Time Series Forecasting

In [3]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
import seaborn as sns

import tensorflow as tf
from tensorflow import keras

from sklearn.preprocessing import MinMaxScaler

from tensorflow.keras.preprocessing.sequence import TimeseriesGenerator

from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, LSTM

from tensorflow.keras.callbacks import EarlyStopping
```

In [14]:
```
dataset_path = 'RSCCASN.xls'
```

In [18]:
```
sales_data = pd.read_csv(dataset_path,  parse_dates=True, index_col='DATE')
```

In [20]:
```
sales_data
```

Out[20]:

	RSCCASN
DATE	
1992-01-01	6938
1992-02-01	7524
1992-03-01	8475
1992-04-01	9401
1992-05-01	9558
...	...
2019-06-01	21123
2019-07-01	21714
2019-08-01	23791
2019-09-01	19695
2019-10-01	21113

334 rows × 1 columns

In [8]:
```
sales_data.columns = ['Sales']
```

In [9]:
```
sales_data.columns
```

Out[9]:
```
Index(['Sales'], dtype='object')
```

In [10]:
```
print(sales_data.info())
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 334 entries, 1992-01-01 to 2019-10-01
Data columns (total 1 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   Sales   334 non-null    int64
dtypes: int64(1)
memory usage: 5.2 KB
None
```

In [11]:
```
print(sales_data.describe())
```

