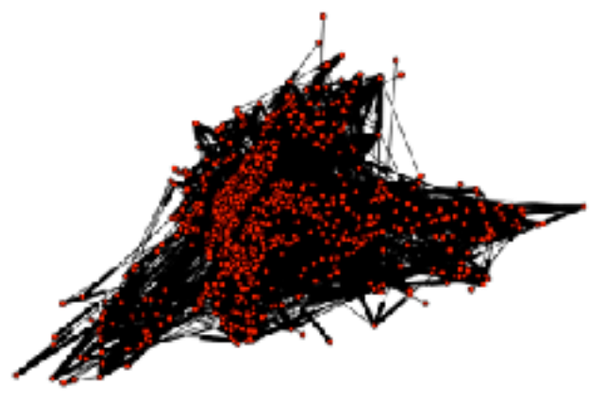
# Spatial Information Retrieval in the city

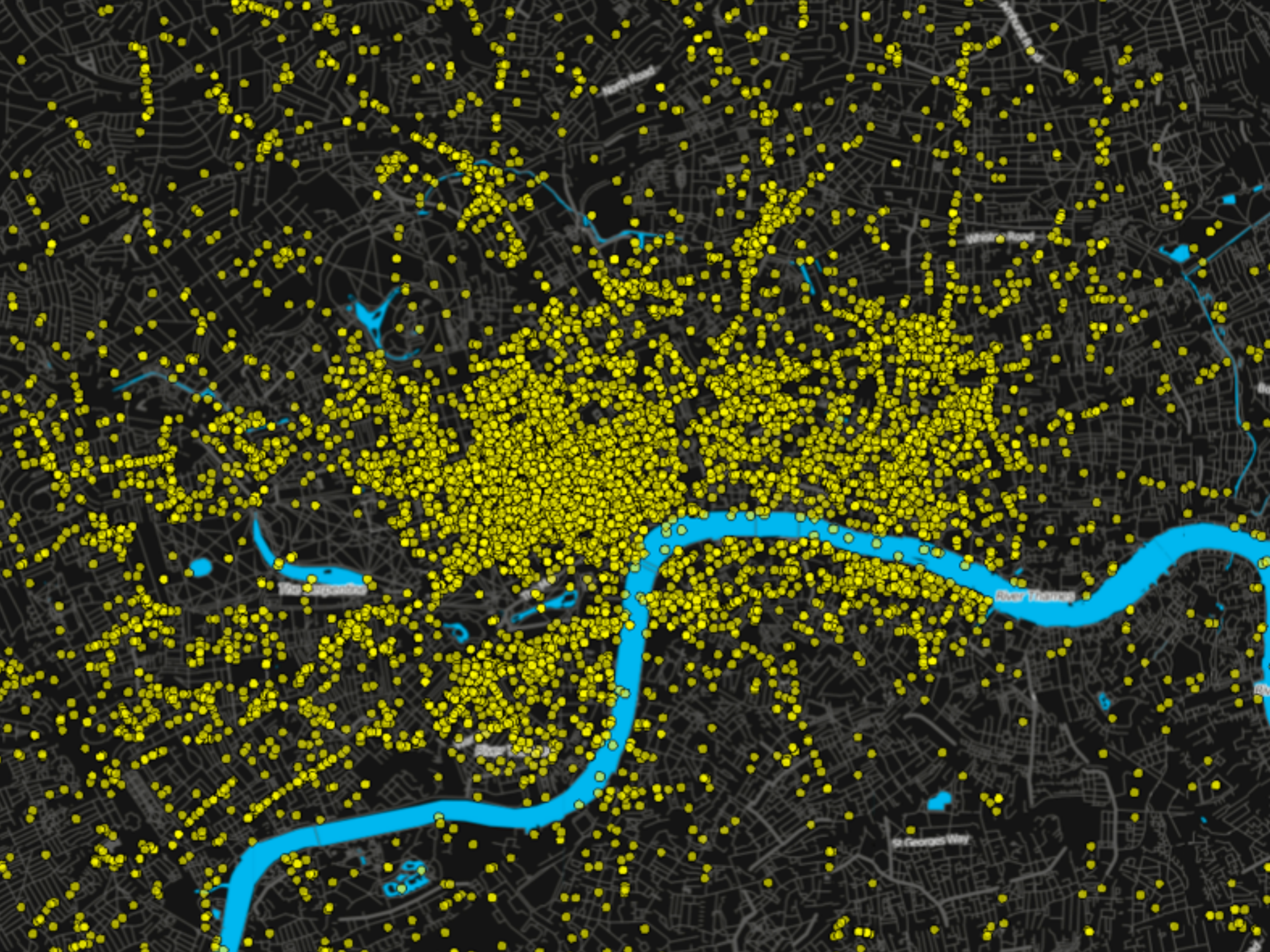
**Anastasios Noulas**
Data Science Institute
School of Computing & Communications
Lancaster University

