CRUDE OIL PRICE PREDICTION

PNT2022TMID06799

Importing libraries

```
import numpy as np
import pandas as pd
import datetime
from pylab import rcParams
import matplotlib.pyplot as plt
import warnings
import itertools
import statsmodels.api as sm
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import LSTM
from keras.layers import Dropout
from sklearn.metrics import mean_squared_error
from keras.callbacks import ReduceLROnPlateau, EarlyStopping,
ModelCheckpoint
from sklearn.metrics import mean_squared_error
from sklearn.metrics import mean_absolute_error
from tensorflow.keras.models import load_model
import seaborn as sns
sns.set_context("paper", font_scale=1.3)
sns.set_style('white')
import math
from sklearn.preprocessing import MinMaxScaler
warnings.filterwarnings("ignore")
plt.style.use('fivethirtyeight')
import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))
```

Importing data

```
dateparse = lambda x: pd.datetime.strptime(x, '%b %d, %Y')
from google.colab import files
uploaded = files.upload()
```

```
<IPython.core.display.HTML object>
```

```
Saving Crude Oil Prices Daily.xlsx to Crude Oil Prices Daily.xlsx
```

```
import io
df = pd.read_excel(io.BytesIO(uploaded['Crude Oil Prices
```

```
Daily.xlsx']))
df.head()
df[:10]
```

```
        Date  Closing Value
0 1986-01-02          25.56
1 1986-01-03          26.00
2 1986-01-06          26.53
3 1986-01-07          25.85
4 1986-01-08          25.87
5 1986-01-09          26.03
6 1986-01-10          25.65
7 1986-01-13          25.08
8 1986-01-14          24.97
9 1986-01-15          25.18
```

```
#Sort dataset by column Date
df = df.sort_values('Date')
df = df.groupby('Date')['Closing Value'].sum().reset_index()
df.set_index('Date', inplace=True)
df=df.loc[datetime.date(year=2000,month=1,day=1):]

df.head()
```

```
            Closing Value
Date
2000-01-04          25.56
2000-01-05          24.65
2000-01-06          24.79
2000-01-07          24.79
2000-01-10          24.71
```

Data preprocessing

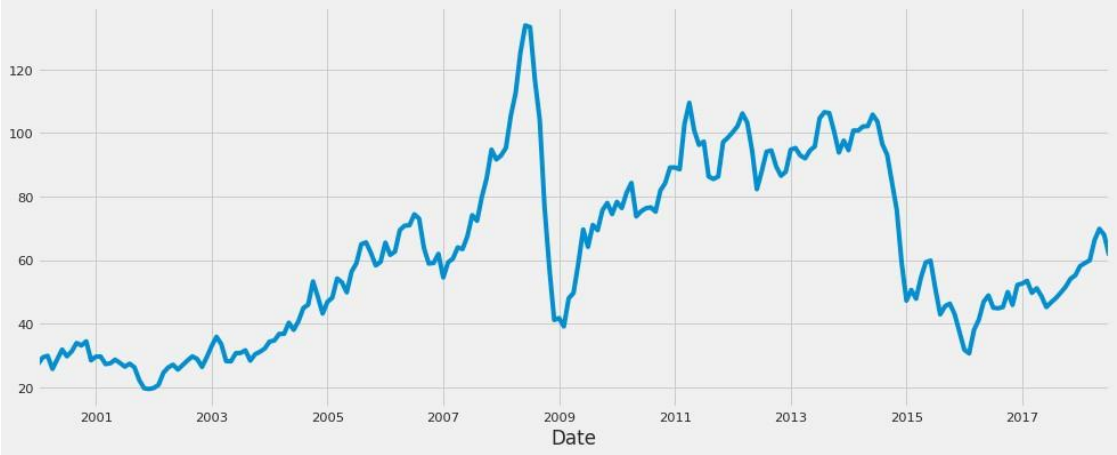
```
def DfInfo(df_initial):
    tab_info = pd.DataFrame(df_initial.dtypes).T.rename(index={0:
'column type'})
    tab_info =
tab_info.append(pd.DataFrame(df_initial.isnull().sum()).T.rename(index
={0: 'null values (nb)'}))
    tab_info = tab_info.append(pd.DataFrame(df_initial.isnull().sum()
/ df_initial.shape[0] * 100).T.rename(index={0: 'null values (%)'}))
    return tab_info

DfInfo(df)
```

```
                 Closing Value
column type            float64
null values (nb)               0
null values (%)              0.0
```

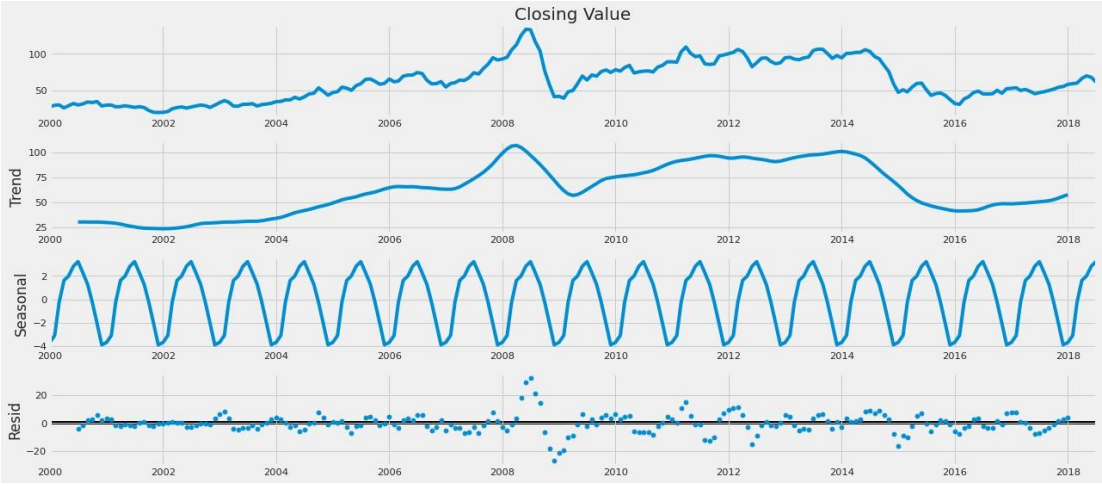
```
df.index
```

```
 DatetimeIndex(['2000-01-04', '2000-01-05', '2000-01-06', '2000-01-07',
                '2000-01-10', '2000-01-11', '2000-01-12', '2000-01-13',
               '2000-01-14', '2000-01-18',
               ...
