In [ ]:

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import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import pymongo as pm
import pprint
from enum import Enum
from datetime import datetime, timedelta
import pytz

#------------------------------------------------------------ Connect to MongoDB
client = pm.MongoClient('bigdatadb.polito.it',
                        ssl=True,
                        authSource = 'carsharing',
                        username = 'ictts',
                        password ='Ict4SM22!',
                        tlsAllowInvalidCertificates=True)
db = client['carsharing']
#Choose the DB to use
permenant_booking = db['PermanentBookings']
permenant_parking = db['PermanentParkings']
enjoy_permenant_booking = db['enjoy_PermanentBookings']
enjoy_permenant_parking = db['enjoy_PermanentParkings']
#ENUM of cities
class CITY_ENUM(Enum):
    TO = 'Torino'
    SEA = 'Seattle'
    STU = 'Stuttgart'
class CITY_TIMEZONES(Enum):
    TO = 'Europe/Rome'
    SEA = 'America/Los_Angeles'
    STU = 'Europe/Berlin'

# def get_start_end_unix_zone(timezone):
#     # start_timestamp = datetime(2018, 1, 1,0,0,0,0, pytz.timezone(timezone)).timestamp()
#     # end_timestamp  = datetime(2018, 1, 31,23,59,59,0, pytz.timezone(timezone)).timestamp()
#     return start_timestamp,end_timestamp
start_unix_time = datetime.strptime("27/12/2017", "%d/%m/%Y").timestamp()
end_unix_time = datetime.strptime("27/01/2018", "%d/%m/%Y").timestamp()

#pipeline for getting the data for the rentals with the filteration of the data
#too short and too long rentals are filtered out
#considered if car is moved
def filter_pipeline(city,start_unix_time,end_unix_time):
    return [
    {
        '$match': {
            'city': city,
            'init_time': {
                '$gte': start_unix_time,
                '$lt': end_unix_time
            },
            'final_time': {
                '$gte': start_unix_time,
                '$lt': end_unix_time
            }
        }
    },
    {
        '$project': {
            '_id': 0,
            'duration': {
                '$divide': [
                    { '$subtract': ['$final_time', '$init_time'] },
                    60  # Divide by 60 to convert seconds to minutes
                ]
            },
            'day': {'$dayOfMonth': '$init_date'},
            'hour': {'$hour': '$init_date'},
            'date': {
                '$dateToString': {
                    'format': '%Y-%m-%d',
                    'date': '$init_date'
                }
            },
            'moved': {
                '$ne':[
                    {"$arrayElemAt": [ "$origin_destination.coordinates", 0]},
                    {"$arrayElemAt": [ "$origin_destination.coordinates", 1]}
                 ]
            }
        }
    },
    {
        '$match': {
            'moved': True,
            'duration':{'$gt':5, '$lt':180},

        }
    },
    {
        '$group':{
            '_id': {'day': '$day', 'hour': '$hour', 'date': '$date'},
            'total_count': {'$sum': 1},
        }
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    },
    {
        '$sort': {
            '_id': 1,
        }
    },
]
#------------------------------------------------------------ Get the data from MongoDB
TO_Data = list(enjoy_permenant_booking.aggregate(filter_pipeline(CITY_ENUM.TO.value,
          start_unix_time,end_unix_time)))
SEA_Data = list(permenant_booking.aggregate(filter_pipeline(CITY_ENUM.SEA.value,
          start_unix_time,end_unix_time)))
STU_Data = list(permenant_booking.aggregate(filter_pipeline(CITY_ENUM.STU.value,
          start_unix_time,end_unix_time)))
cities_data_array = [(CITY_ENUM.TO.value,TO_Data),(CITY_ENUM.SEA.value,SEA_Data),(CITY_ENUM.STU.value,STU_Data)]
#------------------------------------------------------------ check for missing data
print("TO_Data",len(TO_Data))
print("SEA_Data",len(SEA_Data))
print("STU_Data",len(STU_Data))
#------------------------------------------------------------ Dropping _id and Flattening the data
def dfModifier(city_list):
  df = pd.DataFrame(city_list, columns =['_id', 'total_count'])
  df['date'] = df['_id'].apply(lambda x: x['date'])
  df['day'] = df['_id'].apply(lambda x: x['day'])
  df['hour'] = df['_id'].apply(lambda x: x['hour'])
  df['myIndex'] = (df['day']-1)*24 + (df['hour']+1)
  df.drop(['_id'], axis=1, inplace=True)
  return df
#day | hour
#1   | 0 -> day*24 + hour => 1*24 + 0 = 24
#1   | 1 -> day*24 + hour => 1*24 + 1 = 25
#1   | 2 -> day*24 + hour => 1*24 + 2 = 26
#day | hour
#0   | 1 -> day*24 + hour => 0*24 + 1 = 1
#0   | 2 -> day*24 + hour => 0*24 + 2 = 2
#0   | 3 -> day*24 + hour => 0*24 + 3 = 3
TO_df = dfModifier(TO_Data)
SEA_df = dfModifier(SEA_Data)
STU_df = dfModifier(STU_Data)
cities_df_array = [(CITY_ENUM.TO.value,TO_df),(CITY_ENUM.SEA.value,SEA_df),(CITY_ENUM.STU.value,STU_df)]
#------------------------------------------------------------ Calculating hourly mean
# calculating the avg for each hour of the day
TO_hourly_avg = TO_df.groupby('hour')['total_count'].mean().round().reset_index().astype(int)['total_count'].tolist()
SEA_hourly_avg = SEA_df.groupby('hour')['total_count'].mean().round().reset_index().astype(int)['total_count'].tolist()
STU_hourly_avg = STU_df.groupby('hour')['total_count'].mean().round().reset_index().astype(int)['total_count'].tolist()
#------------------------------------------------------------ Filling the missing data with the mean
def fillMissingValues(df:pd.DataFrame, avg_df):
  missingValues=set(np.arange(1,31*24+1)).difference(set(df['myIndex']))
  # dfMean = round(np.mean(df['total_count']))
  print("Missing values are:", len(missingValues), missingValues)
  df2 = df
  for value in missingValues:
    dayOfValue = int((value-1)/24)+1
    hourOfValue = (value-1)%24
    new_row = pd.DataFrame({'total_count':avg_df[hourOfValue],'date':f'2018-01-{dayOfValue:02d}',
                            'day':dayOfValue,'hour':hourOfValue,'myIndex':value}, index =[0])
    df2 = pd.concat([new_row,df2.loc[:]]).reset_index(drop = True)
  df2.sort_values(by=['myIndex'], inplace=True)
  return df2