ICWSM'17, Tutorial on Spatial Datasets and Urban Applications, Montreal, Canada

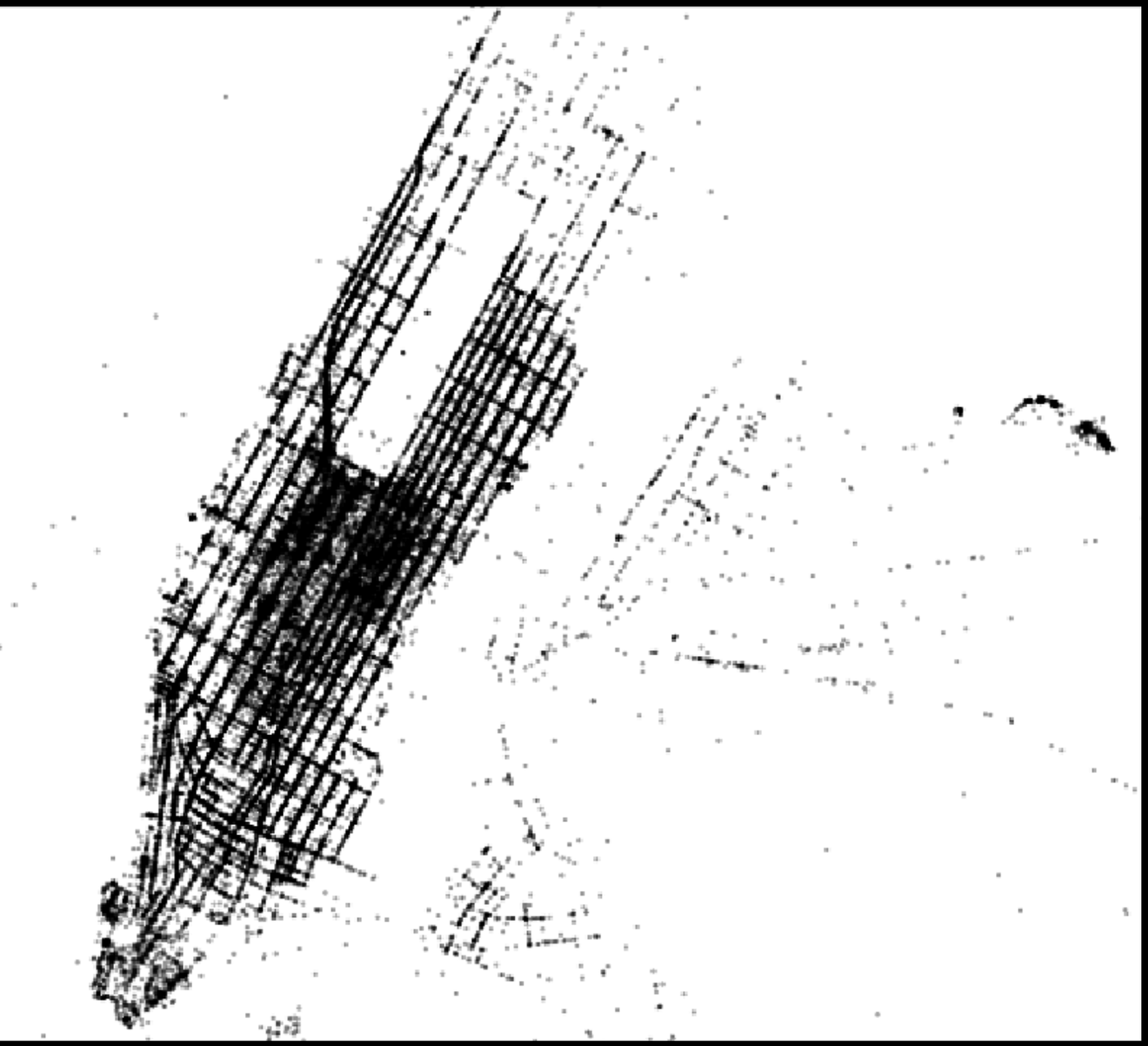
# Practical: Outline

- Introduce basic spatial retrieval methods.
- Define and explore place networks using networks.
- Showcase Uber's deck.gl visualisation framework.