               '2018-06-26', '2018-06-27', '2018-06-28', '2018-06-29',
               '2018-07-02', '2018-07-03', '2018-07-04', '2018-07-05',
               '2018-07-06', '2018-07-09'],
              dtype='datetime64[ns]', name='Date', length=4673,
freq=None)
```

```
y = df['Closing Value'].resample('MS').mean()
y.plot(figsize=(15, 6))
plt.show()
```




```
rcParams['figure.figsize'] = 18, 8
decomposition = sm.tsa.seasonal_decompose(y, model='additive')
fig = decomposition.plot()
plt.show()
```



```
sc = MinMaxScaler(feature_range = (0, 1))
df = sc.fit_transform(df)
```

Training and testing

```
train_size = int(len(df) * 0.70)
test_size = len(df) - train_size
train, test = df[0:train_size, :], df[train_size:len(df), :]

def create_data_set(_data_set, _look_back=1):
    data_x, data_y = [], []
    for i in range(len(_data_set) - _look_back - 1):
        a = _data_set[i:(i + _look_back), 0]
        data_x.append(a)
        data_y.append(_data_set[i + _look_back, 0])
    return np.array(data_x), np.array(data_y)

look_back =90
X_train,Y_train,X_test,Ytest = [],[],[],[]
X_train,Y_train=create_data_set(train,look_back)
X_train = np.reshape(X_train, (X_train.shape[0], X_train.shape[1], 1))
X_test,Y_test=create_data_set(test,look_back)
X_test = np.reshape(X_test, (X_test.shape[0], X_test.shape[1], 1))
```

LSTM layer

```
regressor = Sequential()
regressor.add(LSTM(units = 60, return_sequences = True, input_shape =
(X_train.shape[1], 1)))
regressor.add(Dropout(0.1))
regressor.add(LSTM(units = 60, return_sequences = True))
regressor.add(Dropout(0.1))
regressor.add(LSTM(units = 60))
regressor.add(Dropout(0.1))
regressor.add(Dense(units = 1))

regressor.compile(optimizer = 'adam', loss = 'mean_squared_error')
reduce_lr = ReduceLROnPlateau(monitor='val_loss',patience=5)
history =regressor.fit(X_train, Y_train, epochs = 20, batch_size =
15,validation_data=(X_test, Y_test),
callbacks=[reduce_lr],shuffle=False)
```

```
Epoch 1/20
212/212 [==============================] - 31s 119ms/step - loss:
0.0049 - val_loss: 0.0220 - lr: 0.0010
Epoch 2/20
212/212 [==============================] - 24s 111ms/step - loss:
0.0112 - val_loss: 0.0487 - lr: 0.0010
Epoch 3/20
212/212 [==============================] - 23s 111ms/step - loss:
```

```
0.0124 - val_loss: 0.0549 - lr: 0.0010
Epoch 4/20
212/212 [==============================] - 24s 111ms/step - loss:
0.0164 - val_loss: 0.0484 - lr: 0.0010
Epoch 5/20
212/212 [==============================] - 23s 111ms/step - loss:
0.0199 - val_loss: 0.0546 - lr: 0.0010
Epoch 6/20
212/212 [==============================] - 23s 110ms/step - loss:
0.0179 - val_loss: 0.0516 - lr: 0.0010
Epoch 7/20
212/212 [==============================] - 24s 111ms/step - loss:
0.0203 - val_loss: 0.0034 - lr: 1.0000e-04
Epoch 8/20
212/212 [==============================] - 23s 111ms/step - loss:
0.0034 - val_loss: 0.0027 - lr: 1.0000e-04
Epoch 9/20
212/212 [==============================] - 23s 110ms/step - loss:
0.0026 - val_loss: 0.0021 - lr: 1.0000e-04
Epoch 10/20
212/212 [==============================] - 23s 110ms/step - loss:
0.0023 - val_loss: 0.0018 - lr: 1.0000e-04
Epoch 11/20
212/212 [==============================] - 23s 110ms/step - loss:
0.0019 - val_loss: 0.0018 - lr: 1.0000e-04