```
              Sales
count    334.000000
mean   16325.095808
std     5369.839014
min     6938.000000
25%    12298.500000
50%    15878.500000
75%    19772.500000
max    34706.000000
```

In [12]:
```
sales_data.head()
```

Out[12]:

	Sales
DATE	
1992-01-01	6938
1992-02-01	7524
1992-03-01	8475
1992-04-01	9401
1992-05-01	9558

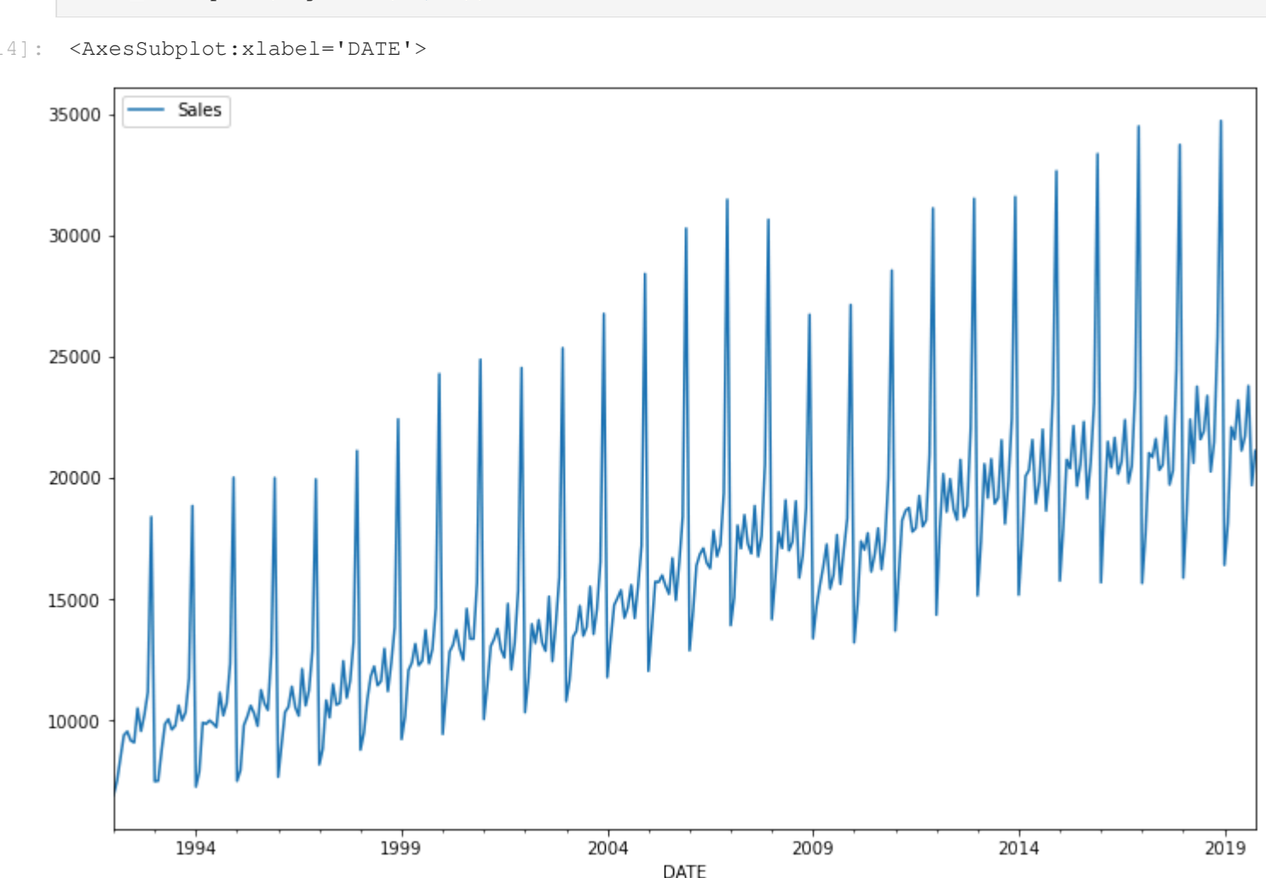
In [13]:
```
sales_data.tail()
```

Out[13]:

	Sales
DATE	
2019-06-01	21123
2019-07-01	21714
2019-08-01	23791
2019-09-01	19695
2019-10-01	21113

In [14]:
```
sales_data.plot(figsize=(12, 8))
```

Out[14]:
```
<AxesSubplot:xlabel='DATE'>
```



In [15]:
```
len(sales_data)
```

Out[15]: 334

In [16]:
```
len(sales_data) - 18    # 1.5 year
```

Out[16]: 316

In [17]:
```
test_size = 18
test_index = len(sales_data) - test_size
```

In [18]:
```
test_index
```

Out[18]: 316

In [19]:
```
train = sales_data.iloc[:test_index]
test = sales_data.iloc[test_index:]
```

In [20]:
```
train.head()
```

Out[20]:

	Sales
DATE	
1992-01-01	6938
1992-02-01	7524
1992-03-01	8475
1992-04-01	9401
1992-05-01	9558

In [21]:
```
train.tail()
```

Out[21]:

	Sales
DATE	
2017-12-01	33720
2018-01-01	15881
2018-02-01	18585
2018-03-01	22404
2018-04-01	20616

In [22]:
```
test.head()
```

Out[22]:

	Sales
DATE	
2018-05-01	23764
2018-06-01	21589
2018-07-01	21919
2018-08-01	23381
2018-09-01	20260

In [23]:
```
test.tail()
```

Out[23]:

	Sales
DATE	
2019-06-01	21123
2019-07-01	21714