North Road
Whistler Road
River Thames
St Georges Way

# THE NEW YORK CITY TAXI DATASET



**FOIL**ing NYC's Taxi Trip Data

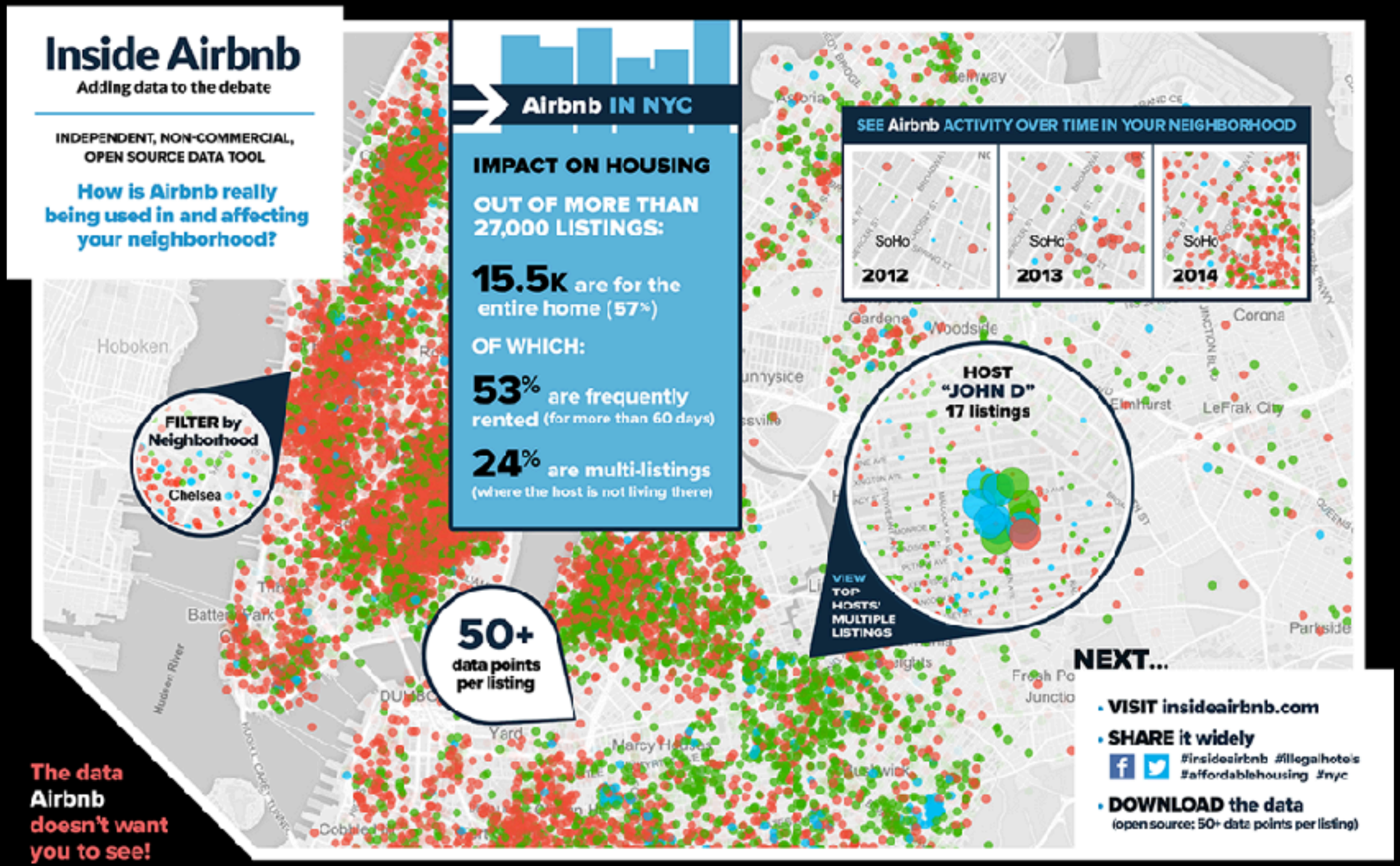
Freedom of Information Law

2013 Trip Data, 11GB, zipped!

2013 Fare Data, 7.7GB

**Idea:** Uber Vs Yellow Taxi Price Comparison.

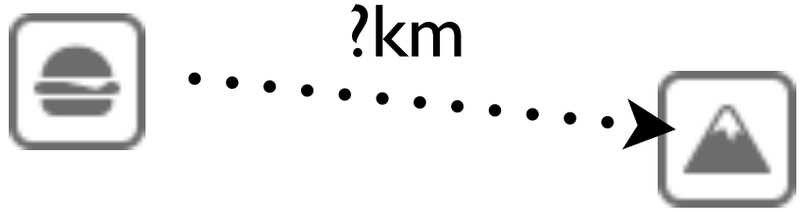
http://www.nyc.gov/html/tlc/html/about/trip_record_data.shtml




http://insideairbnb.com/about.html

# We will learn ..

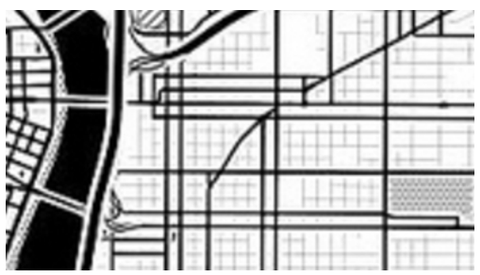
**To measure the geographic distance between pairs of venues.**



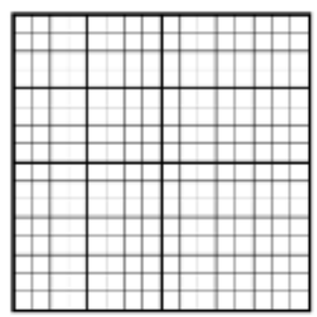

**To infer the geographic center of a city.**

**To get all places within a radius given a pair of geographic coordinates.**

**Create our own Maps**



**Apply a grid over a city.**



**amongst others :)**

# What's the "true" centre of Europe?

https://en.wikipedia.org/wiki/Geographical_midpoint_of_Europe

*the Centre of Europe*, a sculpture park containing the world's largest sculpture made of TV sets.[3]

## Belarus [ edit ]

In 2000 Belarusian scientists Alexey Solomonov and Valery Anoshko published a report that stated the geographic centre of Europe was located near Lake Sho (55°10′55″N 28°15′30″E; Belarusian: Шо) in Vitsebsk Voblast.[4]

Scientists from the Russian Central Research Institute of Geodesy, Aerial Survey and Cartography (Russian: ЦНИИГАиК) confirmed the calculations of Belarusian geodesists that the geographical centre of Europe is located in Polotsk 55°30′0″N 28°48′0″E. A small monument to the Geographical Centre of Europe was set up in Polotsk on May 31, 2008.[5]

*See also: Geographic center of Belarus*

## Hungary [ edit ]

It is claimed that a 1992 survey found that the geometric centre of Europe is in the village of Tállya, Hungary 48.23610°N 21.22574°E.[6][7] In 2000, a sculpture was erected in the village, with a table on it declaring the place the "Geometric Centre of Europe".[8]

## Estonia [ edit ]

It is claimed that if all the islands of Europe – from the Azores to Franz Joseph Land and from Crete to Iceland – are taken into consideration then the centre of Europe lies at 58°18′14″N 22°16′44″E in the village of Mõnnuste, on Saaremaa island in western Estonia. Again, no author and no method of calculation have been disclosed. The local Kärla Parish is seeking to verify the location and to turn it into a tourist location.[9]

## Other claimants [ edit ]

Locations currently vying for the distinction of being the centre of Europe include:

- the village of Kremnické Bane or the neighbouring village Krahule, near Kremnica, in central Slovakia [10]
- the small town of Rakhiv, or the village of Dilove near Rakhiv, in western Ukraine [11]
- the village of Bernotai, or Purnuškės, near Vilnius, in Lithuania [12][13]
- a point on the island of Saaremaa in Estonia [14]
- a point near Polotsk, or in Vitebsk, or near Babruysk, or near lake Sho in Belarus [15]
- a point near the town of Tállya, in north-eastern Hungary [16]


Current measurements of extreme points of Europe and its centres

Monument in Purnuškės, Lithuania

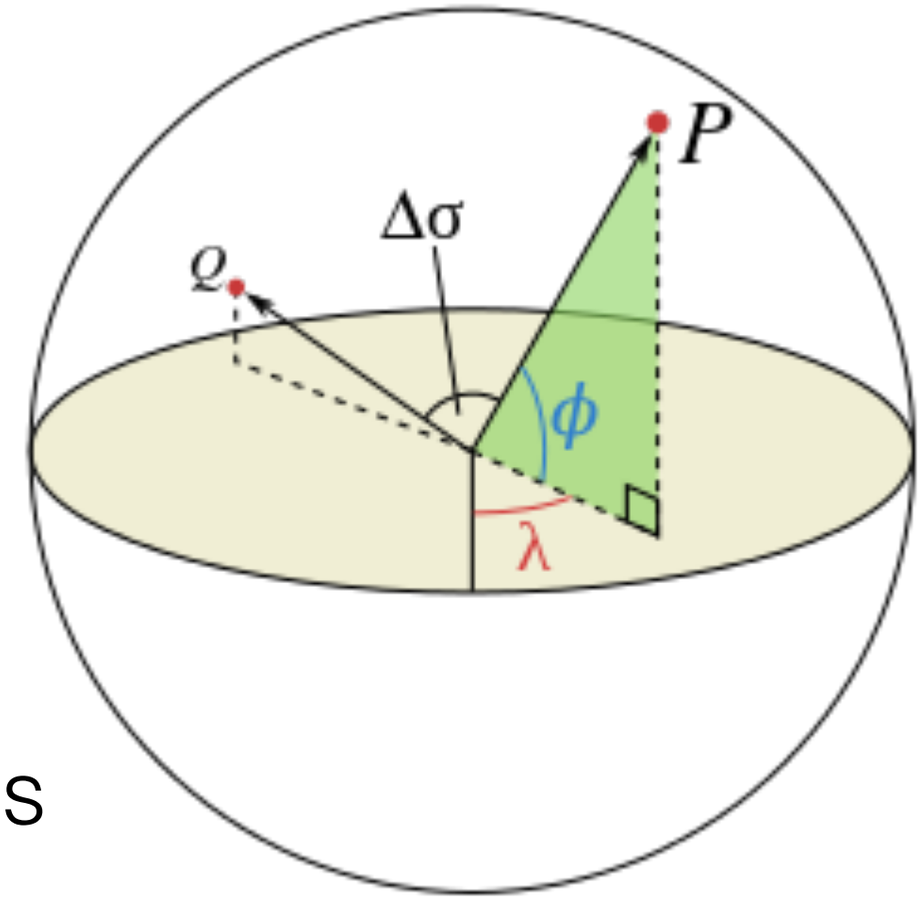
Monument to the Geographical

# Calculating geographic distances

The Earth is not flat :)

So we use a spherical  object as an - abstraction - of it.