Epoch 12/20
212/212 [==============================] - 23s 111ms/step - loss:
0.0016 - val_loss: 0.0016 - lr: 1.0000e-04
Epoch 13/20
212/212 [==============================] - 23s 111ms/step - loss:
0.0014 - val_loss: 0.0015 - lr: 1.0000e-04
Epoch 14/20
212/212 [==============================] - 24s 112ms/step - loss:
0.0012 - val_loss: 0.0014 - lr: 1.0000e-04
Epoch 15/20
212/212 [==============================] - 24s 113ms/step - loss:
0.0011 - val_loss: 0.0013 - lr: 1.0000e-04
Epoch 16/20
212/212 [==============================] - 24s 113ms/step - loss:
0.0010 - val_loss: 0.0013 - lr: 1.0000e-04
Epoch 17/20
212/212 [==============================] - 24s 115ms/step - loss:
0.0010 - val_loss: 0.0013 - lr: 1.0000e-04
Epoch 18/20
212/212 [==============================] - 24s 112ms/step - loss:
0.0010 - val_loss: 0.0014 - lr: 1.0000e-04
Epoch 19/20
212/212 [==============================] - 24s 113ms/step - loss:
9.6307e-04 - val_loss: 0.0014 - lr: 1.0000e-04
Epoch 20/20
```

```
212/212 [==============================] - 24s 112ms/step - loss:
9.6895e-04 - val_loss: 0.0013 - lr: 1.0000e-04
```

Model training

```
train_predict = regressor.predict(X_train)
test_predict = regressor.predict(X_test)
```

```
100/100 [==============================] - 3s 35ms/step
41/41 [==============================] - 1s 35ms/step
```

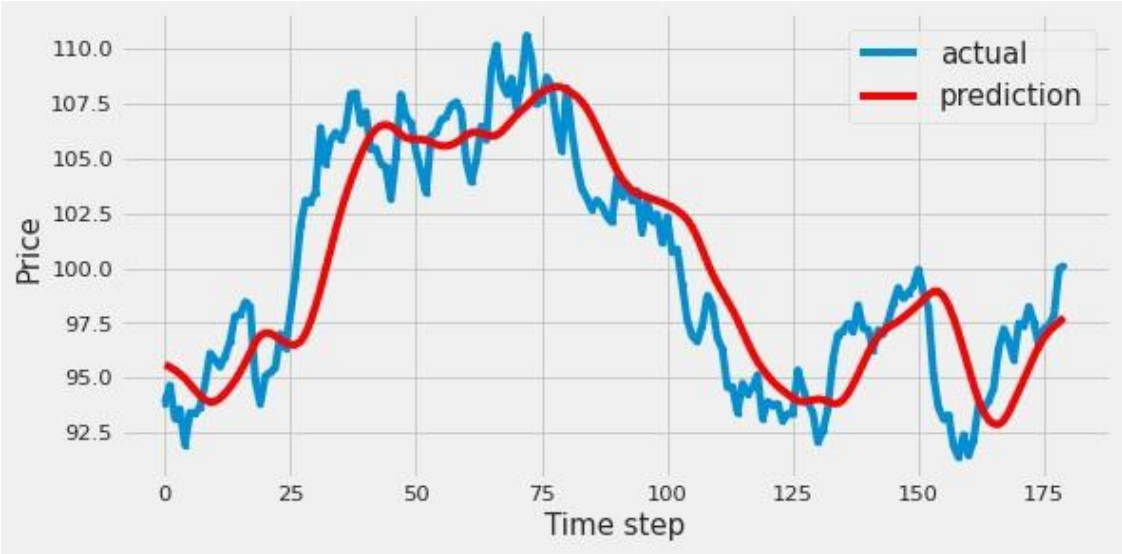
```
train_predict = sc.inverse_transform(train_predict)
Y_train = sc.inverse_transform([Y_train])
test_predict = sc.inverse_transform(test_predict)
Y_test = sc.inverse_transform([Y_test])
```

Prediction

```
print('Train Mean Absolute Error:', mean_absolute_error(Y_train[0],
train_predict[:,0]))
print('Train Root Mean Squared
Error:',np.sqrt(mean_squared_error(Y_train[0], train_predict[:,0])))
print('Test Mean Absolute Error:', mean_absolute_error(Y_test[0],
test_predict[:,0]))
print('Test Root Mean Squared
Error:',np.sqrt(mean_squared_error(Y_test[0], test_predict[:,0])))
plt.figure(figsize=(8,4))
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Test Loss')
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epochs')
plt.legend(loc='upper right')
plt.show();
```

```
Train Mean Absolute Error: 2.42441411734527
Train Root Mean Squared Error: 3.3282435008105846
Test Mean Absolute Error: 2.3375842822880166
Test Root Mean Squared Error: 5.285524069216685
```


```
aa=[x for x in range(180)]
plt.figure(figsize=(8,4))
plt.plot(aa, Y_test[0][:180], marker='.', label="actual")
plt.plot(aa, test_predict[:,0][:180], 'r', label="prediction")
plt.tight_layout()
sns.despine(top=True)
plt.subplots_adjust(left=0.07)
plt.ylabel('Price', size=15)
plt.xlabel('Time step', size=15)
plt.legend(fontsize=15)
plt.show();
```




```
regressor.save('crudeoil.h5')

!tar -zcvf crudeoil-prediction.tgz crudeoil.h5
```

```
crudeoil.h5
```

IBM Deployment

```
!pip install watson-machine-learning-client
```

```
Looking in indexes: https://pypi.org/simple, https://us-
python.pkg.dev/colab-wheels/public/simple/
Collecting watson-machine-learning-client
  Downloading watson_machine_learning_client-1.0.391-py3-none-any.whl
(538 kB)
ent already satisfied: urllib3 in /usr/local/lib/python3.7/dist-
packages (from watson-machine-learning-client) (1.24.3)