2019-08-01	23791
2019-09-01	19695
2019-10-01	21113

In [24]:
```
# help(MinMaxScaler)
```

In [25]:
```
scaler = MinMaxScaler()
```

In [26]:
```
scaler.fit(train)
```

Out[26]:
```
MinMaxScaler()
```

In [27]:
```
scaled_train = scaler.transform(train)
scaled_test = scaler.transform(test)
```

In [28]:
```
scaled_train[:5]
```

Out[28]:
```
array([[0.        ],
       [0.02127505],
       [0.05580163],
       [0.08942056],
       [0.09512053]])
```

In [29]:
```
scaled_test[:5]
```

Out[29]:
```
array([[0.61087714],
       [0.53191258],
       [0.54389341],
       [0.59697212],
       [0.4836625 ]])
```

In [30]:
```
# help(TimeseriesGenerator)
```

In [31]:
```
length = 12
```

In [32]:
```
generator = TimeseriesGenerator(scaled_train, scaled_train, length=length, batch_size=1)
```

In [33]:
```
X, y = generator[0]
```

In [34]:
```
X
```

Out[34]:
```
array([[[0.        ],
        [0.02127505],
        [0.05580163],
        [0.08942056],
        [0.09512053],
        [0.08146965],
        [0.07860151],
        [0.12979233],
        [0.09566512],
        [0.1203892 ],
        [0.15426227],
        [0.41595266]]])
```

In [35]:
```
y
```

Out[35]:
```
array([[0.02047633]])
```

In [36]:
```
len(X[0])
```

Out[36]: 12

In [37]:
```
# help(LSTM)
```

In [38]:
```
n_features = 1
```

In [81]:
```
from keras.models import Sequential
from keras.layers import LSTM, Dense, Dropout, BatchNormalization
from keras.optimizers import Adam

