-04 -
mean_squared_error: 9.8808e-04 - val_loss: 0.0087 - val_mean_squared_error:
0.0087
Epoch 52/80
6/6 [==============================] - 1s 235ms/step - loss: 7.5369e-04 -
mean_squared_error: 7.5369e-04 - val_loss: 0.0014 - val_mean_squared_error:
0.0014
Epoch 53/80
6/6 [==============================] - 1s 239ms/step - loss: 7.6372e-04 -
mean_squared_error: 7.6372e-04 - val_loss: 2.1822e-04 - val_mean_squared_error:
2.1822e-04
```

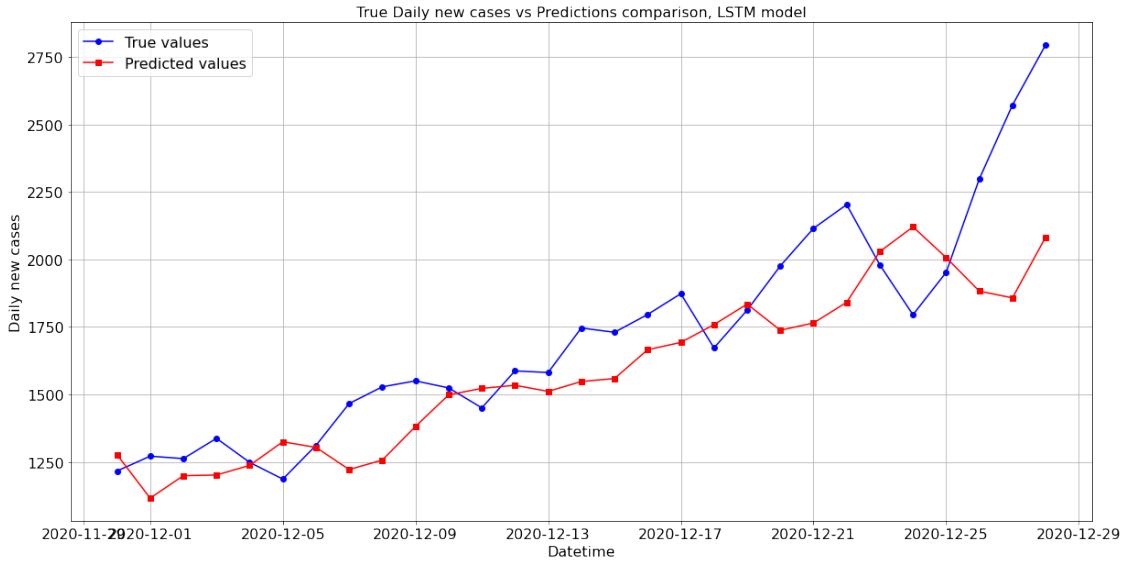
```
Epoch 54/80
6/6 [==============================] - 1s 242ms/step - loss: 6.5357e-04 -
mean_squared_error: 6.5357e-04 - val_loss: 0.0027 - val_mean_squared_error:
0.0027
Epoch 55/80
6/6 [==============================] - 1s 239ms/step - loss: 5.6196e-04 -
mean_squared_error: 5.6196e-04 - val_loss: 0.0070 - val_mean_squared_error:
0.0070
Epoch 56/80
6/6 [==============================] - 1s 244ms/step - loss: 4.8416e-04 -
mean_squared_error: 4.8416e-04 - val_loss: 0.0061 - val_mean_squared_error:
0.0061
Epoch 57/80
6/6 [==============================] - 1s 240ms/step - loss: 5.6177e-04 -
mean_squared_error: 5.6177e-04 - val_loss: 0.0083 - val_mean_squared_error:
0.0083
Epoch 58/80
6/6 [==============================] - 1s 242ms/step - loss: 6.1471e-04 -
mean_squared_error: 6.1471e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 59/80
6/6 [==============================] - 1s 247ms/step - loss: 6.0036e-04 -
mean_squared_error: 6.0036e-04 - val_loss: 0.0022 - val_mean_squared_error:
0.0022
Epoch 60/80
6/6 [==============================] - 1s 242ms/step - loss: 7.3599e-04 -
mean_squared_error: 7.3599e-04 - val_loss: 0.0112 - val_mean_squared_error:
0.0112
Epoch 61/80
6/6 [==============================] - 1s 236ms/step - loss: 8.6388e-04 -
mean_squared_error: 8.6388e-04 - val_loss: 0.0130 - val_mean_squared_error:
0.0130
Epoch 62/80
6/6 [==============================] - 1s 241ms/step - loss: 0.0011 -
mean_squared_error: 0.0011 - val_loss: 0.0059 - val_mean_squared_error: 0.0059
Epoch 63/80
6/6 [==============================] - 1s 238ms/step - loss: 7.2987e-04 -
mean_squared_error: 7.2987e-04 - val_loss: 0.0037 - val_mean_squared_error:
0.0037
Epoch 64/80
6/6 [==============================] - 1s 232ms/step - loss: 5.6987e-04 -
mean_squared_error: 5.6987e-04 - val_loss: 0.0017 - val_mean_squared_error:
0.0017
Epoch 65/80
6/6 [==============================] - 1s 230ms/step - loss: 4.4226e-04 -
mean_squared_error: 4.4226e-04 - val_loss: 0.0057 - val_mean_squared_error:
0.0057
Epoch 66/80
```

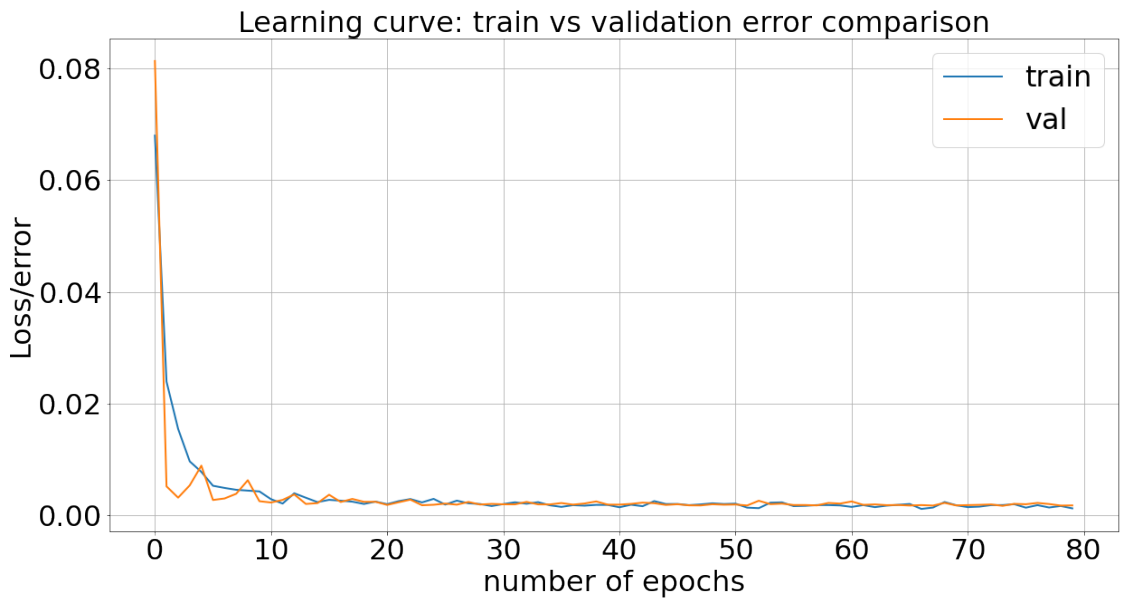
```
6/6 [==============================] - 1s 242ms/step - loss: 4.3015e-04 -
mean_squared_error: 4.3015e-04 - val_loss: 0.0034 - val_mean_squared_error:
0.0034
Epoch 67/80
6/6 [==============================] - 1s 236ms/step - loss: 5.1295e-04 -
mean_squared_error: 5.1295e-04 - val_loss: 0.0023 - val_mean_squared_error:
0.0023
Epoch 68/80
6/6 [==============================] - 1s 239ms/step - loss: 5.8710e-04 -
mean_squared_error: 5.8710e-04 - val_loss: 0.0045 - val_mean_squared_error:
0.0045
Epoch 69/80
6/6 [==============================] - 1s 233ms/step - loss: 5.4396e-04 -
mean_squared_error: 5.4396e-04 - val_loss: 0.0097 - val_mean_squared_error:
0.0097
Epoch 70/80
6/6 [==============================] - 1s 234ms/step - loss: 4.7923e-04 -
mean_squared_error: 4.7923e-04 - val_loss: 0.0095 - val_mean_squared_error:
0.0095
Epoch 71/80
6/6 [==============================] - 1s 240ms/step - loss: 4.7689e-04 -
mean_squared_error: 4.7689e-04 - val_loss: 0.0035 - val_mean_squared_error:
0.0035
Epoch 72/80
6/6 [==============================] - 1s 234ms/step - loss: 4.7002e-04 -
mean_squared_error: 4.7002e-04 - val_loss: 0.0031 - val_mean_squared_error:
0.0031
Epoch 73/80
6/6 [==============================] - 1s 249ms/step - loss: 5.7051e-04 -
mean_squared_error: 5.7051e-04 - val_loss: 0.0046 - val_mean_squared_error:
0.0046
Epoch 74/80
6/6 [==============================] - 1s 246ms/step - loss: 4.5692e-04 -
mean_squared_error: 4.5692e-04 - val_loss: 0.0070 - val_mean_squared_error:
0.0070
Epoch 75/80
6/6 [==============================] - 1s 237ms/step - loss: 4.0013e-04 -
mean_squared_error: 4.0013e-04 - val_loss: 0.0070 - val_mean_squared_error:
0.0070
Epoch 76/80
6/6 [==============================] - 1s 248ms/step - loss: 3.5249e-04 -
mean_squared_error: 3.5249e-04 - val_loss: 0.0067 - val_mean_squared_error:
0.0067
Epoch 77/80
6/6 [==============================] - 1s 229ms/step - loss: 4.0870e-04 -
mean_squared_error: 4.0870e-04 - val_loss: 0.0041 - val_mean_squared_error:
0.0041
Epoch 78/80
```