Requirement already satisfied: tabulate in
/usr/local/lib/python3.7/dist-packages (from watson-machine-learning-
client) (0.8.10)
Collecting lomond
  Downloading lomond-0.3.3-py2.py3-none-any.whl (35 kB)
Requirement already satisfied: certifi in
/usr/local/lib/python3.7/dist-packages (from watson-machine-learning-
client) (2022.9.24)
Collecting boto3
  Downloading boto3-1.26.7-py3-none-any.whl (132 kB)
ent already satisfied: requests in /usr/local/lib/python3.7/dist-
packages (from watson-machine-learning-client) (2.23.0)
Requirement already satisfied: pandas in
/usr/local/lib/python3.7/dist-packages (from watson-machine-learning-
client) (1.3.5)
Requirement already satisfied: tqdm in /usr/local/lib/python3.7/dist-
packages (from watson-machine-learning-client) (4.64.1)
Collecting ibm-cos-sdk
  Downloading ibm-cos-sdk-2.12.0.tar.gz (55 kB)
espath<2.0.0,>=0.7.1
  Downloading jmespath-1.0.1-py3-none-any.whl (20 kB)
Collecting s3transfer<0.7.0,>=0.6.0
  Downloading s3transfer-0.6.0-py3-none-any.whl (79 kB)
ent already satisfied: python-dateutil<3.0.0,>=2.1 in
/usr/local/lib/python3.7/dist-packages (from botocore<1.30.0,>=1.29.7-
>boto3->watson-machine-learning-client) (2.8.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.7/dist-packages (from python-
dateutil<3.0.0,>=2.1->botocore<1.30.0,>=1.29.7->boto3->watson-machine-
learning-client) (1.15.0)
Collecting ibm-cos-sdk-core==2.12.0
  Downloading ibm-cos-sdk-core-2.12.0.tar.gz (956 kB)
-cos-sdk-s3transfer==2.12.0
  Downloading ibm-cos-sdk-s3transfer-2.12.0.tar.gz (135 kB)
espath<2.0.0,>=0.7.1
  Downloading jmespath-0.10.0-py2.py3-none-any.whl (24 kB)
Collecting requests
```

```
  Downloading requests-2.28.1-py3-none-any.whl (62 kB)
ent already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.7/dist-
packages (from requests->watson-machine-learning-client) (2.10)
Requirement already satisfied: charset-normalizer<3,>=2 in
/usr/local/lib/python3.7/dist-packages (from requests->watson-machine-
learning-client) (2.1.1)
Requirement already satisfied: pytz>=2017.3 in
/usr/local/lib/python3.7/dist-packages (from pandas->watson-machine-
learning-client) (2022.6)
Requirement already satisfied: numpy>=1.17.3 in
/usr/local/lib/python3.7/dist-packages (from pandas->watson-machine-
learning-client) (1.21.6)
Building wheels for collected packages: ibm-cos-sdk, ibm-cos-sdk-core,
ibm-cos-sdk-s3transfer
  Building wheel for ibm-cos-sdk (setup.py) ... -cos-sdk:
filename=ibm_cos_sdk-2.12.0-py3-none-any.whl size=73931
sha256=40521eb23c69343f6cb0ff09ca1de338cd0f97721f6a23c547e435e1c31aaf8
d
  Stored in directory:
/root/.cache/pip/wheels/ec/94/29/2b57327cf00664b6614304f7958abd29d77ea
0e5bbece2ea57
  Building wheel for ibm-cos-sdk-core (setup.py) ... -cos-sdk-core:
filename=ibm_cos_sdk_core-2.12.0-py3-none-any.whl size=562962
sha256=17b57b548ee5e5cdac2ad1380f3c82f6f242f1a26bac985f3ef67c0294305dd
0
  Stored in directory:
/root/.cache/pip/wheels/64/56/fb/5cd6f4f40406c828a5289b95b2752a4d142a9
afb359244ed8d
  Building wheel for ibm-cos-sdk-s3transfer (setup.py) ... -cos-sdk-
s3transfer: filename=ibm_cos_sdk_s3transfer-2.12.0-py3-none-any.whl
size=89778
sha256=9a6dcd72513363e86b5542b137def2c8a591af72c8d28b0514d240e78826394
d
  Stored in directory:
/root/.cache/pip/wheels/57/79/6a/ffe3370ed7ebc00604f9f76766e1e0348dcdc
ad2b2e32df9e1
Successfully built ibm-cos-sdk ibm-cos-sdk-core ibm-cos-sdk-s3transfer
Installing collected packages: urllib3, requests, jmespath, ibm-cos-
sdk-core, botocore, s3transfer, ibm-cos-sdk-s3transfer, lomond, ibm-
cos-sdk, boto3, watson-machine-learning-client
  Attempting uninstall: urllib3
    Found existing installation: urllib3 1.24.3
    Uninstalling urllib3-1.24.3:
      Successfully uninstalled urllib3-1.24.3
  Attempting uninstall: requests
    Found existing installation: requests 2.23.0
    Uninstalling requests-2.23.0:
      Successfully uninstalled requests-2.23.0
Successfully installed boto3-1.26.7 botocore-1.29.7 ibm-cos-sdk-2.12.0
ibm-cos-sdk-core-2.12.0 ibm-cos-sdk-s3transfer-2.12.0 jmespath-0.10.0
```

```
lomond-0.3.3 requests-2.28.1 s3transfer-0.6.0 urllib3-1.26.12 watson-
machine-learning-client-1.0.391
```

```
{"pip_warning":{"packages":["requests","urllib3"]}}
```

```
!pip install ibm_watson_machine_learning
```

```
Looking in indexes: https://pypi.org/simple, https://us-
python.pkg.dev/colab-wheels/public/simple/
Collecting ibm_watson_machine_learning
  Downloading ibm_watson_machine_learning-1.0.257-py3-none-any.whl
(1.8 MB)
ent already satisfied: pandas<1.5.0,>=0.24.2 in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (1.3.5)
Requirement already satisfied: tabulate in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (0.8.10)
Requirement already satisfied: requests in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (2.28.1)
Requirement already satisfied: lomond in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (0.3.3)
Requirement already satisfied: certifi in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (2022.9.24)
Requirement already satisfied: urllib3 in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (1.26.12)
Collecting ibm-cos-sdk==2.7.*
  Downloading ibm-cos-sdk-2.7.0.tar.gz (51 kB)
ent already satisfied: importlib-metadata in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (4.13.0)
Requirement already satisfied: packaging in
/usr/local/lib/python3.7/dist-packages (from
ibm_watson_machine_learning) (21.3)
Collecting ibm-cos-sdk-core==2.7.0
  Downloading ibm-cos-sdk-core-2.7.0.tar.gz (824 kB)
-cos-sdk-s3transfer==2.7.0
  Downloading ibm-cos-sdk-s3transfer-2.7.0.tar.gz (133 kB)
ent already satisfied: jmespath<1.0.0,>=0.7.1 in
/usr/local/lib/python3.7/dist-packages (from ibm-cos-sdk==2.7.*-
>ibm_watson_machine_learning) (0.10.0)
Collecting docutils<0.16,>=0.10
  Downloading docutils-0.15.2-py3-none-any.whl (547 kB)
ent already satisfied: python-dateutil<3.0.0,>=2.1 in
/usr/local/lib/python3.7/dist-packages (from ibm-cos-sdk-core==2.7.0-
>ibm-cos-sdk==2.7.*->ibm_watson_machine_learning) (2.8.2)
Requirement already satisfied: numpy>=1.17.3 in
```

```
/usr/local/lib/python3.7/dist-packages (from pandas<1.5.0,>=0.24.2-
>ibm_watson_machine_learning) (1.21.6)
Requirement already satisfied: pytz>=2017.3 in
/usr/local/lib/python3.7/dist-packages (from pandas<1.5.0,>=0.24.2-
>ibm_watson_machine_learning) (2022.6)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.7/dist-packages (from python-
dateutil<3.0.0,>=2.1->ibm-cos-sdk-core==2.7.0->ibm-cos-sdk==2.7.*-
>ibm_watson_machine_learning) (1.15.0)