model = Sequential()
# First LSTM layer with Dropout and BatchNormalization
model.add(LSTM(128, activation='relu', return_sequences=True, input_shape=(length, n_features)))
model.add(Dropout(0.3))


# Second LSTM layer with Dropout
model.add(LSTM(64, activation='relu'))
model.add(Dropout(0.3))

# Output layer
model.add(Dense(1))  # For regression tasks

# Compile the model with Adam optimizer and a smaller learning rate
optimizer = Adam(learning_rate=0.001)
model.compile(optimizer=optimizer, loss='mse')

# Model summary for verification
model.summary()
```

```
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_6 (LSTM)                (None, 12, 128)           66560
_________________________________________________________________
dropout_4 (Dropout)          (None, 12, 128)           0
_________________________________________________________________
lstm_7 (LSTM)                (None, 64)                49408
_________________________________________________________________
dropout_5 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_4 (Dense)              (None, 1)                 65
=================================================================
Total params: 116,033
Trainable params: 116,033
Non-trainable params: 0
_________________________________________________________________
```

In [82]:
```
model.summary()
```


```
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_6 (LSTM)                (None, 12, 128)           66560
_________________________________________________________________
dropout_4 (Dropout)          (None, 12, 128)           0
_________________________________________________________________
lstm_7 (LSTM)                (None, 64)                49408
_________________________________________________________________
dropout_5 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_4 (Dense)              (None, 1)                 65
=================================================================
Total params: 116,033
Trainable params: 116,033
Non-trainable params: 0
_________________________________________________________________
```


In [83]:
```
# help(EarlyStopping)
```

In [84]:
```
early_stop = EarlyStopping(monitor='val_loss', patience=2)
```

In [85]:
```
validation_generator = TimeseriesGenerator(scaled_test, scaled_test, length=length, batch_size=1)
```

In [86]:
```
model.fit(generator, epochs=20,
          validation_data=validation_generator,
          callbacks=[early_stop])
```

```
Epoch 1/20
322/322 [==============================] - 12s 32ms/step - loss: 0.0364 - val_loss: 0.0038
Epoch 2/20
322/322 [==============================] - 10s 31ms/step - loss: 0.0206 - val_loss: 0.0036
Epoch 3/20
322/322 [==============================] - 10s 32ms/step - loss: 0.0133 - val_loss: 7.6729e-04
Epoch 4/20
322/322 [==============================] - 10s 31ms/step - loss: 0.0085 - val_loss: 0.0021
Epoch 5/20
322/322 [==============================] - 10s 31ms/step - loss: 0.0051 - val_loss: 4.0616e-04
Epoch 6/20
322/322 [==============================] - 10s 32ms/step - loss: 0.0069 - val_loss: 0.0174
Epoch 7/20
322/322 [==============================] - 10s 31ms/step - loss: 0.0117 - val_loss: 3.3967e-04
Epoch 8/20
322/322 [==============================] - 10s 31ms/step - loss: 0.0032 - val_loss: 2.4422e-04
Epoch 9/20
322/322 [==============================] - 10s 31ms/step - loss: 0.0025 - val_loss: 8.8511e-04
Epoch 10/20
322/322 [==============================] - 10s 31ms/step - loss: 0.0049 - val_loss: 0.0014
```

Out[86]:
```
<tensorflow.python.keras.callbacks.History at 0x7a83503c0790>
```

In [87]:
```
losses = pd.DataFrame(model.history.history)
```

In [88]:
```
losses.plot()
```

Out[88]:
```
<AxesSubplot:>
```

In [89]:
```
test_predictions = []

first_eval_batch = scaled_train[-length:]
current_batch = first_eval_batch.reshape((1, length, n_features))

for i in range(len(test)):