To_FilledValues = fillMissingValues(TO_df, TO_hourly_avg)
SEA_FilledValues = fillMissingValues(SEA_df,SEA_hourly_avg)
STU_FilledValues = fillMissingValues(STU_df,SEA_hourly_avg)
#------------------------------------------------------------ Plotting the data with Rolling mean and checking for stationarity
def plotter(plotTitle, df:pd.DataFrame):
    mean = df['total_count'].rolling(window=24*7).mean()
    std = df['total_count'].rolling(window=24*7).std()
    plt.figure(figsize=(14, 6))
    plt.plot(df['myIndex'], mean, label='Rolling Mean', color='red')
    plt.plot(df['myIndex'], std, label='Rolling Std', color='green')
    plt.plot()
    plt.plot(df['myIndex'], df['total_count'], label='Rental', color='blue')
    plt.xlabel('Date')
    plt.ylabel('Total Count')
    plt.legend()
    plt.grid(True)
    plt.title(f'Total Counts in Dates and Hours in - {plotTitle}')
    plt.grid(True)
    plt.savefig(f'{plotTitle}-Roolings-mean-std')
    plt.clf()
plotter('Torino',To_FilledValues)
plotter('Seattle',SEA_FilledValues)
plotter('Stuttgart',STU_FilledValues)
#------------------------------------------------------------ making a clean data
cleanFilledCities = [(CITY_ENUM.TO.value,To_FilledValues),(CITY_ENUM.SEA.value,SEA_FilledValues),(CITY_ENUM.STU.value,STU_Fi
#------------------------------------------------------------ Computing ACF and PACF and Plotting them
from statsmodels.tsa.stattools import acf,pacf
from statsmodels.graphics.tsaplots import plot_pacf, plot_acf

# Use ACF to find q.
# Use PACF to find p.

def ACF_PACF(city_data):
  # plot acf
  plt.figure(figsize=(6,4))
  plot_acf(city_data[1]["total_count"], lags=48)
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  plt.title(f'Autocorrelation Function 48 Hours - {city_data[0]}')
  plt.xlabel('Lags')
  plt.grid(True)
  # plt.show()
  plt.savefig(f'{city_data[0]}-ACF')

  # plot pacf
  plt.figure(figsize=(6,4))
  plot_pacf(city_data[1]["total_count"], lags=48)
  plt.title(f'Partial Autocorrelation Function 48 Hours - {city_data[0]}')
  plt.xlabel('Lags')
  plt.grid(True)
  # plt.show()
  plt.savefig(f'{city_data[0]}-PACF')

for city_data in cities_df_array:
  ACF_PACF(city_data)

#------------------------------------------------------------ ARIMA model and prediction
from statsmodels.tsa.arima.model import ARIMA
import warnings
from statsmodels.tools.sm_exceptions import ConvergenceWarning
warnings.simplefilter('ignore', ConvergenceWarning)

q = 4
p = 2
d = 0
train_size = 24 * 7 * 2 # 24 * 7 * 3 # 3 weeks -> we will change this to 14 days
test_size = 24 * 3 # 10 days -> this takes too long to run so we will use 72 hours
myModel = None
def Predictor(cleanCity):
  originalData = list(cleanCity[1]['total_count'][:train_size])#.tolist()
  y_hat = [None for _ in range(train_size)] # should it be a list or pandas array?
  for record in range(train_size,train_size+test_size):
    model = ARIMA(originalData, order=(p,d,q))
    model_fit = model.fit()
    prediction = int(model_fit.forecast()[0])
    y_hat.append(prediction)
    originalData.append(cleanCity[1]['total_count'][record])
    originalData = originalData[1:]
    myModel = model_fit