```
6/6 [==============================] - 1s 243ms/step - loss: 5.0617e-04 -
mean_squared_error: 5.0617e-04 - val_loss: 0.0015 - val_mean_squared_error:
0.0015
Epoch 79/80
6/6 [==============================] - 1s 237ms/step - loss: 9.4512e-04 -
mean_squared_error: 9.4512e-04 - val_loss: 0.0025 - val_mean_squared_error:
0.0025
Epoch 80/80
6/6 [==============================] - 1s 233ms/step - loss: 6.3640e-04 -
mean_squared_error: 6.3640e-04 - val_loss: 0.0044 - val_mean_squared_error:
0.0044

--------------------------------------------------
LSTM model: {'time_lag': 21, 'num_LSTM_layer': 2, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}, RMSE=344.1888749068746
--------------------------------------------------


-------------------------***--------------------------
Best LSTM model:{'time_lag': 7, 'num_LSTM_layer': 1, 'learning_rate': 0.001,
'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch':
32}, RMSE=261.5880688924358
```





******
LSTM test rmse: 261.5880688924358 with optimal parameter set: {'time_lag': 7, 'num_LSTM_layer': 1, 'learning_rate': 0.001, 'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'num_epochs': 80, 'num_batch': 32}

----------2.3.2 ARIMA prediction on daily new healthcare----------

---
ARIMA model: (0, 0, 0), RMSE=654.9551075344466

ARIMA model: (0, 0, 1), RMSE=403.4662953232788

ARIMA model: (0, 0, 2), RMSE=254.00690372988436

ARIMA model: (0, 1, 0), RMSE=111.85779833209193

```
------------------------------------------------
ARIMA model: (0, 1, 1), RMSE=111.95747713769516
------------------------------------------------


------------------------------------------------
ARIMA model: (0, 1, 2), RMSE=121.1495595144991
------------------------------------------------


------------------------------------------------
ARIMA model: (1, 0, 0), RMSE=111.9906874532725
------------------------------------------------


------------------------------------------------
ARIMA model: (1, 0, 1), RMSE=112.12343371852675
------------------------------------------------


------------------------------------------------
ARIMA model: (1, 0, 2), RMSE=121.64923526074301
------------------------------------------------


------------------------------------------------
ARIMA model: (1, 1, 0), RMSE=112.07323612900147
------------------------------------------------


------------------------------------------------
ARIMA model: (1, 1, 1), RMSE=114.17578927911421
------------------------------------------------


------------------------------------------------
ARIMA model: (1, 1, 2), RMSE=121.24041073457823
------------------------------------------------


------------------------------------------------
ARIMA model: (2, 0, 0), RMSE=112.22419643935649
------------------------------------------------