    # get prediction 1 time  stamp ahead
    current_pred = model.predict(current_batch)[0]

    # store prediction
    test_predictions.append(current_pred)

    # update batch to now include prediction and drop first value
    current_batch = np.append(current_batch[:, 1:, :], [[current_pred]], axis=1)
```

In [90]:
```
true_prediction = scaler.inverse_transform(test_predictions)
```

In [91]:
```
test['Predictions'] = true_prediction
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-
  """Entry point for launching an IPython kernel.
```

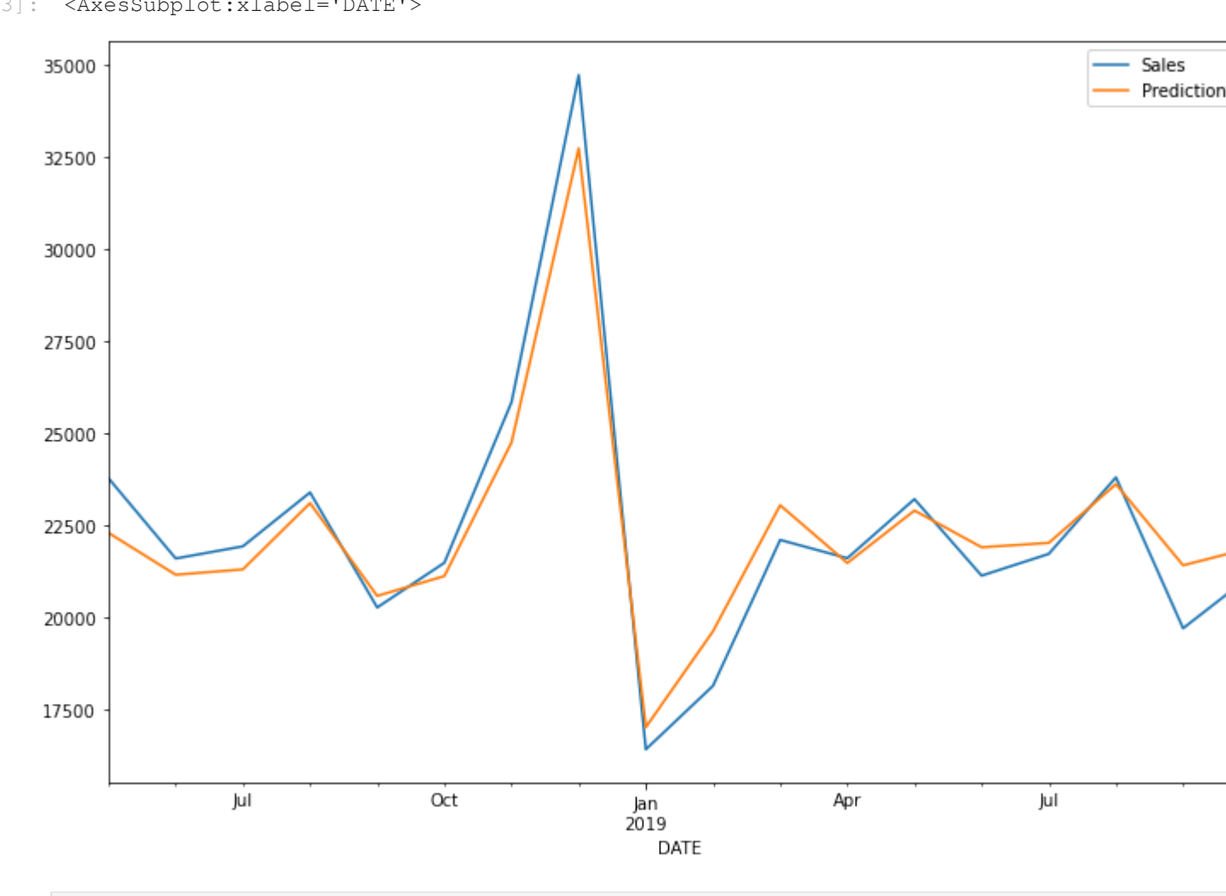
In [92]:
```
test
```

Out[92]:

	Sales	Predictions
DATE		
2018-05-01	23764	22284.356484
2018-06-01	21589	21147.877799
2018-07-01	21919	21293.410758
2018-08-01	23381	23091.549305
2018-09-01	20260	20573.570547
2018-10-01	21473	21111.076324
2018-11-01	25831	24738.940695
2018-12-01	34706	32719.472659
2019-01-01	16410	17011.697151
2019-02-01	18134	19614.130009
2019-03-01	22093	23034.846532
2019-04-01	21597	21467.198239
2019-05-01	23200	22890.602347
2019-06-01	21123	21893.577219
2019-07-01	21714	22011.990104
2019-08-01	23791	23605.453279
2019-09-01	19695	21403.928465
2019-10-01	21113	21869.466474

In [93]:
```
test.plot(figsize=(12, 8))
```

Out[93]:
```
<AxesSubplot:xlabel='DATE'>
```



In [94]:
```
forecast = []
# Replace periods with whatever forecast lengt you want
periods = 12