The so-call haversine formula provides a satisfactory, non-perfect, way to measure geographic distances between two points on the planet.




$$\Delta\sigma = 2\arcsin\sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + \cos\phi_1 \cdot \cos\phi_2 \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)}.$$

**Download** https://www.dropbox.com/s/e288u70hdckxatb/geolocator.py?dl=0

source: wikipedia

# Harvesine formula in Python

geolocator.py

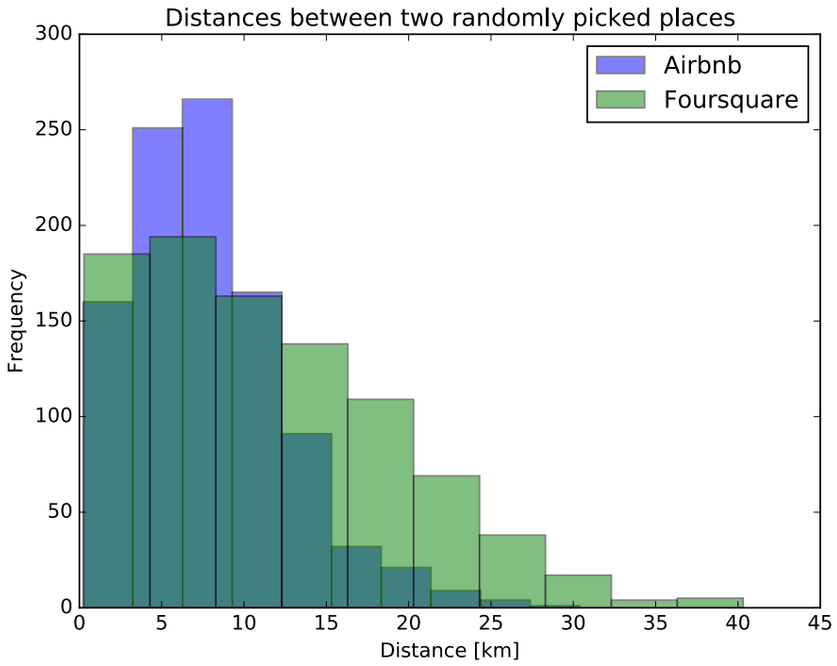
```
20  # earth's mean radius = 6,371km
21  earthradius = 6371.0
22
23  def getDistance(loc1, loc2):
24      "aliased default algorithm; args are (lat_decimal,lon_decimal) tuples"
25
26      return getDistanceByHaversine(loc1, loc2)
27
28  def getDistanceByHaversine(loc1, loc2):
29      "Haversine formula - give coordinates as (lat_decimal,lon_decimal) tuples"
30
31      lat1, lon1 = loc1
32      lat2, lon2 = loc2
33      # convert to radians
34      lon1 = lon1 * pi / 180.0
35      lon2 = lon2 * pi / 180.0
36      lat1 = lat1 * pi / 180.0
37      lat2 = lat2 * pi / 180.0
38
39      # haversine formula
40      dlon = lon2 - lon1
41      dlat = lat2 - lat1
42      a = (sin(dlat/2))**2 + cos(lat1) * cos(lat2) * (sin(dlon/2.0))**2
43      c = 2.0 * atan2(sqrt(a), sqrt(1.0-a))
44      km = earthradius * c
45      return km
```

main.py

```
1  ##########################################
2  # Reading CSV file with Airbnb Listings  #
3  # Data from insideairbnb.com/            #
4  ##########################################
5
6  #read a csv file with location information
7  #let's start with Airbnb listings
8  import csv
9  import random
10
11 input_file = csv.DictReader(open('london_listings.csv'))
12
13 #CSV headers: id,name,host_id,host_name,neighbourhood_group,neighbourhood,latitude,longitude,roo
14
15 airbnb_listings = {}  # dictionary key is listing id, values are listing info in a python <list>
16 for row in input_file:
17
18     if random.random() > 1.0: #control sample size: 100% here
19         continue
20
21
22     listing_id = row['id']
23     latitude = row['latitude']
24     longitude = row['longitude']
25     num_reviews = row['number_of_reviews']
26     price = row['price']
27
28     airbnb_listings[listing_id] = [float(latitude), float(longitude), num_reviews, float(price)]
29
30
31 num_listings = len(airbnb_listings)
32 print 'Number of Airbnb listings in London: ' + str(num_listings)
```

main.py

```
125  ###############################################
126  # Geographic Analysis: Measure Distances      #
127  ###############################################
128
129  import sys
130  sys.path.append('./location_central/') #adding directory to python path
131  import geolocator
132
133  num_samples = 1000
134  airbnb_distances = []
135  foursquare_distances = []
136  for i in xrange(0, num_samples):
137
138      #sample two airbnb venues
139      listing1 = random.choice(airbnb_listings.keys())
140      listing2 = random.choice(airbnb_listings.keys())
141
142      #sample two foursquare venues
143      venue1 = random.choice(foursquare_venues.keys())
144      venue2 = random.choice(foursquare_venues.keys())
145
146      air_distance = geolocator.getDistance(airbnb_listings[listing1][0:2], airbnb_listings[listing2][0:2])
147      venue_distance= geolocator.getDistance(foursquare_venues[venue1][0:2], foursquare_venues[venue2][0:2])
148
149      airbnb_distances.append(air_distance)
150      foursquare_distances.append(venue_distance)
151
152  #filtering out extreme values
153  airbnb_distances = [d for d in airbnb_distances if d < 50]
154  foursquare_distances = [d for d in foursquare_distances if d < 50]
155
156  pylab.title('Distances between two randomly picked places')
157  pylab.ylabel('Frequency')
158  pylab.xlabel('Distance [km]')
159  pylab.hist(airbnb_distances, alpha=0.5, label='Airbnb')
160  pylab.hist(foursquare_distances, alpha=0.5, label='Foursquare')
161  pylab.legend()
162  pylab.savefig('./graphs/distances.pdf')
```