------------------------------------------------
ARIMA model: (2, 0, 1), RMSE=114.25584053511731
```

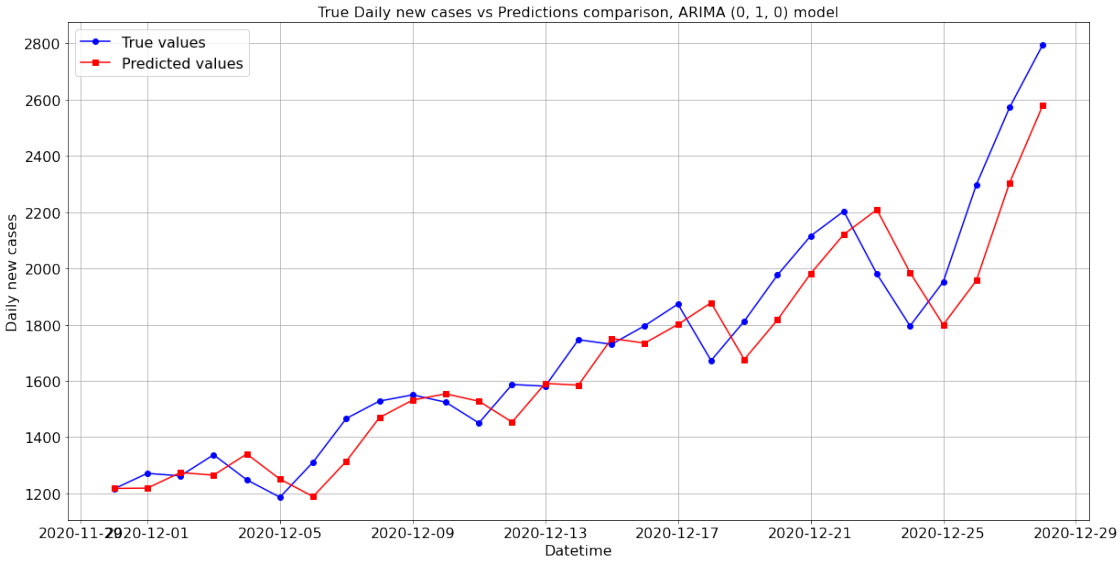
```
------------------------------------------------


------------------------------------------------
ARIMA model: (2, 0, 2), RMSE=120.88582746055239
------------------------------------------------


------------------------------------------------
ARIMA model: (2, 1, 0), RMSE=114.82282420937261
------------------------------------------------


------------------------------------------------
ARIMA model: (2, 1, 1), RMSE=116.5775586837089
------------------------------------------------


-------------------------***---------------------------
Best ARIMA model:(0, 1, 0), RMSE=111.85779833209193
```




```
******
ARIMA test rmse: 141.5128712197218 with optimal parameter set: (0, 1, 0)


------------2.3.3 SARIMAX prediction on daily new healthcare------------


------------------------------------------------
```

```
SARIMAX model: [(0, 1, 0), (0, 0, 0, 7), 'n'], RMSE=111.76262219959871
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 0, 7), 'c'], RMSE=111.89280855934217
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 0, 7), 't'], RMSE=112.2194750567774
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 0, 7), 'ct'], RMSE=112.4467897573697
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 0, 14), 'n'], RMSE=111.76262219959871
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 0, 14), 'c'], RMSE=111.89280855934217
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 0, 14), 't'], RMSE=112.2194750567774
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 0, 14), 'ct'], RMSE=112.4467897573697
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 7), 'n'], RMSE=101.21907219132432
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 7), 'c'], RMSE=101.64506572025444
--------------------------------------------------
```

```
--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 7), 't'], RMSE=101.76908776009459
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 7), 'ct'], RMSE=102.7710239269653
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 14), 'n'], RMSE=96.95034662924978
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 14), 'c'], RMSE=97.7523817674889
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 14), 't'], RMSE=97.53682466380926
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 1, 14), 'ct'], RMSE=101.1183026635679
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 7), 'n'], RMSE=92.29567017726332
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 7), 'c'], RMSE=92.77293111342046
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 7), 't'], RMSE=92.8990085491475
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 7), 'ct'], RMSE=95.29460058617431
```

```
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 14), 'n'], RMSE=93.40660541392066
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 14), 'c'], RMSE=93.7197640905796
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 14), 't'], RMSE=94.15437544245451
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 0, 2, 14), 'ct'], RMSE=97.09177775372792
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 7), 'n'], RMSE=98.54381624906883
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 7), 'c'], RMSE=98.42942239857054
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 7), 't'], RMSE=99.25353772924221
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 7), 'ct'], RMSE=101.24597252511737
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 14), 'n'], RMSE=91.90250142102708
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 14), 'c'], RMSE=91.11618921348509
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 14), 't'], RMSE=92.53834471338735
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 0, 14), 'ct'], RMSE=98.78371414517937
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 7), 'n'], RMSE=82.18542566373512
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 7), 'c'], RMSE=81.75942389215616
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 7), 't'], RMSE=83.18581346282728
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 7), 'ct'], RMSE=88.77469153005417
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 14), 'n'], RMSE=90.31325060771078
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 14), 'c'], RMSE=90.84755124065167
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 14), 't'], RMSE=91.61320560180349
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 1, 14), 'ct'], RMSE=92.20177957564633
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 7), 'n'], RMSE=88.67255109852353
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 7), 'c'], RMSE=88.98278076032136
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 7), 't'], RMSE=89.67608572373054
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 7), 'ct'], RMSE=90.54883853645691
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 14), 'n'], RMSE=91.55425976093174
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 14), 'c'], RMSE=93.37984441185758
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 14), 't'], RMSE=93.81094181560844
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 1, 2, 14), 'ct'], RMSE=91.75434725207035
------------------------------------------------


------------------------------------------------
```

```
SARIMAX model: [(0, 1, 0), (0, 2, 0, 7), 'n'], RMSE=180.18911254309953
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 0, 7), 'c'], RMSE=180.68061429823751
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 0, 7), 't'], RMSE=181.4140212907303
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 0, 7), 'ct'], RMSE=181.91746280528886
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 0, 14), 'n'], RMSE=137.0854427160344
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 0, 14), 'c'], RMSE=139.55903026886926
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 0, 14), 't'], RMSE=138.38445595919126
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 0, 14), 'ct'], RMSE=138.44028406027576
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 7), 'n'], RMSE=100.11044852942878
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 7), 'c'], RMSE=102.84217825523163
--------------------------------------------------
```

```
--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 7), 't'], RMSE=102.78241160519335
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 7), 'ct'], RMSE=102.11094809767262
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 14), 'n'], RMSE=107.99666695855583
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 14), 'c'], RMSE=109.72768744478931
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 14), 't'], RMSE=109.5567407346717
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 1, 14), 'ct'], RMSE=102.83215986872511
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 7), 'n'], RMSE=93.93518431429054
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 7), 'c'], RMSE=96.04252979808469
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 7), 't'], RMSE=96.67218106865612
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 7), 'ct'], RMSE=95.51205325759086
```

