Presentation of my Diploma project within the specialization "Machine Learning and Data Analysis" (Coursera)

Time Series analysis and prediction

In [ ]:

```
# The project is based on processing of raw data describing Yellow taxi trips in New
# in the first half of 2016, downloaded from the official web-site:
# www.nyc.gov/html/tlc/html/about/trip_record_data.shtml
```

PROBLEM: Create prediction model for the trips in June 2016 training on the Jan-May 2016 trips data

In [ ]:

```
# The following analysis was performed within the project:
# 1. Initial raw data processing (cleaning, formating, aggregation, separation by re
# 2. Application of SARIMAX model for prediction of time series data
# 3. Clustering of geographical zones by time series behaviour
# 4. Features selection for application of alternative model - Regression
# 5. Optimization of regression model by addition of new features
```

In [ ]:

```
# Due to huge amount of code while the analysis above,
# this presentational notebook summarizes the main results of the project
```

In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import datetime
import warnings
import folium
from folium.plugins import HeatMap
import ipywidgets as widgets
from ipywidgets import interactive
from IPython.display import display, HTML

from IPython.display import Image
```

In [2]:

```
# load the trip data from the regions with the number of trips per hour more than 4.
data = pd.read_csv('Data/DataTrips102.csv', sep=',')
data['time'] = pd.to_datetime(data['time'])
# leave only data from June
data = data[data.time >= datetime.datetime(2016, 6, 1)]
# set time as index
data.set_index('time',inplace=True)
data.tail(2)
```

Out[2]:

	zone	num_trips
time		
2016-06-30 23:00:00	2119	119.0
2016-06-30 23:00:00	2168	0.0

In [3]:

```
# load the predictions made by the best model - optimized regression model
dataPred = pd.read_csv('Data/pred_table.csv', sep=',')
dataPred.drop('Unnamed: 0', axis=1, inplace=True)
dataPred['time'] = pd.to_datetime(dataPred['time'])
dataPred.head(2)
```

Out[3]:

	time	region	y1	y2	y3	y4	y5	y6
0	2016-05-31 23:00:00	1075	23.862931	10.386250	-4.938699	-10.669369	-6.297226	3.525538
1	2016-06-01 00:00:00	1075	9.513744	-2.924906	-8.022060	-0.565592	9.133963	24.968098

In [4]:

```
# the list of regions
reg_list = np.unique(list(data.zone))
# indroduce the object - New-York map with coordinates of Empire State Building
latt_ESB = 40.74778
long_ESB = -73.98583
map = folium.Map(location=[latt_ESB, long_ESB], zoom_start=12)
```

1. Visualization of the real and predicted demand for taxi in selected by user time

In [5]:

```
# load the splitting of the city by 50x50 = 2500 zones
regions = pd.read_csv('Data/regions.csv', sep=';')
# keep only considering 102 regions where the number of trips per hour is more than
def regenv(reg, reg_list):
    if reg in reg_list:
        return True
    else:
        return False
regions['regs102'] = regions.apply(lambda x: regenv(x['region'], reg_list), axis=1)
regions = regions[regions.regs102 == True]
regions.drop('regs102', axis=1, inplace=True)
# calculate the center of each region
def cent(a,b):
    return (a+b)/2
regions['latt'] = regions.apply(lambda x: cent(x['south'], x['north']), axis=1)
regions['long'] = regions.apply(lambda x: cent(x['west'], x['east']), axis=1)
regions.drop(['west','east','south','north'], axis=1, inplace=True)
regions.head(2)
```

Out[5]:

	region	latt	long
1074	1075	40.701631	-74.016691
1075	1076	40.710019	-74.016691

In [8]:

```
# Create a function of plotting the real and predicted trips, where:
# day - selected day of month (June)
# hour - selected hour of the choosen day of month
# predNum - predicted time lag in hours (from 1 to 6)
def Visualization(day, hour, predNum):
    time = datetime.datetime(2016, 6, day, hour)
    # make a list of trips in the selected time for all the 102 regions
    subdata = list(data[data.index == time].num_trips)
    map_real = folium.Map(location=[latt_ESB, long_ESB], zoom_start=10)
    map_real.add_child(HeatMap(zip(regions['latt'].values, regions['long'].values, s
    map_real.save('trips_real.html')
    # create a list of predicted trips in the selected time from the all of 102 regi
    dT = datetime.timedelta(hours=1)
    if predNum == 1:
        subdata_pred = list(dataPred[dataPred.time == (time - predNum*dT)].y1)
    if predNum == 2:
        subdata_pred = list(dataPred[dataPred.time == (time - predNum*dT)].y2)
    if predNum == 3:
        subdata_pred = list(dataPred[dataPred.time == (time - predNum*dT)].y3)
    if predNum == 4:
        subdata_pred = list(dataPred[dataPred.time == (time - predNum*dT)].y4)
    if predNum == 5:
        subdata_pred = list(dataPred[dataPred.time == (time - predNum*dT)].y5)
    if predNum == 6:
        subdata_pred = list(dataPred[dataPred.time == (time - predNum*dT)].y6)
    map_pred = folium.Map(location=[latt_ESB, long_ESB], zoom_start=10)
    map_pred.add_child(HeatMap(zip(regions['latt'].values, regions['long'].values, s
    map_pred.save('trips_pred.html')