Requirement already satisfied: charset-normalizer<3,>=2 in
/usr/local/lib/python3.7/dist-packages (from requests-
>ibm_watson_machine_learning) (2.1.1)
Requirement already satisfied: idna<4,>=2.5 in
/usr/local/lib/python3.7/dist-packages (from requests-
>ibm_watson_machine_learning) (2.10)
Requirement already satisfied: typing-extensions>=3.6.4 in
/usr/local/lib/python3.7/dist-packages (from importlib-metadata-
>ibm_watson_machine_learning) (4.1.1)
Requirement already satisfied: zipp>=0.5 in
/usr/local/lib/python3.7/dist-packages (from importlib-metadata-
>ibm_watson_machine_learning) (3.10.0)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in
/usr/local/lib/python3.7/dist-packages (from packaging-
>ibm_watson_machine_learning) (3.0.9)
Building wheels for collected packages: ibm-cos-sdk, ibm-cos-sdk-core,
ibm-cos-sdk-s3transfer
  Building wheel for ibm-cos-sdk (setup.py) ... -cos-sdk:
filename=ibm_cos_sdk-2.7.0-py2.py3-none-any.whl size=72563
sha256=883aff6a2eb4f64d9725c3360d1fd6aef738ae8d47e4b1dc28c821f5addd01f
2
  Stored in directory:
/root/.cache/pip/wheels/47/22/bf/e1154ff0f5de93cc477acd0ca69abfbb8b799
c5b28a66b44c2
  Building wheel for ibm-cos-sdk-core (setup.py) ... -cos-sdk-core:
filename=ibm_cos_sdk_core-2.7.0-py2.py3-none-any.whl size=501013
sha256=e2a695e1a2fbdf2b3a09b1fd4ce25506bd957e6ee42589f47c7a68d37e82edb
e
  Stored in directory:
/root/.cache/pip/wheels/6c/a2/e4/c16d02f809a3ea998e17cfd02c13369281f3d
232aaf5902c19
  Building wheel for ibm-cos-sdk-s3transfer (setup.py) ... -cos-sdk-
s3transfer: filename=ibm_cos_sdk_s3transfer-2.7.0-py2.py3-none-any.whl
size=88622
sha256=60711740f2411fa7b564df2dd6ac2f326bcb75aacea1807fde89935938e80ce
4
  Stored in directory:
/root/.cache/pip/wheels/5f/b7/14/fbe02bc1ef1af890650c7e51743d1c8389085
2e598d164b9da
Successfully built ibm-cos-sdk ibm-cos-sdk-core ibm-cos-sdk-s3transfer
Installing collected packages: docutils, ibm-cos-sdk-core, ibm-cos-
```

```
sdk-s3transfer, ibm-cos-sdk, ibm-watson-machine-learning
  Attempting uninstall: docutils
    Found existing installation: docutils 0.17.1
    Uninstalling docutils-0.17.1:
      Successfully uninstalled docutils-0.17.1
  Attempting uninstall: ibm-cos-sdk-core
    Found existing installation: ibm-cos-sdk-core 2.12.0
    Uninstalling ibm-cos-sdk-core-2.12.0:
      Successfully uninstalled ibm-cos-sdk-core-2.12.0
  Attempting uninstall: ibm-cos-sdk-s3transfer
    Found existing installation: ibm-cos-sdk-s3transfer 2.12.0
    Uninstalling ibm-cos-sdk-s3transfer-2.12.0:
      Successfully uninstalled ibm-cos-sdk-s3transfer-2.12.0
  Attempting uninstall: ibm-cos-sdk
    Found existing installation: ibm-cos-sdk 2.12.0
    Uninstalling ibm-cos-sdk-2.12.0:
      Successfully uninstalled ibm-cos-sdk-2.12.0
Successfully installed docutils-0.15.2 ibm-cos-sdk-2.7.0 ibm-cos-sdk-
core-2.7.0 ibm-cos-sdk-s3transfer-2.7.0 ibm-watson-machine-learning-
1.0.257
```

```
from ibm_watson_machine_learning import APIClient

wml_credentials = {
    "url":"https://eu-gb.ml.cloud.ibm.com",
    "apikey":"OegDZFbgmd2nJVPQW7buYfvlXEQRhY64_lkDLz_kHpLF"
}

client = APIClient(wml_credentials)
```

```
Python 3.7 and 3.8 frameworks are deprecated and will be removed in a
future release. Use Python 3.9 framework instead.