```
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 14), 'n'], RMSE=107.62223389616638
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 14), 'c'], RMSE=108.57501989416005
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 14), 't'], RMSE=108.07345260170645
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (0, 2, 2, 14), 'ct'], RMSE=103.83615517920727
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 7), 'n'], RMSE=98.8447748639312
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 7), 'c'], RMSE=99.28227406517595
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 7), 't'], RMSE=99.41716138061474
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 7), 'ct'], RMSE=100.35128010630204
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 14), 'n'], RMSE=106.86121927023623
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 14), 'c'], RMSE=108.09508177912402
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 14), 't'], RMSE=107.445008098448
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 0, 14), 'ct'], RMSE=110.54058051955283
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 7), 'n'], RMSE=104.22735464315377
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 7), 'c'], RMSE=102.4282466307511
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 7), 't'], RMSE=101.69207418174885
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 7), 'ct'], RMSE=109.30536316664997
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 14), 'n'], RMSE=96.81169726404917
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 14), 'c'], RMSE=97.39353946053613
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 14), 't'], RMSE=97.37196045602755
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 1, 14), 'ct'], RMSE=99.97314425839164
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 7), 'n'], RMSE=91.28409250502202
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 7), 'c'], RMSE=91.73091535074782
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 7), 't'], RMSE=91.8924497261037
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 7), 'ct'], RMSE=94.26314152736892
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 14), 'n'], RMSE=96.3164231235365
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 14), 'c'], RMSE=95.35638225581646
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 14), 't'], RMSE=97.44000485126189
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 0, 2, 14), 'ct'], RMSE=98.928048652775
------------------------------------------------


------------------------------------------------
```

```
SARIMAX model: [(0, 1, 0), (1, 1, 0, 7), 'n'], RMSE=81.27475091743712
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 0, 7), 'c'], RMSE=80.69063221865014
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 0, 7), 't'], RMSE=81.846663678513
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 0, 7), 'ct'], RMSE=86.84135236818051
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 0, 14), 'n'], RMSE=91.6447676266181
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 0, 14), 'c'], RMSE=92.39848587398976
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 0, 14), 't'], RMSE=92.98583177833942
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 0, 14), 'ct'], RMSE=92.73786964991932
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 7), 'n'], RMSE=88.14830876665984
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 7), 'c'], RMSE=81.84801814205677
--------------------------------------------------
```

```
--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 7), 't'], RMSE=83.31114906642061
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 7), 'ct'], RMSE=86.39950696639708
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 14), 'n'], RMSE=92.92982729651865
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 14), 'c'], RMSE=93.58720776143704
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 14), 't'], RMSE=94.30690216800981
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 1, 14), 'ct'], RMSE=95.69207638003098
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 7), 'n'], RMSE=86.97838303149707
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 7), 'c'], RMSE=88.0738931149355
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 7), 't'], RMSE=87.88608872651771
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 7), 'ct'], RMSE=87.20991048176116
```

```
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 14), 'n'], RMSE=90.79348899668092
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 14), 'c'], RMSE=92.3161257638692
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 14), 't'], RMSE=92.91143284677854
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 1, 2, 14), 'ct'], RMSE=91.62505124551737
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 7), 'n'], RMSE=124.99086995753629
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 7), 'c'], RMSE=125.88814568162935
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 7), 't'], RMSE=125.93722226896368
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 7), 'ct'], RMSE=126.93011792092199
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 14), 'n'], RMSE=117.83263611380721
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 14), 'c'], RMSE=118.75404120570659
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 14), 't'], RMSE=118.5403589223325
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 0, 14), 'ct'], RMSE=117.3402106723011
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 7), 'n'], RMSE=96.09066620599972
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 7), 'c'], RMSE=98.77097551218289
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 7), 't'], RMSE=98.81121530963134
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 7), 'ct'], RMSE=97.4244370959853
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 14), 'n'], RMSE=101.20463158452183
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 14), 'c'], RMSE=103.39754635184536
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 14), 't'], RMSE=102.72694670074264
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 1, 14), 'ct'], RMSE=98.36477077918562
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 7), 'n'], RMSE=93.97027139783332
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 7), 'c'], RMSE=96.96776494452328
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 7), 't'], RMSE=96.50124924732356
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 7), 'ct'], RMSE=104.44205138838504
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 14), 'n'], RMSE=98.32878088831774
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 14), 'c'], RMSE=100.50894187311685
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 14), 't'], RMSE=98.49484631049998
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (1, 2, 2, 14), 'ct'], RMSE=97.21399929495664
------------------------------------------------


------------------------------------------------
```

```
SARIMAX model: [(0, 1, 0), (2, 0, 0, 7), 'n'], RMSE=99.91774827318095
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 0, 7), 'c'], RMSE=101.05485157998159
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 0, 7), 't'], RMSE=100.52891275862157
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 0, 7), 'ct'], RMSE=104.59703106431762
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 0, 14), 'n'], RMSE=94.71834063805635
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 0, 14), 'c'], RMSE=95.04722639664276
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 0, 14), 't'], RMSE=95.5172063116277
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 0, 14), 'ct'], RMSE=99.07928457800887
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 7), 'n'], RMSE=99.9548986183701
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 7), 'c'], RMSE=100.20920961256002
--------------------------------------------------
```

```
--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 7), 't'], RMSE=100.60247331923243
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 7), 'ct'], RMSE=101.0124015578846
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 14), 'n'], RMSE=97.36314421360805
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 14), 'c'], RMSE=100.40906386334385
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 14), 't'], RMSE=100.80493877659735
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 1, 14), 'ct'], RMSE=99.4446920433397
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 7), 'n'], RMSE=91.34574977319222
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 7), 'c'], RMSE=91.9438756590757
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 7), 't'], RMSE=92.06671527828651
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 7), 'ct'], RMSE=94.70689105451652
```

```
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 14), 'n'], RMSE=96.40556774389866
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 14), 'c'], RMSE=97.3650279288233
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 14), 't'], RMSE=99.61443667610176
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 0, 2, 14), 'ct'], RMSE=98.52549752894933
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 7), 'n'], RMSE=88.52646478203124
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 7), 'c'], RMSE=88.91249891942513
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 7), 't'], RMSE=89.41293781416013
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 7), 'ct'], RMSE=89.73476046046191
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 14), 'n'], RMSE=92.62954759266188
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 14), 'c'], RMSE=94.04543254218486
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 14), 't'], RMSE=94.32018819036938
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 0, 14), 'ct'], RMSE=93.14622205424641
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 7), 'n'], RMSE=85.72283032715265
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 7), 'c'], RMSE=89.19070059312192
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 7), 't'], RMSE=90.26385741722939
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 7), 'ct'], RMSE=87.05867020426889
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 14), 'n'], RMSE=95.76485919085458
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 14), 'c'], RMSE=96.76108448011513
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 14), 't'], RMSE=95.59703801957701
------------------------------------------------
```

```
------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 1, 14), 'ct'], RMSE=93.4030572315922
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 7), 'n'], RMSE=87.28777026495726
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 7), 'c'], RMSE=88.41814621858676
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 7), 't'], RMSE=88.62522428411029
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 7), 'ct'], RMSE=89.47082936340769
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 14), 'n'], RMSE=91.07783554820205
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 14), 'c'], RMSE=92.19084316138122
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 14), 't'], RMSE=92.99995524311095
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 1, 2, 14), 'ct'], RMSE=93.97268412747489
------------------------------------------------