    real_title = u'Real data:'
    pred_title = u'Predicted to ' + str(predNum) + ' hours:'
    # plot the defined maps above in html
    disp = u'Date: {0:0>2}.06.2016 Time: {1:0>2}:00:00'.format(day, hour)
    htmlText = ''
    htmlText = htmlText + '<table>'
    htmlText = htmlText + '<tr><td colspan="2" style="text-align:center;"><h3>' + di
    htmlText = htmlText + '<tr><td><h3 style="text-align:center;">' + real_title + '
    htmlText = htmlText + '<tr><td><iframe src="trips_real.html" width="400" height=
    htmlText = htmlText + '<td><iframe src="trips_pred.html" width="400" height="300
    htmlText = htmlText + '</table>'

    display(HTML(htmlText))
```

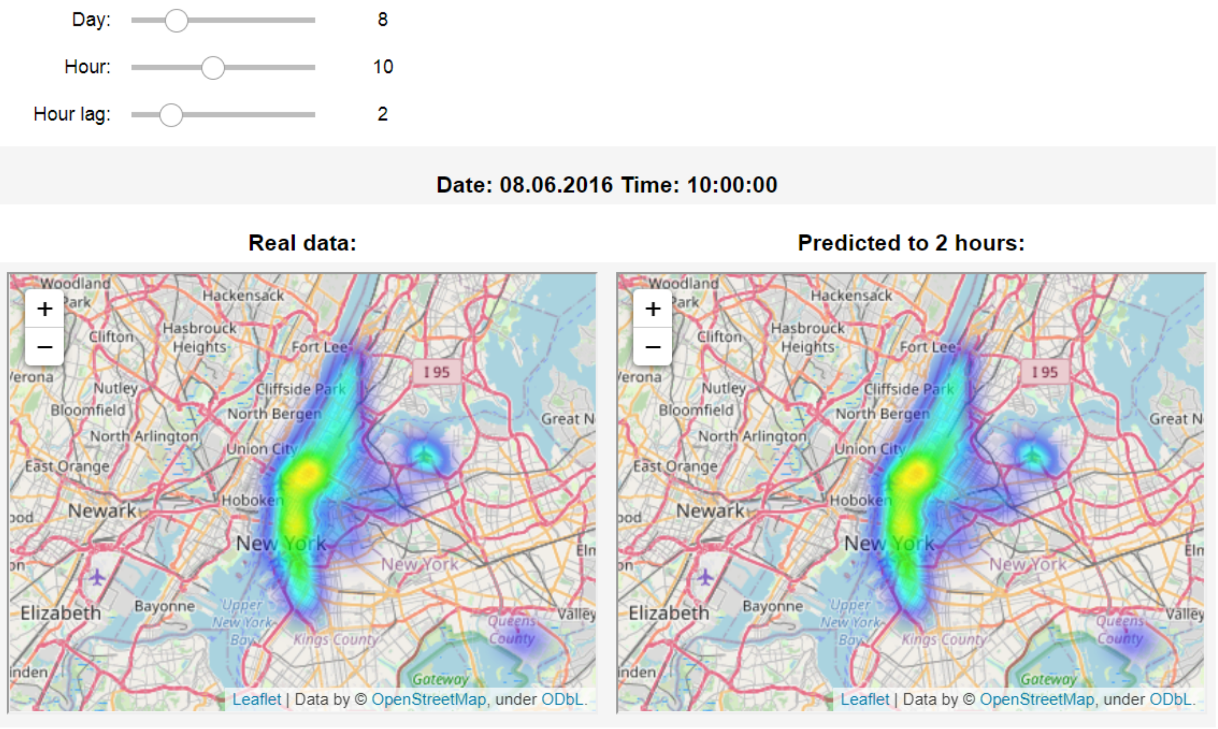
In [9]:

```
# plot the maps of real and predicted trips with user-activated parameters selection
InteractData = interactive(Visualization,
                    day=widgets.IntSlider(min=1,max=31,step=1,value=1,description=u'
                    hour=widgets.IntSlider(min=0,max=23,step=1,value=0,description=u
                    predNum=widgets.IntSlider(min=1,max=6,step=1,value=1,description
display(InteractData)
```

In [10]:

```
# The interactive graphs presented in this notebook can't be transformed correctly t
Image("Data/Fig1_TaxiW7.PNG")
```

Out[10]:



Day: 8

Hour: 10

Hour lag: 2

Date: 08.06.2016 Time: 10:00:00

Real data:

Predicted to 2 hours:

2. Time series of the real and predicted taxi demand in the selected region.

In [ ]:

```
# Keep for simplicity the prediction for the 1 hour time lag
```

In [13]:

```
# add the marks of all 102 regions (centers) to the map
for reg, latt, long in zip(regions['region'], regions['latt'], regions['long']):
    text = u'Region#' + str(reg)
    folium.Marker([latt, long], popup=text).add_to(map)
```

In [14]:

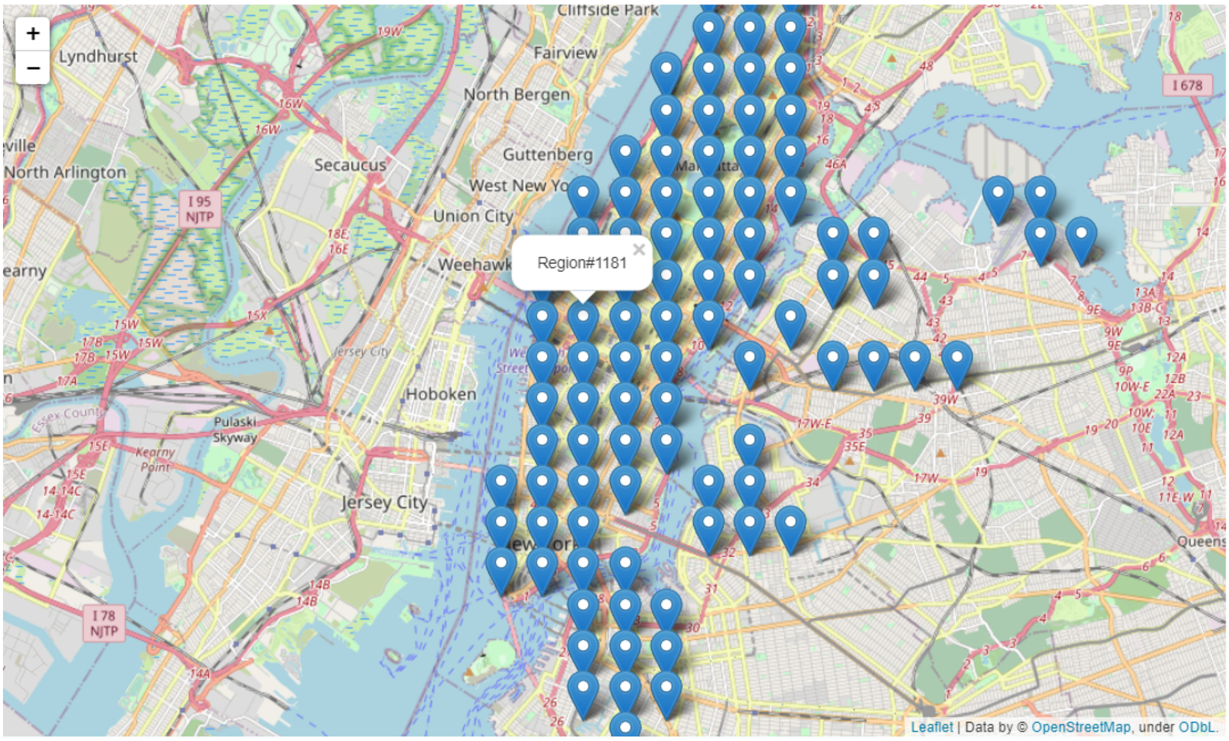
```
# plot the map where user can click on the region to understand its number
map
```

Out[14]: Make this Notebook Trusted to load map: File -> Trust Notebook

In [15]:

```
# The interactive graphs presented in this notebook can't be transformed correctly t
Image("Data/Fig2_TaxiW7.PNG")
```

Out[15]:



In [16]:

```
def PlotTimeSeries(reg):
    # the real trips from the region
    subdata = data[data.zone == reg]
    # construction of the predicted trips from the region:
```

```
    # take hours prediction y1 until 30.06.2016 18:00 and the rest predicted hour La
    subdata_pred = dataPred[dataPred.region == reg]
    sub1 = list(subdata_pred.y1)
    sub2 = [subdata_pred.iloc[subdata_pred.shape[0]-1].y2,subdata_pred.iloc[subdata_
        subdata_pred.iloc[subdata_pred.shape[0]-1].y4,subdata_pred.iloc[subdata_pred
        subdata_pred.iloc[subdata_pred.shape[0]-1].y6]
    subdata_pred = sub1 + sub2