# Spatial Retrieval (1)

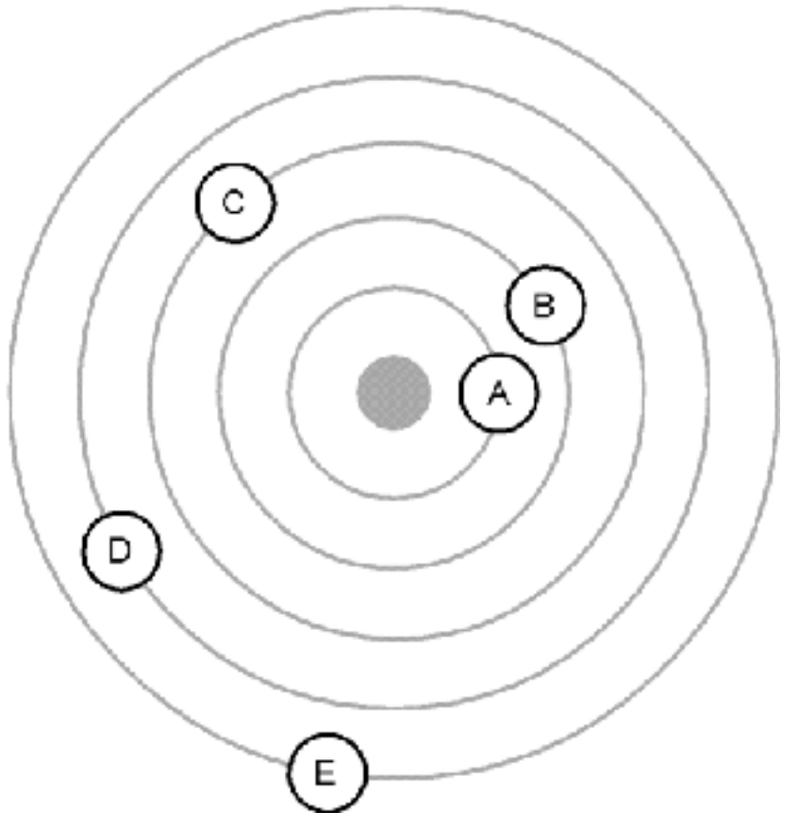
SpatialRetriever.py

```
1  import sys
2  import numpy as np
3  import math
4  from math import *
5  from sets import Set
6  import geolocator
7  import random
8
9
10 class SpatialRetriever:
11     '''The Spatial Retriever is a module optimized for spatial queries.'''
12     def __init__(self, spatialElements):
13         self.spatialElements = spatialElements
14         self.load_location_data()
15
16
17     def load_location_data(self):
18         allLatLongs = []
19         allLatsDict = {}
20         allLongsDict = {}
21         allLats = []
22         allLongs = []
23         locationData = {}
24
25         for spatialElementId in self.spatialElements:
26             [latFloat, longFloat] = self.spatialElements[spatialElementId][0:2
27             try:
28                 locationData[spatialElementId] = [latFloat,longFloat]
29             except:
30                 print sys.exc_info()
```

# Spatial Retrieval (2)

SpatialRetriever.py

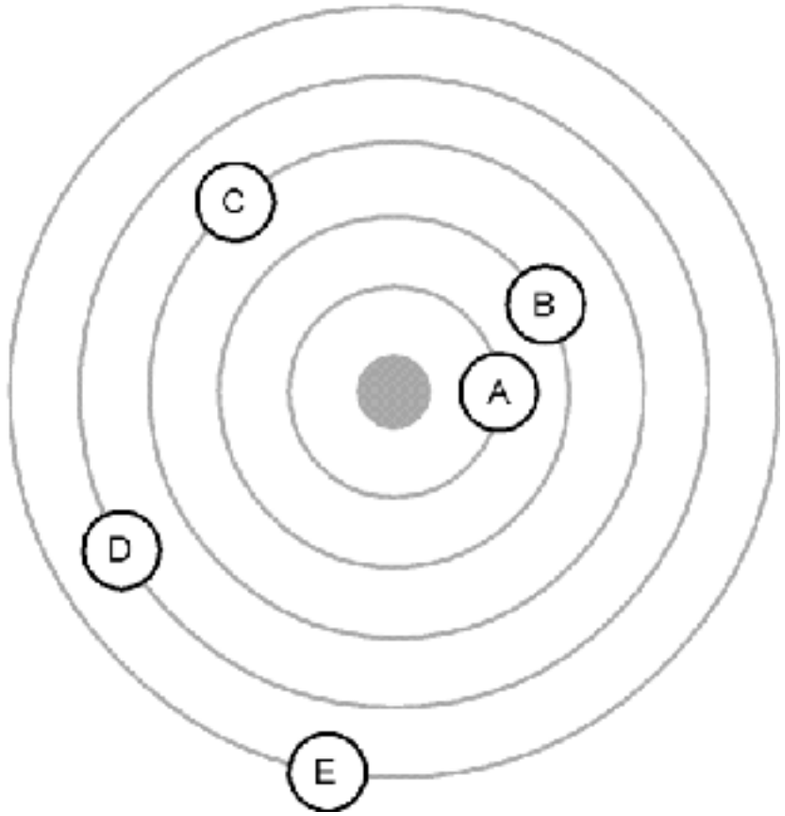
```
66
67      def binary_search_optimized(self,sec,item):
68          left = 0
69          right = len(sec) - 1
70          while True:
71              mid = (left+right)/2
72              if item < sec[mid]:
73                  right = mid
74              else:
75                  left = mid
76
77              if right ==  left+1:
78                  return sec[left:left+2]
79
80
81
82      def get_nearby_locations(self,latitude,longitude,distance,area_shape='square'):
83           #returns nearby locations given a point
84          ([lat_up,lat_down],[long_left,long_right]) = self.get_rectangle_coordinates(latitude,
85          #get lat list values
86          lat_left_limit_value = self.binary_search_optimized(self.allLats,lat_down)[1]
87          lat_right_limit_value = self.binary_search_optimized(self.allLats,lat_up)[0]
88
89          #...and indices
90          lat_left_limit_index = self.allLats.index(lat_left_limit_value)
91          lat_right_limit_index = self.allLats.index(lat_right_limit_value)
92
93          #get long list values
94          long_left_limit_value = self.binary_search_optimized(self.allLongs,long_left)[1]
95          long_right_limit_value = self.binary_search_optimized(self.allLongs,long_right)[0]
96
```