  plt.figure(figsize=(15,5))
  plt.title("Predicted values vs Real values")
  plt.plot(list(cleanCity[1]['total_count'][train_size:train_size+test_size]), color='blue', label="Real values")
  plt.plot(list(y_hat[train_size: train_size+test_size]), color='red', label="Predicted values")
  plt.legend()
  plt.xlabel("Lags")
  plt.ylabel("Rentals")
  plt.grid(True)
  plt.savefig(f'2 day prediction {cleanCity[0]}')
  plt.clf()
  # plot residual errors
  residuals = pd.DataFrame(myModel.resid)
  residuals.plot()
  plt.title(f'Residuals - {cleanCity[0]}')
  plt.xlabel("Residual Error")
  plt.ylabel("Residuals")
  plt.grid(True)
  plt.savefig(f'2 day Residuals {cleanCity[0]}')
  plt.clf()
  #plot the gaussian density of the residuals
  residuals.plot(kind='kde')
  plt.title(f'Density of Residuals - {cleanCity[0]}')
  plt.xlabel("Residual Error")
  plt.ylabel("Density")
  plt.grid(True)
  plt.savefig(f'2 day Density of Residuals {cleanCity[0]}')
  plt.clf()
  return y_hat, model_fit
#------------------------------------------------------------ Prediction for 3 days
#create an array to store the results to be used for the comparison and metrics
comparisonArray = []
for city_data in cleanFilledCities:
  print(city_data[0])
  y_hat, model_fit = Predictor(city_data)
  y_hat = y_hat[train_size:train_size+test_size]
  comparisonArray.append((city_data[0],city_data[1]['total_count'][train_size:train_size+test_size], y_hat, model_fit))
#------------------------------------------------------------ Metrics
from sklearn.metrics import mean_squared_error,r2_score, mean_absolute_percentage_error
for item in comparisonArray:
  mse = mean_squared_error(item[1], item[2])
  rmse = np.sqrt(mse)
  r2 = r2_score(item[1], item[2])
  mape = mean_absolute_percentage_error(item[1], item[2])
  print(f'{item[0]} -> MSE: {mse:.2f}, RMSE: {rmse:.2f}, R2: {r2:.2f}, MAPE: {mape:.2f}')
#------------------------------------------------------------ Runninf model for different P and Q values
p = [1,2,3,4,5,6]
q = [1,2,3,4]
d = 0
finalValues = []

for cleanCity in cleanFilledCities:
  for i in p:
    for j in q:
      worked = False
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      originalData = list(cleanCity[1]['total_count'][:train_size])#.tolist()
      y_hat = [None for _ in range(train_size)] # should it be a list or pandas array?
      for record in range(train_size,train_size+test_size):
        try:
          model = ARIMA(originalData, order=(i,d,j))
          model_fit = model.fit()
          prediction = int(model_fit.forecast()[0])
          # print(f'Prediction for {cleanCity[0]} at {record} is {prediction}')
          y_hat.append(prediction) #shoudl it be int(prediction) or prediction as a float
          originalData.append(cleanCity[1]['total_count'][record])
          originalData = originalData[1:]
          worked = True
        except:
          print("error")
          worked = False
          continue
      if worked:
        actual_values = cleanCity[1]['total_count'][train_size:train_size+test_size]
        prediction_values = y_hat[train_size:train_size+test_size]
        mse = mean_squared_error(actual_values, prediction_values)
        rmse = np.sqrt(mse)
        r2 = r2_score(actual_values, prediction_values)
        mape = mean_absolute_percentage_error(actual_values, prediction_values)
        finalValues.append((cleanCity[0],i,j,mse,rmse,r2,mape))
      elif not worked:
        finalValues.append((cleanCity[0],i,j,0,0,0,0))
#------------------------------------------------------------ Plotting a heatmap for the results
#get the list and  change it to a 2d array to fit the heatmap
from itertools import groupby
import seaborn as sb

# print(finalValues)
dont_touch_this = finalValues
touchthis = finalValues
touchThat = pd.DataFrame(touchthis, columns=['city','p','q','mse','rmse','r2','mape'])
#group by city
touchThat = touchThat.groupby('city')
for name, group in touchThat:
    mapeList = group['mape'].tolist()
    mapPD = pd.DataFrame(mapeList)
    MAPE2d = mapPD.values.reshape(6,4)
    print(MAPE2d)
    sb.heatmap(MAPE2d, annot=True, cmap="YlGnBu", fmt=".2f", linewidths=.5,
            xticklabels=[1,2,3,4], yticklabels=[1,2,3,4,5,6])
    plt.title(f'MAPE - {name}')
    plt.xlabel("q")
    plt.ylabel("p")
    # plt.show()
    plt.savefig(f'MAPE - {name}')
    plt.clf()
```