    # Make input parameters for series plot
    x = range(subdata.shape[0])
    x_labels = subdata.index.tolist()
    y = list(subdata.num_trips)
    y_pred = list(subdata_pred)

    # Make marks and graph format
    ticks = range(0, len(x), 12)
    x_ticks = [x[i] for i in ticks] + [x[len(x)-1]]
    x_labels_ticks = [x_labels[i] for i in ticks] + [x_labels[len(x_labels)-1]]
    f, (ax1) = plt.subplots(figsize=(20,10))
    ax1.set(title='Trips in June', xlabel='Departure hour', ylabel='Number of trips'
    pl_real = ax1.plot(x, y, label='Real data')
    pl_forecast = ax1.plot(x, y_pred, 'g', label='Prediction')
    plt.xticks(x_ticks, x_labels_ticks, rotation='vertical')
    handles, labels = ax1.get_legend_handles_labels()
    ax1.legend(handles, labels)
    plt.show()

def VisualizeSeries(reg):
    if len(reg)>0:
        r = reg[0]
        PlotTimeSeries(r)
```

In [17]:

```
TimeSer = interactive(VisualizeSeries, reg=widgets.SelectMultiple(
    options=reg_list, description=u'Select the region:', disabled=False))
display(TimeSer)
```

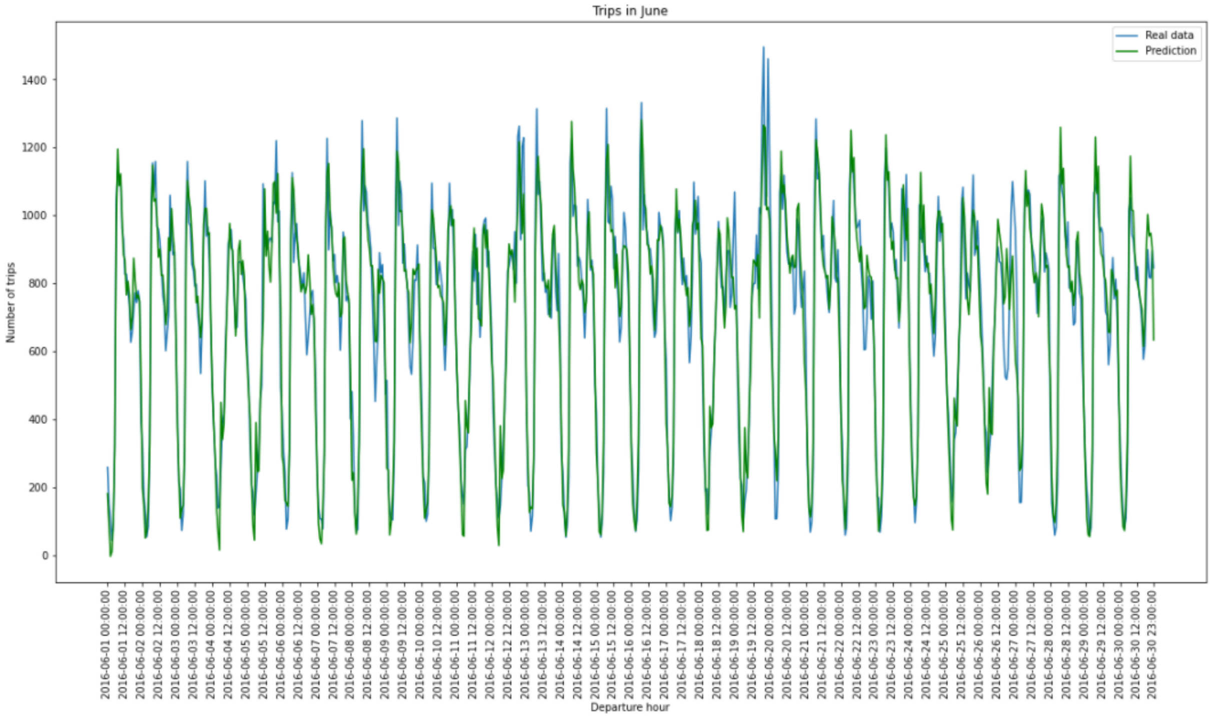
In [18]:

```
# The interactive graphs presented in this notebook can't be transformed correctly t
Image("Data/Fig3_TaxiW7.PNG")
```

Out[18]:

Select the r…

1179
1180
1181
1182
1183


Trips in June
Real data
Prediction
Number of trips
Departure hour
2016-06-01 00:00:00
2016-06-01 12:00:00
2016-06-02 00:00:00
2016-06-02 12:00:00
2016-06-03 00:00:00
2016-06-03 12:00:00
2016-06-04 00:00:00
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