# Spatial Retrieval (2++)

SpatialRetriever.py

....




```
all_lat_locs_cleared = []
for locs in all_locs_from_lat_list:
    for loc in locs:
        all_lat_locs_cleared.append(loc)

all_long_locs_cleared = []
for locs in all_locs_from_long_list:
    for loc in locs:
        all_long_locs_cleared.append(loc)

latSet = Set(all_lat_locs_cleared)
longSet = Set(all_long_locs_cleared)

all_locs_in_square_set = latSet.intersection(longSet)

location_list_insquare = list(all_locs_in_square_set)

if area_shape == 'square':
    return location_list_insquare

elif area_shape == 'circle':
    location_list_incircle = []
    for location in location_list_insquare:
        if geolocator.getDistance([latitude,longitude],self.locationData[location][0:2]) <= distance
            location_list_incircle.append(location)
    return location_list_incircle
```

# Spatial Retrieval (3)

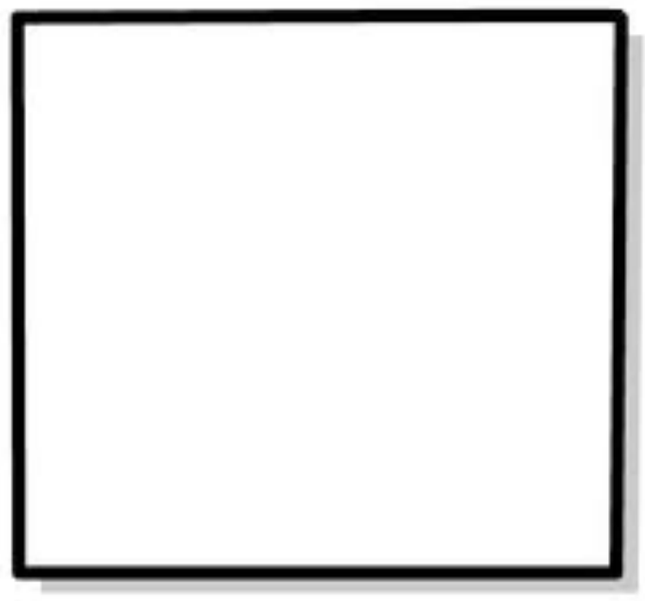
SpatialRetriever.py

```
def get_rectangle_coordinates(self,latitude,longitude,distance):
        d = distance            #distance in km
        R = 6371.0              #earth radius in km

        lat1 = latitude
        long1 = longitude

        #convert to radians
        long1 = long1 * pi / 180.0
        lat1 = lat1 * pi / 180.0
```

• • • •

**Key method used by the previous method: afterall to get a grid of cell, you need to get a cell in the first place ...**

**The rest of the code is gibberish maths which i worked out one fine day during the first days of my phd ... it is the opposite process of the haversine formula for distance measurment..**



# Spatial Retrieval (3)

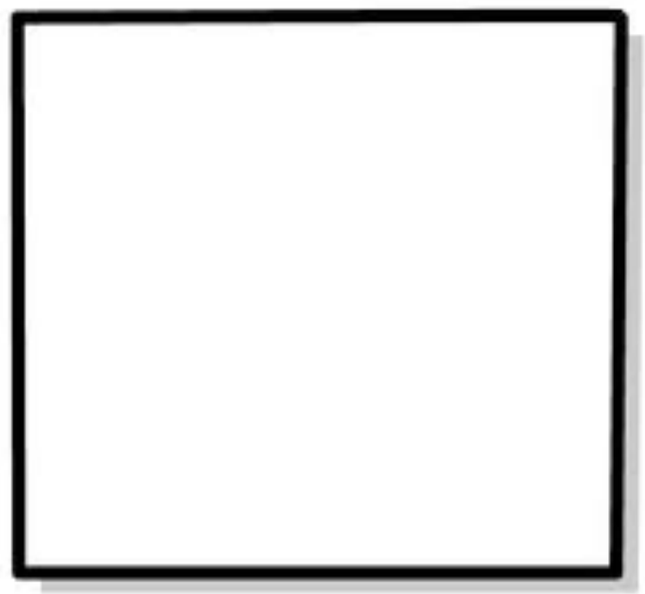
SpatialRetriever.py

....

```
#convert to radians
long1 = long1 * pi / 180.0
lat1 = lat1 * pi / 180.0

#case 1: lat1 == lat2
lat_up = lat1 + 2.0*asin(1.0/2.0 * sqrt(-sqrt(-4*pow(tan(d/(2.0*R)), 2) +1) +1)*sqrt(2))              #up
lat_down = lat1 - 2.0*asin(1.0/2.0 * sqrt(-sqrt(-4*pow(tan(d/(2.0*R)), 2) +1) +1)*sqrt(2))          #down
#case 2: long1 == long2
long_right = long1 + 2.0*asin(1.0/2.0 * sqrt(-sqrt(-4*pow(tan(d/(2.0*R)), 2) +1) +1)*sqrt(2)/pow(cos(lat1),1))
long_left = long1 - 2.0*asin(1.0/2.0 * sqrt(-sqrt(-4*pow(tan(d/(2.0*R)), 2) +1) +1)*sqrt(2)/pow(cos(lat1),1))
```

```
# convert from radians
lat_up = lat_up / pi * 180.0
lat_down = lat_down / pi * 180.0
long_left = long_left / pi * 180.0
long_right = long_right / pi * 180.0

lat2 = [lat_up,lat_down]                    #up,down
long2 = [long_left,long_right]             #left,right

return (lat2,long2)
```

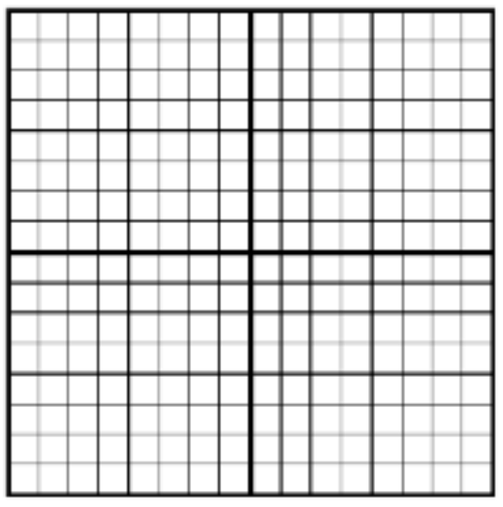
**Reverse engineering of the harvesine formula using maths can give you the coordinates of rectangle for a given geographic center!**