------------------------------------------------
```

```
SARIMAX model: [(0, 1, 0), (2, 2, 0, 7), 'n'], RMSE=119.90735201886483
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 0, 7), 'c'], RMSE=120.3768364119167
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 0, 7), 't'], RMSE=120.79218629317694
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 0, 7), 'ct'], RMSE=120.04764458974772
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 0, 14), 'n'], RMSE=110.6839925457952
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 0, 14), 'c'], RMSE=111.00899280699016
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 0, 14), 't'], RMSE=110.97003615074644
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 0, 14), 'ct'], RMSE=110.44397560433937
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 7), 'n'], RMSE=100.94882898714829
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 7), 'c'], RMSE=102.81192836301341
--------------------------------------------------
```

```
--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 7), 't'], RMSE=104.85029435973978
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 7), 'ct'], RMSE=101.69186605956162
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 14), 'n'], RMSE=96.76733097025478
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 14), 'c'], RMSE=98.10863725541788
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 14), 't'], RMSE=96.43573479119851
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 1, 14), 'ct'], RMSE=97.58284358263809
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 7), 'n'], RMSE=102.97622326409028
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 7), 'c'], RMSE=91.58602459420582
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 7), 't'], RMSE=89.91658174311753
--------------------------------------------------


--------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 7), 'ct'], RMSE=94.04698980153935
```

```
------------------------------------------------

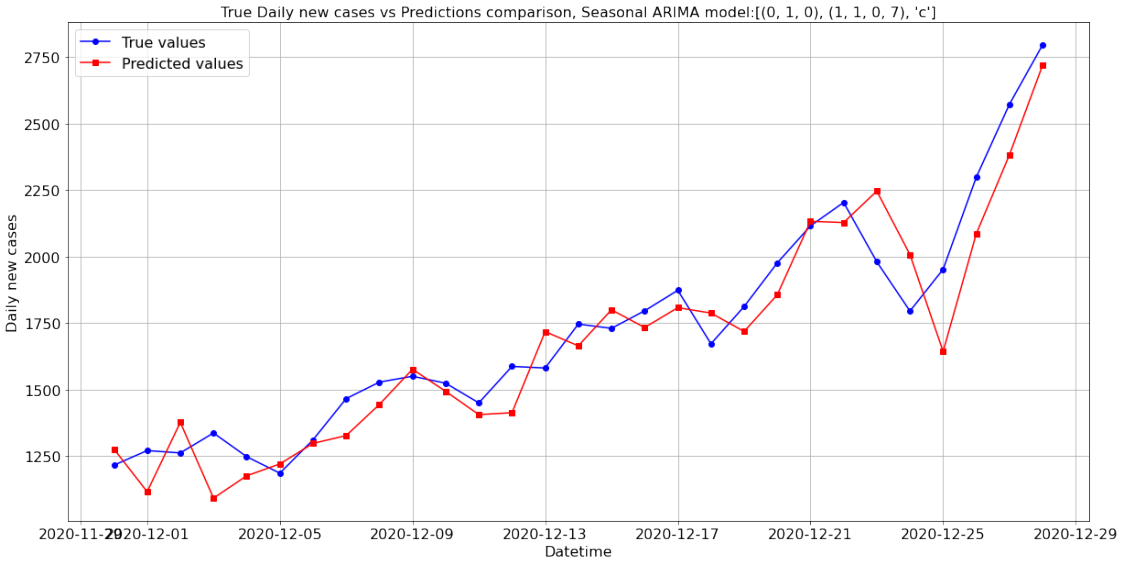

------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 14), 'n'], RMSE=103.03884851267027
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 14), 'c'], RMSE=104.40062280434404
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 14), 't'], RMSE=97.79193054208537
------------------------------------------------


------------------------------------------------
SARIMAX model: [(0, 1, 0), (2, 2, 2, 14), 'ct'], RMSE=104.3309324713705
------------------------------------------------


-------------------------***---------------------------
Best SARIMAX model:[(0, 1, 0), (1, 1, 0, 7), 'c'], RMSE=80.69063221865014
```




```
******
SARIMAX test rmse: 137.25523024664096 with optimal parameter set: [(0, 1, 0),
(1, 1, 0, 7), 'c']
```

```
----------2.3.4 SES prediction on daily new healthcare----------------

111.87121672570495

--------------------------------------------------
SES model: {'initialization_method': None}, RMSE=111.87121672570495
--------------------------------------------------

111.87124172603

--------------------------------------------------
SES model: {'initialization_method': 'estimated'}, RMSE=111.87124172603
--------------------------------------------------

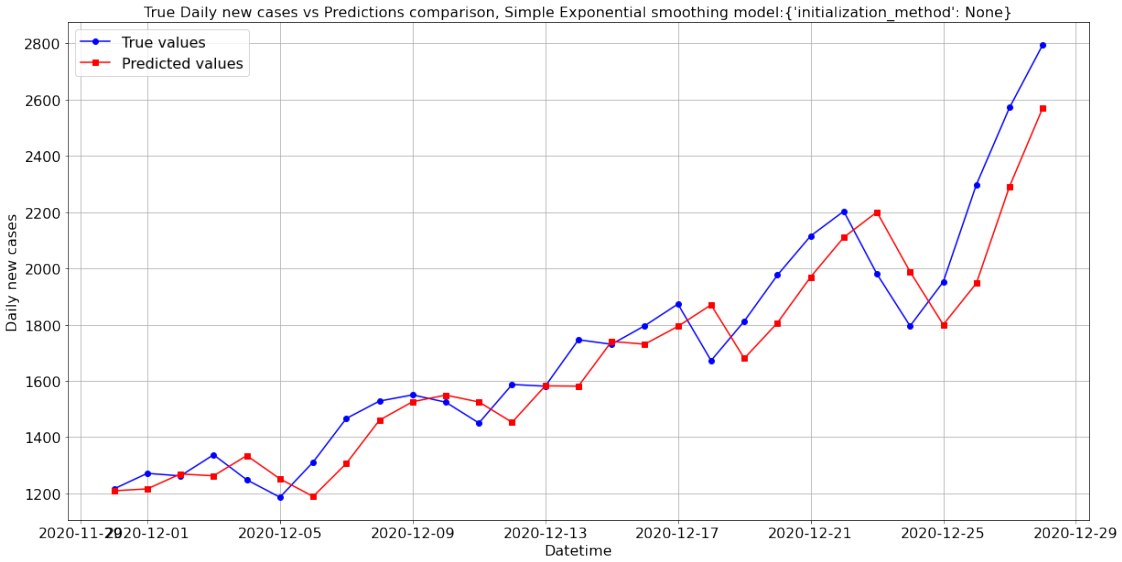
111.87124172603

--------------------------------------------------
SES model: {'initialization_method': 'heuristic'}, RMSE=111.87124172603
--------------------------------------------------

111.87121672570495

--------------------------------------------------
SES model: {'initialization_method': 'legacy-heuristic'},
RMSE=111.87121672570495
--------------------------------------------------