```

```
client
```

```
<ibm_watson_machine_learning.client.APIClient at 0x7f8a6bc7a250>
```

```
client.spaces.get_details()
```

```
{'resources': [{'entity': {'compute': [{'crn':
'crn:v1:bluemix:public:pm-20:eu-gb:a/223be9e216084bc6831c3b6c556758f9:
756bb1ab-f9dd-48ea-bf89-de831b79e2ac::',
      'guid': '756bb1ab-f9dd-48ea-bf89-de831b79e2ac',
      'name': 'Watson Machine Learning-nr',
      'type': 'machine_learning'}],
    'description': '',
    'name': 'crude oil',
    'scope': {'bss_account_id': '223be9e216084bc6831c3b6c556758f9'},
    'stage': {'production': False},
    'status': {'state': 'active'},
    'storage': {'properties': {'bucket_name': '4ff2d233-098c-4391-
```

```
8449-57d3b94013be',
      'bucket_region': 'eu-gb-standard',
      'credentials': {'admin': {'access_key_id':
'0e38cf6e31944f938daa9652d79eb602',
        'api_key': 'AE90AJ0_-7FpZ7LGtI5WHTAxiHjDDh7pnJ1VeWjTlnL5',
        'secret_access_key':
'2ea791ab1804e89f786e59b4b5a7835ffbd7fffad6e00aa2',
        'service_id': 'ServiceId-59cf7746-ff50-4ca8-89d3-
2cf2e5d7f45c'},
       'editor': {'access_key_id': '074aa8d8552d4c2e8e5f7911eccff9fc',
        'api_key': 'NRIvdwOcdoHLA4vcmrqDJYrGlZOrbKryOTenSBKX5GIo',
        'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-
storage:global:a/223be9e216084bc6831c3b6c556758f9:f11a9507-df7d-41fc-
8b4e-4b913e22d2e3::',
        'secret_access_key':
'0d93d72466f97abf01611c2e37e2a1e1e7f0db4eb0f5fe4b',
        'service_id': 'ServiceId-a1e5087b-ec41-42c3-af4a-
212d1d5e4464'},
       'viewer': {'access_key_id': 'e2ab1c2855fc48fab2086f196493a241',
        'api_key': 'cAyzIXrDLUmfVyyQpjNb-GB0sg1IPTspM24A04TfpWk9',
        'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-
storage:global:a/223be9e216084bc6831c3b6c556758f9:f11a9507-df7d-41fc-
8b4e-4b913e22d2e3::',
        'secret_access_key':
'7de3c08ec568240c79cde117ba40d04282b31ac9c91c06af',
        'service_id': 'ServiceId-dac6f800-269c-42e0-821e-
07f1e84a061c'}},
      'endpoint_url': 'https://s3.eu-gb.cloud-object-
storage.appdomain.cloud',
      'guid': 'f11a9507-df7d-41fc-8b4e-4b913e22d2e3',
      'resource_crn': 'crn:v1:bluemix:public:cloud-object-
storage:global:a/223be9e216084bc6831c3b6c556758f9:f11a9507-df7d-41fc-
8b4e-4b913e22d2e3::'},
     'type': 'bmcos_object_storage'}},
   'metadata': {'created_at': '2022-11-07T10:20:17.909Z',
    'creator_id': 'IBMid-668000ETEJ',
    'id': '8920acc3-e00b-4c42-9e35-627fbd388e49',
    'updated_at': '2022-11-07T10:20:35.258Z',
    'url': '/v2/spaces/8920acc3-e00b-4c42-9e35-627fbd388e49'}}]}

client.spaces.list()

Note: 'limit' is not provided. Only first 50 records will be displayed
if the number of records exceed 50
------------------------------------  ----------
-------------------------
ID                                    NAME       CREATED
8920acc3-e00b-4c42-9e35-627fbd388e49  crude oil  2022-11-
07T10:20:17.909Z
------------------------------------  ----------
-------------------------
```

```
space_uid = "8920acc3-e00b-4c42-9e35-627fbd388e49"
space_uid
```

```
{"type":"string"}
```

```
client.set.default_space(space_uid)
```

```
{"type":"string"}
```

```
client.software_specifications.list()
```

```
------------------------------  ------------------------------------
-----
NAME                            ASSET_ID
TYPE
default_py3.6                   0062b8c9-8b7d-44a0-a9b9-46c416adcbd9
base
kernel-spark3.2-scala2.12       020d69ce-7ac1-5e68-ac1a-31189867356a
base
pytorch-onnx_1.3-py3.7-edt      069ea134-3346-5748-b513-49120e15d288
base
scikit-learn_0.20-py3.6         09c5a1d0-9c1e-4473-a344-eb7b665ff687
base
spark-mllib_3.0-scala_2.12      09f4cff0-90a7-5899-b9ed-1ef348aebdee
base
pytorch-onnx_rt22.1-py3.9       0b848dd4-e681-5599-be41-b5f6fccc6471
base
ai-function_0.1-py3.6           0cdb0f1e-5376-4f4d-92dd-da3b69aa9bda
base
shiny-r3.6                      0e6e79df-875e-4f24-8ae9-62dcc2148306
base
tensorflow_2.4-py3.7-horovod    1092590a-307d-563d-9b62-4eb7d64b3f22
base
pytorch_1.1-py3.6               10ac12d6-6b30-4ccd-8392-3e922c096a92
base
tensorflow_1.15-py3.6-ddl       111e41b3-de2d-5422-a4d6-bf776828c4b7
base
autoai-kb_rt22.2-py3.10         125b6d9a-5b1f-5e8d-972a-b251688ccf40
base
runtime-22.1-py3.9              12b83a17-24d8-5082-900f-0ab31fbfd3cb