# Spatial Retrieval (4)

SpatialRetriever.py

```
def area_recursive_splitter_v2(self,latitude,longitude,distance,numberOfSquares):
        #split an area in squares of certain minimum size: number of squares better be power of 4
        ([lat_up,lat_down],[long_left,long_right]) = self.get_rectangle_coordinates(latitude,longitude,distance/2.0)
        if numberOfSquares >= 4: #check
                newDist = distance/2.0
                newNumberOfSquares = numberOfSquares/4

                #0.86*
                pointsNW = self.area_recursive_splitter_v2(lat_up,long_left,newDist,newNumberOfSquares)
                pointsNE = self.area_recursive_splitter_v2(lat_up,long_right,newDist,newNumberOfSquares)
                pointsSE = self.area_recursive_splitter_v2(lat_down,long_right,newDist,newNumberOfSquares)
                pointsSW = self.area_recursive_splitter_v2(lat_down,long_left,newDist,newNumberOfSquares)

                return pointsSE + pointsSW + pointsNW + pointsNE
        else:
                return [(latitude,longitude)]
```



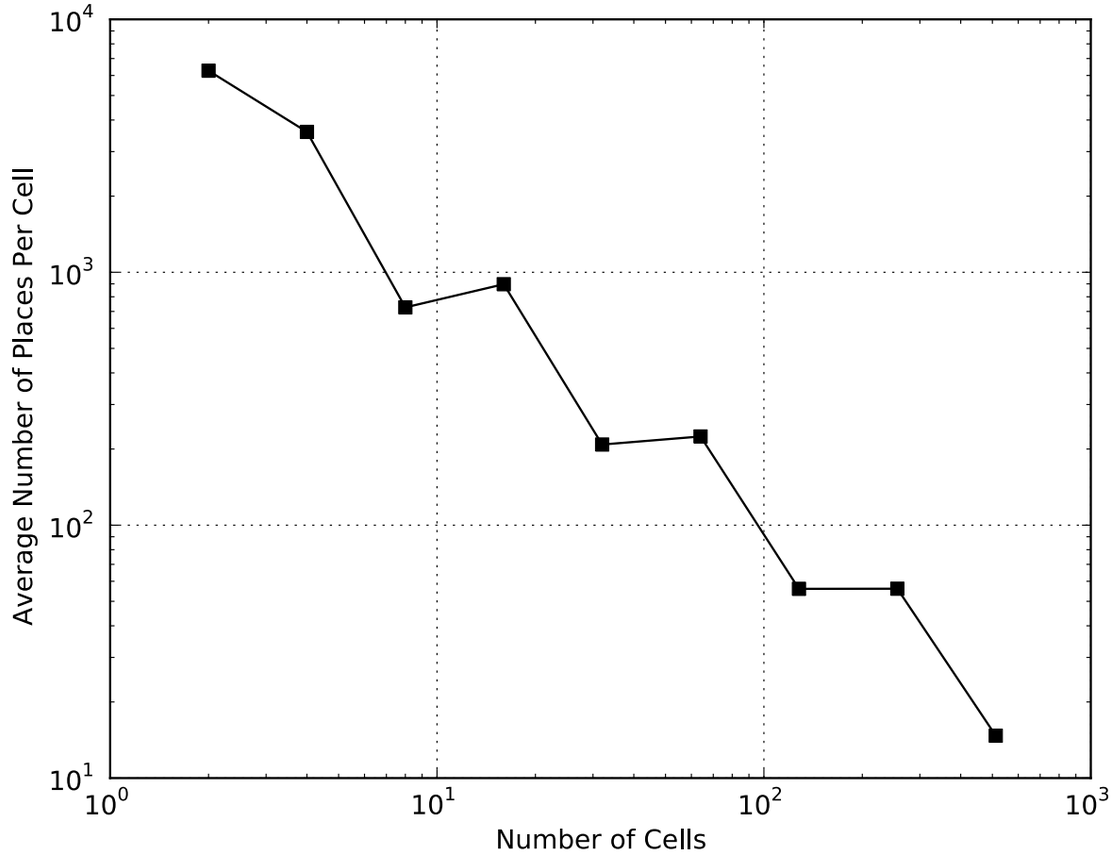
Given a central point (x,y)  and a radius (distance), return a grid centered a (x,y).

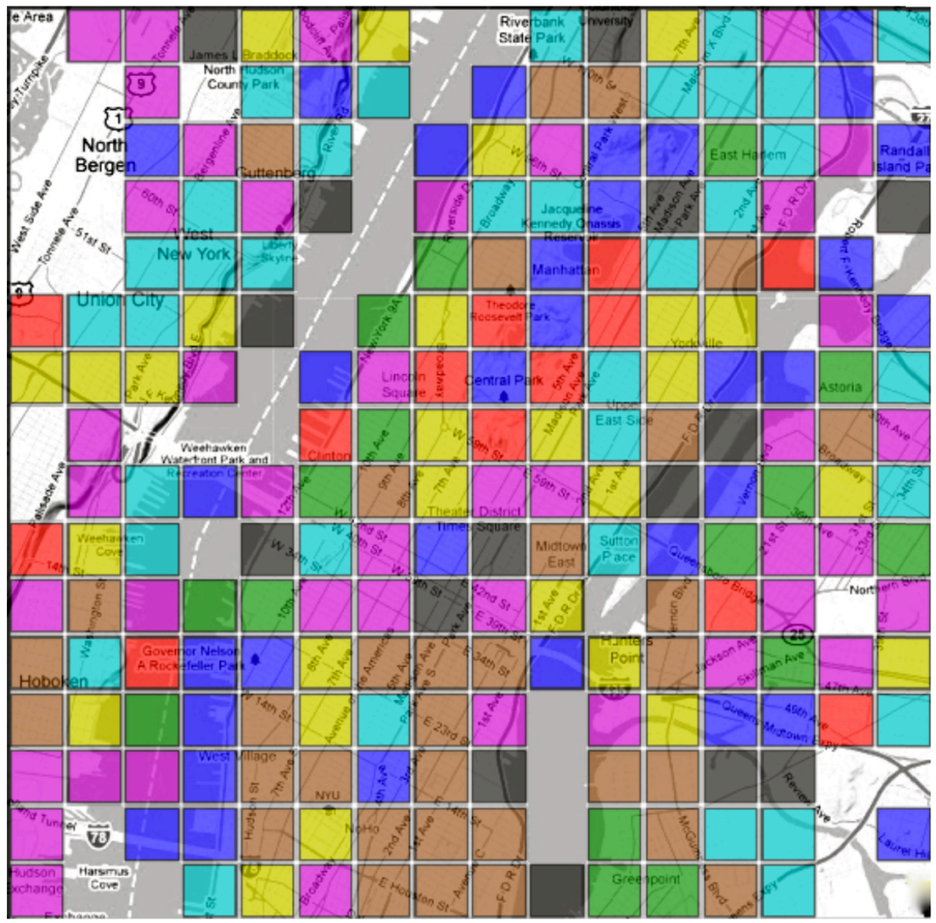
The grid is represented as a list of tuples, where each tuple is the center of the grid's cell represented with geographic coordinates