------------------------***--------------------------
Best SES model:{'initialization_method': None}, RMSE=111.87121672570495
```



******
SES test rmse: 144.45627952769814 with optimal parameter set:
{'initialization_method': None}

----------2.3.5 HWES predictions on daily new healthcare----------

90.18351232382963

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'additive'}, RMSE=90.18351232382963

107.1004680470469

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'multiplicative'}, RMSE=107.1004680470469

88.36878085320045

HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'additive'}, RMSE=88.36878085320045

113.27264574020656

```
------------------------------------------------
HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'multiplicative'}, RMSE=113.27264574020656
------------------------------------------------

107.9616661671484

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'additive'}, RMSE=107.9616661671484
------------------------------------------------

118.505317546211

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'multiplicative'}, RMSE=118.505317546211
------------------------------------------------

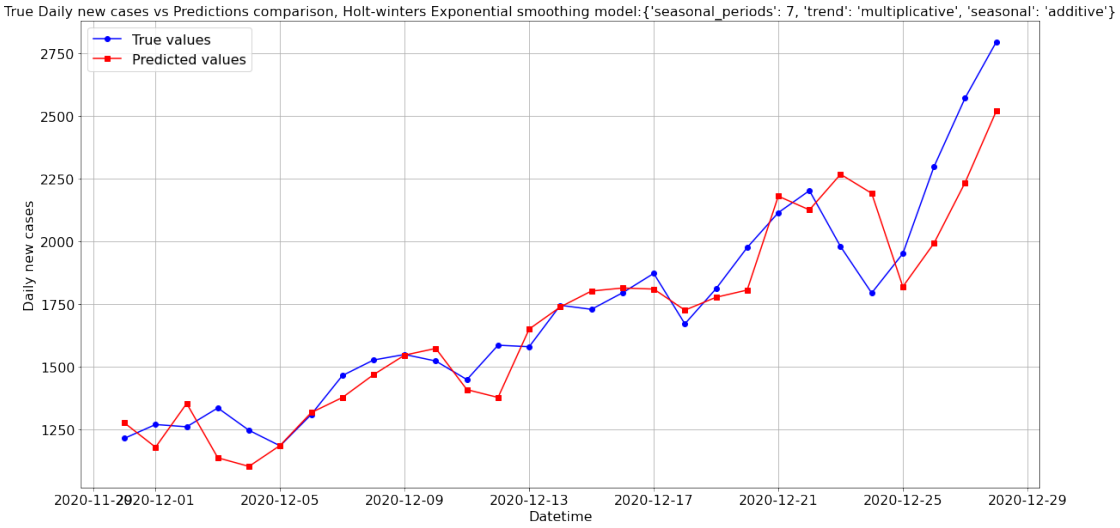
126.35997164602121

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'additive'}, RMSE=126.35997164602121
------------------------------------------------

252.45280693823895

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'multiplicative'}, RMSE=252.45280693823895
------------------------------------------------


------------------------***-------------------------
Best HWES model:{'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'additive'}, RMSE=88.36878085320045
```



******
HWES test rmse: 159.45552295686153 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal': 'additive'}

----------2.3.6 HWES with damping predictions on daily new
healthcare----------

84.97532261000933

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'additive',
'damped_trend': 'True'}, RMSE=84.97532261000933

105.8664536951156

HWES model: {'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=105.8664536951156

87.76308946947634

HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=87.76308946947634

114.52770104253746

```
------------------------------------------------
HWES model: {'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=114.52770104253746
------------------------------------------------

107.09124494624541

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=107.09124494624541
------------------------------------------------

133.99756253479788

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'additive', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=133.99756253479788
------------------------------------------------

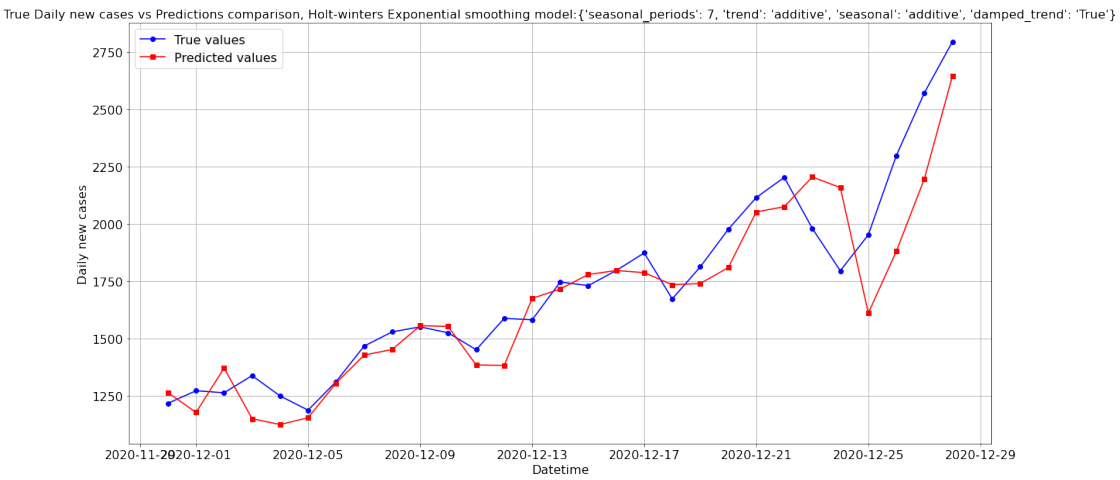
115.73628947822816

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=115.73628947822816
------------------------------------------------

241.37369479471153

------------------------------------------------
HWES model: {'seasonal_periods': 14, 'trend': 'multiplicative', 'seasonal':
'multiplicative', 'damped_trend': 'True'}, RMSE=241.37369479471153
------------------------------------------------