base
scikit-learn_0.22-py3.6         154010fa-5b3b-4ac1-82af-4d5ee5abbc85
base
default_r3.6                    1b70aec3-ab34-4b87-8aa0-a4a3c8296a36
base
pytorch-onnx_1.3-py3.6          1bc6029a-cc97-56da-b8e0-39c3880dbbe7
base
kernel-spark3.3-r3.6            1c9e5454-f216-59dd-a20e-474a5cdf5988
base
pytorch-onnx_rt22.1-py3.9-edt   1d362186-7ad5-5b59-8b6c-9d0880bde37f
base
```

```
tensorflow_2.1-py3.6            1eb25b84-d6ed-5dde-b6a5-3fbdf1665666
base
spark-mllib_3.2                 20047f72-0a98-58c7-9ff5-a77b012eb8f5
base
tensorflow_2.4-py3.8-horovod    217c16f6-178f-56bf-824a-b19f20564c49
base
runtime-22.1-py3.9-cuda         26215f05-08c3-5a41-a1b0-da66306ce658
base
do_py3.8                        295addb5-9ef9-547e-9bf4-92ae3563e720
base
autoai-ts_3.8-py3.8             2aa0c932-798f-5ae9-abd6-15e0c2402fb5
base
tensorflow_1.15-py3.6           2b73a275-7cbf-420b-a912-eae7f436e0bc
base
kernel-spark3.3-py3.9           2b7961e2-e3b1-5a8c-a491-482c8368839a
base
pytorch_1.2-py3.6               2c8ef57d-2687-4b7d-acce-01f94976dac1
base
spark-mllib_2.3                 2e51f700-bca0-4b0d-88dc-5c6791338875
base
pytorch-onnx_1.1-py3.6-edt      32983cea-3f32-4400-8965-dde874a8d67e
base
spark-mllib_3.0-py37            36507ebe-8770-55ba-ab2a-eafe787600e9
base
spark-mllib_2.4                 390d21f8-e58b-4fac-9c55-d7ceda621326
base
autoai-ts_rt22.2-py3.10         396b2e83-0953-5b86-9a55-7ce1628a406f
base
xgboost_0.82-py3.6              39e31acd-5f30-41dc-ae44-60233c80306e
base
pytorch-onnx_1.2-py3.6-edt      40589d0e-7019-4e28-8daa-fb03b6f4fe12
base
pytorch-onnx_rt22.2-py3.10      40e73f55-783a-5535-b3fa-0c8b94291431
base
default_r36py38                 41c247d3-45f8-5a71-b065-8580229facf0
base
autoai-ts_rt22.1-py3.9          4269d26e-07ba-5d40-8f66-2d495b0c71f7
base
autoai-obm_3.0                  42b92e18-d9ab-567f-988a-4240ba1ed5f7
base
pmml-3.0_4.3                    493bcb95-16f1-5bc5-bee8-81b8af80e9c7
base
spark-mllib_2.4-r_3.6           49403dff-92e9-4c87-a3d7-a42d0021c095
base
xgboost_0.90-py3.6              4ff8d6c2-1343-4c18-85e1-689c965304d3
base
pytorch-onnx_1.1-py3.6          50f95b2a-bc16-43bb-bc94-b0bed208c60b
base
autoai-ts_3.9-py3.8             52c57136-80fa-572e-8728-a5e7cbb42cde
base
```

```
spark-mllib_2.4-scala_2.11      55a70f99-7320-4be5-9fb9-9edb5a443af5
base
spark-mllib_3.0                 5c1b0ca2-4977-5c2e-9439-ffd44ea8ffe9
base
autoai-obm_2.0                  5c2e37fa-80b8-5e77-840f-d912469614ee
base
spss-modeler_18.1               5c3cad7e-507f-4b2a-a9a3-ab53a21dee8b
base
cuda-py3.8                      5d3232bf-c86b-5df4-a2cd-7bb870a1cd4e
base
autoai-kb_3.1-py3.7             632d4b22-10aa-5180-88f0-f52dfb6444d7
base
pytorch-onnx_1.7-py3.8          634d3cdc-b562-5bf9-a2d4-ea90a478456b
base
------------------------------  ------------------------------------
-----
Note: Only first 50 records were displayed. To display more use
'limit' parameter.
```

```
software_space_uid =
client.software_specifications.get_uid_by_name("tensorflow_rt22.1-
py3.9")
software_space_uid
```

```
{"type":"string"}
```

```
model_details = client.repository.store_model(model="crudeoil-
prediction.tgz", meta_props={
    client.repository.ModelMetaNames.NAME:"Crude Oil Model",
    client.repository.ModelMetaNames.TYPE:"tensorflow_2.7",

client.repository.ModelMetaNames.SOFTWARE_SPEC_UID:software_space_uid
})
```

```
model_details
```

```
{'entity': {'hybrid_pipeline_software_specs': [],
  'software_spec': {'id': 'acd9c798-6974-5d2f-a657-ce06e986df4d',
   'name': 'tensorflow_rt22.1-py3.9'},
  'type': 'tensorflow_2.7'},
 'metadata': {'created_at': '2022-11-15T11:38:43.943Z',
  'id': 'e4854139-835a-4dae-b61e-2c8644333c0d',
  'modified_at': '2022-11-15T11:38:48.290Z',
  'name': 'Crude Oil Model',
  'owner': 'IBMid-668000ETEJ',
  'resource_key': '1bec88c6-df9a-4c62-93f8-13c3591666d0',
  'space_id': '8920acc3-e00b-4c42-9e35-627fbd388e49'},
 'system': {'warnings': []}}
```

```
model_id = client.repository.get_model_id(model_details)
model_id
```

{"type":"string"}

```
client.repository.download(model_id,'Crude_oil_prediction.tgz')
```

```
Successfully saved model content to file: 'Crude_oil_prediction.tgz'
```

{"type":"string"}