first_eval_batch = scaled_full_data[-length:]
current_batch = first_eval_batch.reshape((1, length, n_features))

for i in range(periods):

    # get prediction 1 time  stamp ahead
    current_pred = model.predict(current_batch)[0]

    # store prediction
    forecast.append(current_pred)

    # update batch to now include prediction and drop first value
    current_batch = np.append(current_batch[:, 1:, :], [[current_pred]], axis=1)
```

In [95]:
```
forecast = scaler.inverse_transform(forecast)
```

In [96]:
```
sales_data
```

Out[96]:

	Sales
DATE	
1992-01-01	6938
1992-02-01	7524
1992-03-01	8475
1992-04-01	9401
1992-05-01	9558
...	...
2019-06-01	21123
2019-07-01	21714
2019-08-01	23791
2019-09-01	19695
2019-10-01	21113

334 rows × 1 columns

In [97]:
```
forecast
```

Out[97]:
```
array([[25836.00095463],
       [33405.12013531],
       [17455.94740438],
       [19157.80632424],
       [22671.67822361],
       [22248.8306489 ],
       [23584.47827625],
       [21802.39440536],
       [22306.39534092],
       [24109.42466259],
       [20559.90133381],
       [21804.26928425]])
```

In [98]:
```
forecast_index = pd.date_range(start='2019-11-01', periods=periods,
                               freq='MS')
```

In [99]:
```
forecast_index
```

Out[99]:
```
DatetimeIndex(['2019-11-01', '2019-12-01', '2020-01-01', '2020-02-01',
               '2020-03-01', '2020-04-01', '2020-05-01', '2020-06-01',
               '2020-07-01', '2020-08-01', '2020-09-01', '2020-10-01'],
              dtype='datetime64[ns]', freq='MS')
```

In [100…
```
forecast_data = pd.DataFrame(data=forecast, index=forecast_index,
                             columns=['Forecast'])
```

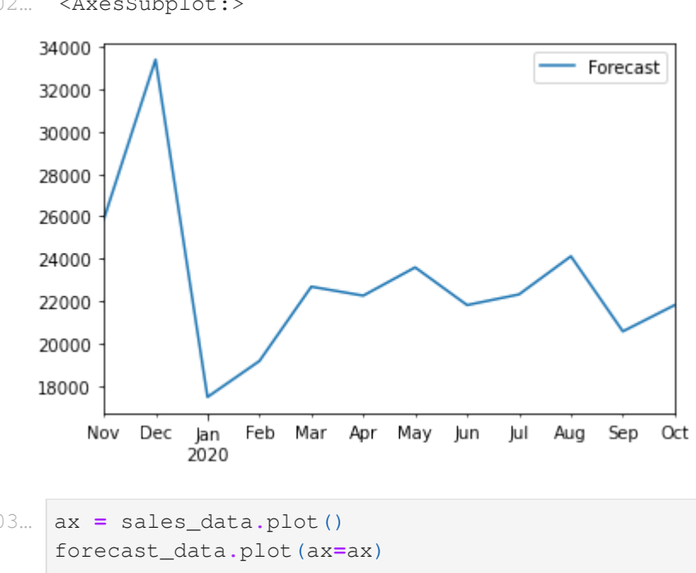
In [101…
```
forecast_data
```

Out[101…

	Forecast
2019-11-01	25836.000955
2019-12-01	33405.120135
2020-01-01	17455.947404
2020-02-01	19157.806324
2020-03-01	22671.678224
2020-04-01	22248.830649
2020-05-01	23584.478276
2020-06-01	21802.394405
2020-07-01	22306.395341
2020-08-01	24109.424663
2020-09-01	20559.901334
2020-10-01	21804.269284

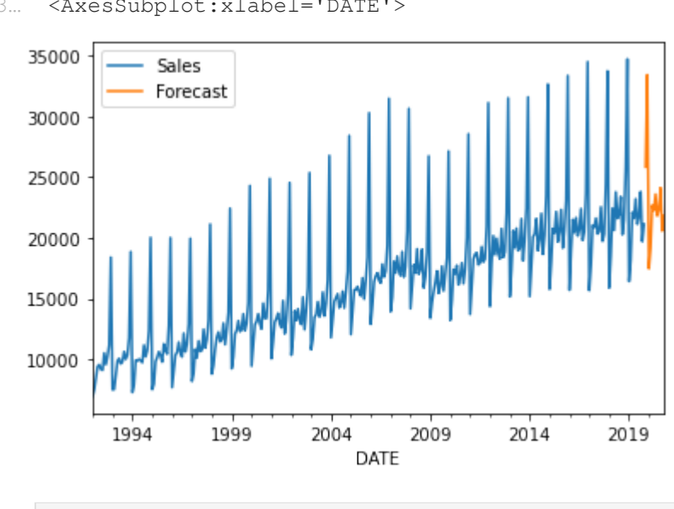
In [102…
```
forecast_data.plot()
```

Out[102…
```
<AxesSubplot:>
```



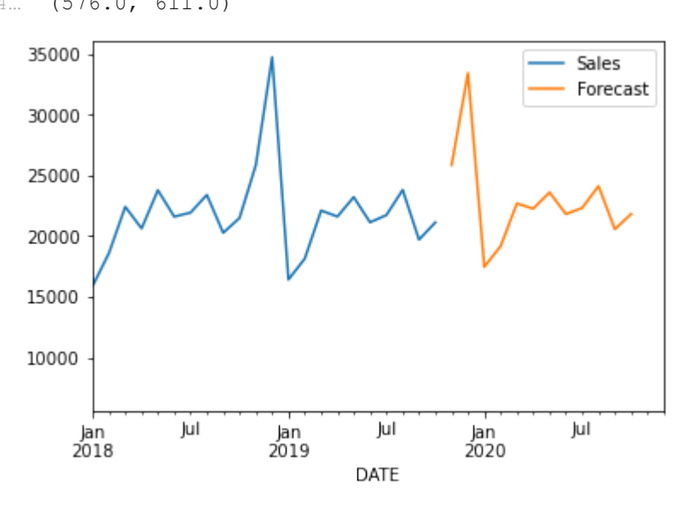
In [103…
```
ax = sales_data.plot()
forecast_data.plot(ax=ax)
```

Out[103…
```
<AxesSubplot:xlabel='DATE'>
```



In [104…
```
ax = sales_data.plot()
forecast_data.plot(ax=ax)
plt.xlim('2018-01-01', '2020-12-01')
```

Out[104…
```
(576.0, 611.0)
```



Happy Learning :)