------------------------***-------------------------
Best HWES model:{'seasonal_periods': 7, 'trend': 'additive', 'seasonal':
'additive', 'damped_trend': 'True'}, RMSE=84.97532261000933
```



******
HWES_damped test rmse: 170.68643785348888 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'additive',
'damped_trend': 'True'}

****
----------Summary of Section 2: Daily New healthcare admissions test
results:--------------
LSTM test rmse: 261.5880688924358 with optimal parameter set: {'time_lag': 7,
'num_LSTM_layer': 1, 'learning_rate': 0.001, 'beta_1': 0.9, 'beta_2': 0.999,
'epsilon': 1e-07, 'num_epochs': 80, 'num_batch': 32}

ARIMA test rmse: 141.5128712197218 with optimal parameter set: (0, 1, 0)

SARIMAX test rmse: 137.25523024664096 with optimal parameter set: [(0, 1, 0),
(1, 1, 0, 7), 'c']

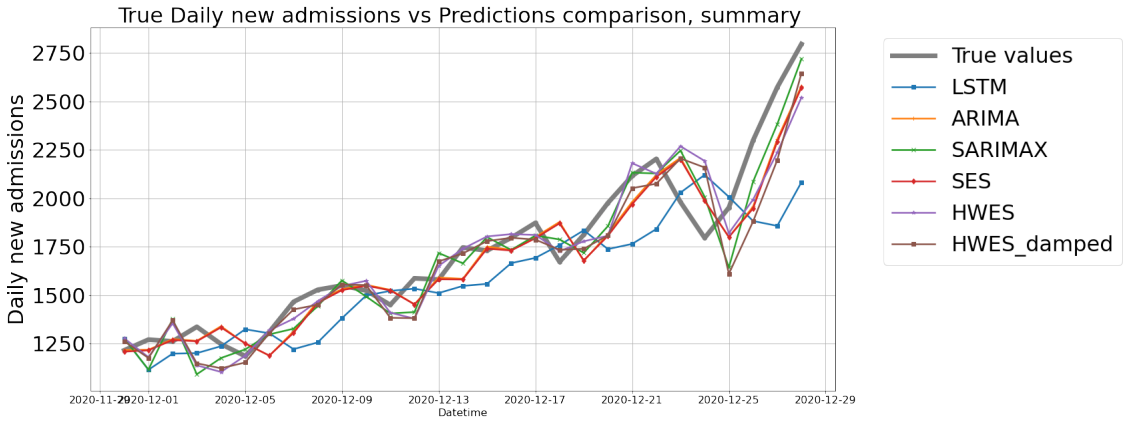
SES test rmse: 144.45627952769814 with optimal parameter set:
{'initialization_method': None}

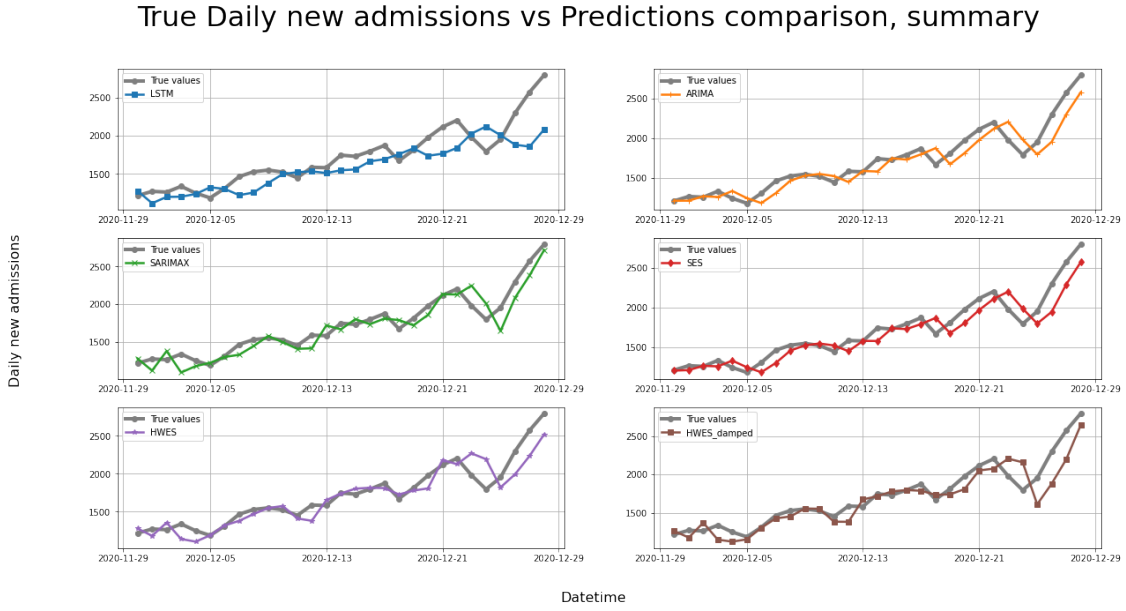
HWES test rmse: 159.45552295686153 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'multiplicative', 'seasonal': 'additive'}

HWES_damped test rmse: 170.68643785348888 with optimal parameter set:
{'seasonal_periods': 7, 'trend': 'additive', 'seasonal': 'additive',
'damped_trend': 'True'}

----print accuracy matrices:------

	LSTM	ARIMA	SARIMAX	SES	HWES	HWES_damped
MAE	189.339747	114.737551	113.622374	116.772520	117.553417	125.841107
RMSE	261.588069	141.512871	137.255230	144.456280	159.455523	170.686438
R2	0.568984	0.873861	0.881337	0.868559	0.839847	0.816492

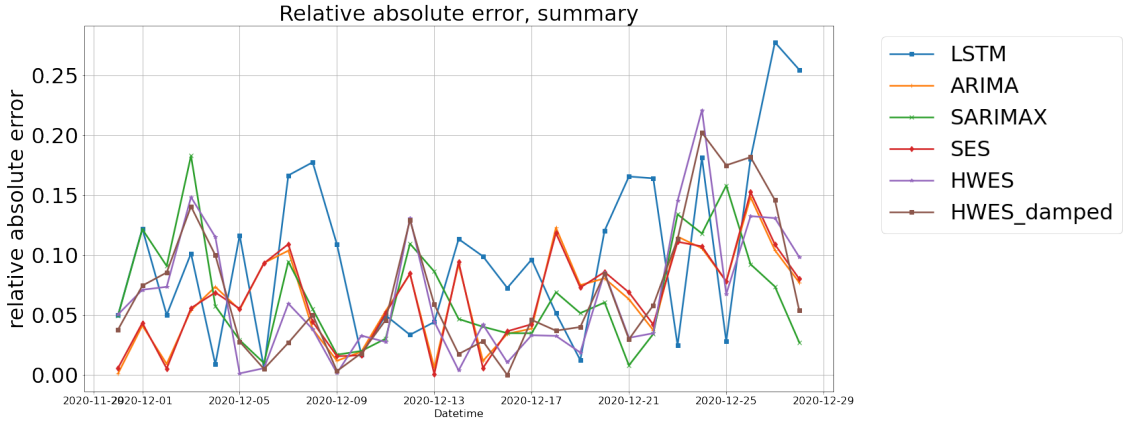




----print relative absolute error table----

	Test Date	LSTM	ARIMA	SARIMAX	SES	HWES	HWES_damped
0	2020-11-30	0.049897	0.001206	0.049658	0.005774	0.050566	0.037889
1	2020-12-01	0.122291	0.041337	0.121734	0.043491	0.071187	0.074602
2	2020-12-02	0.050159	0.009244	0.091044	0.005397	0.073619	0.085583
3	2020-12-03	0.101545	0.054136	0.183079	0.055894	0.148566	0.140733

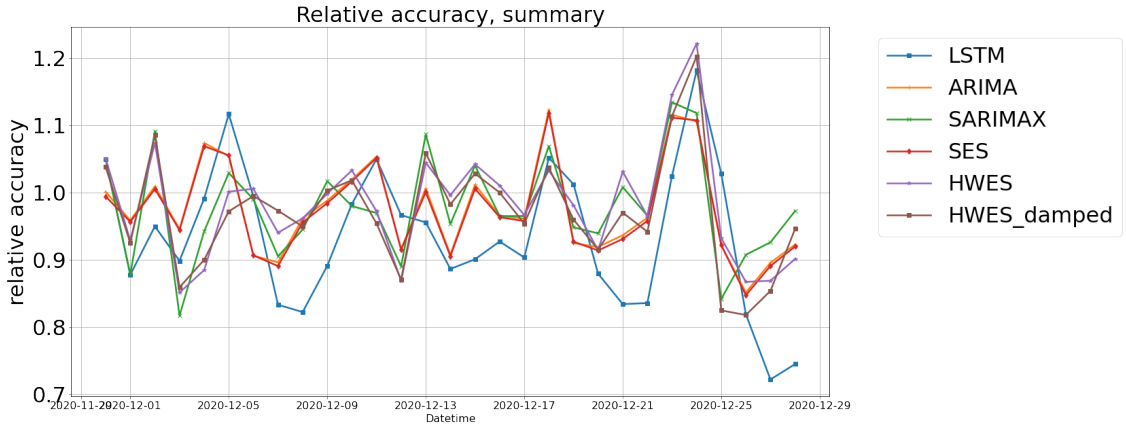
4	2020-12-04	0.008911	0.073638	0.057601	0.068931	0.115223	0.100003
5	2020-12-05	0.116698	0.054423	0.029133	0.055290	0.001338	0.027882
6	2020-12-06	0.005743	0.093594	0.009971	0.093346	0.005680	0.005083
7	2020-12-07	0.166711	0.103842	0.094692	0.109269	0.059638	0.026878
8	2020-12-08	0.177647	0.038386	0.055004	0.044442	0.038291	0.050405
9	2020-12-09	0.108938	0.011891	0.016979	0.015667	0.001579	0.003284
10	2020-12-10	0.016913	0.019447	0.020025	0.016529	0.032903	0.018252
11	2020-12-11	0.049815	0.053466	0.030362	0.051618	0.027625	0.045864
12	2020-12-12	0.033569	0.084287	0.109659	0.084767	0.131112	0.129454
13	2020-12-13	0.044267	0.006158	0.086435	0.000742	0.044545	0.058911
14	2020-12-14	0.113536	0.092383	0.046791	0.094478	0.003793	0.017536
15	2020-12-15	0.099112	0.011732	0.040303	0.005834	0.042110	0.028162
16	2020-12-16	0.072712	0.034398	0.034954	0.036546	0.010526	0.000064
17	2020-12-17	0.096419	0.038735	0.034878	0.042384	0.033246	0.046040
18	2020-12-18	0.051642	0.123035	0.069091	0.118559	0.032651	0.037025
19	2020-12-19	0.012460	0.075075	0.051670	0.072965	0.018806	0.040059
20	2020-12-20	0.120581	0.080740	0.060575	0.086058	0.085672	0.084692
21	2020-12-21	0.165779	0.063340	0.008054	0.068974	0.031062	0.029822
22	2020-12-22	0.164256	0.037440	0.034259	0.042165	0.034875	0.058209
23	2020-12-23	0.024721	0.115564	0.134180	0.111224	0.145495	0.113587
24	2020-12-24	0.181403	0.105848	0.118163	0.107449	0.221249	0.202400
25	2020-12-25	0.028199	0.078218	0.158255	0.078034	0.067596	0.175148
26	2020-12-26	0.180794	0.148450	0.092477	0.152710	0.132680	0.181936
27	2020-12-27	0.277807	0.104171	0.073860	0.109025	0.131026	0.146082
28	2020-12-28	0.254927	0.077275	0.027299	0.080279	0.098544	0.053895



----print relative accuracy table----

	Test Date	LSTM	ARIMA	SARIMAX	SES	HWES	HWES_damped
0	2020-11-30	1.049897	1.001206	1.049658	0.994226	1.050566	1.037889
1	2020-12-01	0.877709	0.958663	0.878266	0.956509	0.928813	0.925398
2	2020-12-02	0.949841	1.009244	1.091044	1.005397	1.073619	1.085583

3	2020-12-03	0.898455	0.945864	0.816921	0.944106	0.851434	0.859267
4	2020-12-04	0.991089	1.073638	0.942399	1.068931	0.884777	0.899997
5	2020-12-05	1.116698	1.054423	1.029133	1.055290	1.001338	0.972118
6	2020-12-06	0.994257	0.906406	0.990029	0.906654	1.005680	0.994917
7	2020-12-07	0.833289	0.896158	0.905308	0.890731	0.940362	0.973122
8	2020-12-08	0.822353	0.961614	0.944996	0.955558	0.961709	0.949595
9	2020-12-09	0.891062	0.988109	1.016979	0.984333	0.998421	1.003284
10	2020-12-10	0.983087	1.019447	0.979975	1.016529	1.032903	1.018252
11	2020-12-11	1.049815	1.053466	0.969638	1.051618	0.972375	0.954136
12	2020-12-12	0.966431	0.915713	0.890341	0.915233	0.868888	0.870546
13	2020-12-13	0.955733	1.006158	1.086435	1.000742	1.044545	1.058911
14	2020-12-14	0.886464	0.907617	0.953209	0.905522	0.996207	0.982464
15	2020-12-15	0.900888	1.011732	1.040303	1.005834	1.042110	1.028162
16	2020-12-16	0.927288	0.965602	0.965046	0.963454	1.010526	1.000064
17	2020-12-17	0.903581	0.961265	0.965122	0.957616	0.966754	0.953960
18	2020-12-18	1.051642	1.123035	1.069091	1.118559	1.032651	1.037025
19	2020-12-19	1.012460	0.924925	0.948330	0.927035	0.981194	0.959941
20	2020-12-20	0.879419	0.919260	0.939425	0.913942	0.914328	0.915308
21	2020-12-21	0.834221	0.936660	1.008054	0.931026	1.031062	0.970178
22	2020-12-22	0.835744	0.962560	0.965741	0.957835	0.965125	0.941791
23	2020-12-23	1.024721	1.115564	1.134180	1.111224	1.145495	1.113587
24	2020-12-24	1.181403	1.105848	1.118163	1.107449	1.221249	1.202400
25	2020-12-25	1.028199	0.921782	0.841745	0.921966	0.932404	0.824852
26	2020-12-26	0.819206	0.851550	0.907523	0.847290	0.867320	0.818064
27	2020-12-27	0.722193	0.895829	0.926140	0.890975	0.868974	0.853918
28	2020-12-28	0.745073	0.922725	0.972701	0.919721	0.901456	0.946105



----End of Section 2: Daily new healthcare admissions ----

Sec 1 runtime: 9241.801067113876, Sec 2 runtime: 5931.259085893631

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