The parameter numberOfSquares is the number of cells in the grid. This version is limited to numberOfSquares being a power of 2 (we will check an alternative grid make later)

# why useful?

calculate the fractal dimension of a city




get nearby categories …
and much more!

# Spatial Retrieval (5)

SpatialRetriever.py

Gives you the top keys of a dictionary based on value number

```
171
172     def getTopDictionaryKeys(self,dictionary,number):
173         topList = []
174         a = dict(dictionary)
175         for i in range(0,number):
176             m = max(a, key=a.get)
177             topList.append([m,a[m]])
178             del a[m]
179
180         return topList
181
182
183     def get_city_center(self):
184         return (np.median(self.allLats), np.median(self.allLongs))
```

Gets “city centre” for the spatial object in question

# Spatial Retrieval [example]

main.py

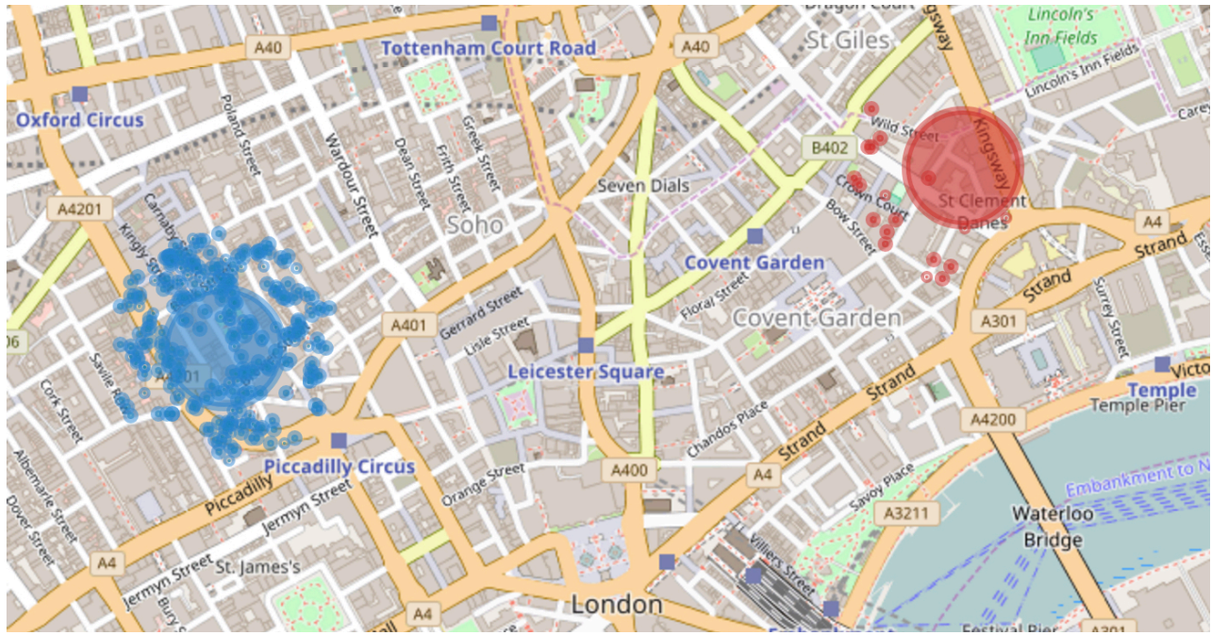
```
126  ##################################################
127  # Object Oriented Programming: Saves time and money!#
128  ##################################################
129  import SpatialRetriever as SR
130
131  srAirbnb = SR.SpatialRetriever(airbnb_listings)
132  srFoursquare = SR.SpatialRetriever(foursquare_venues)
133
134  print srAirbnb.get_city_center()
135  print srFoursquare.get_city_center()
136
137  #Get the locations within 200 meters radius from the Foursquare city center
138  fourquare_center = srFoursquare.get_city_center()
139  nearby_locations = srFoursquare.get_nearby_locations(fourquare_center[0],
140      fourquare_center[1], 0.2, area_shape='circle')
141
142  fourquare_center = srAirbnb.get_city_center()
143  nearby_locations = srAirbnb.get_nearby_locations(fourquare_center[0],
144      fourquare_center[1], 0.2, area_shape='circle')
145
```

main.py

```
149 ##################################################
150 # Visualise results using folium                 #
151 ##################################################
152 import folium
153
154 mymap = folium.Map(location=[city_center[0], city_center[1]], zoom_start=14)
155
156 #plot city center as a coloured circle
157 folium.CircleMarker(location=fourquare_center, radius=100,
158                     popup='Foursquare Centre', color='#3186cc',
159                     fill_color='#3186cc').add_to(mymap)
160
161 #plot city center as a coloured circle
162 folium.CircleMarker(location=airbnb_center, radius=100,
163                     popup='Airbnb Centre', color='#cc3131',
164                     fill_color='#cc3131').add_to(mymap)
165
166
167 for loc_id in nearby_locations_4sq:
168     folium.CircleMarker(srFoursquare.locationData[loc_id][0:2], radius = 5, color='#3186cc',
169                         fill_color='#2186ac').add_to(mymap)
170
171 for loc_id in nearby_locations_airbnb:
172     folium.CircleMarker(srAirbnb.locationData[loc_id][0:2], radius = 5, color='#cc3131',
173                         fill_color='#cc3131').add_to(mymap)
174
175 mymap.save('./graphs/MappingCityCenters.html')
176
```

# folium:

https://github.com/python-visualization/folium

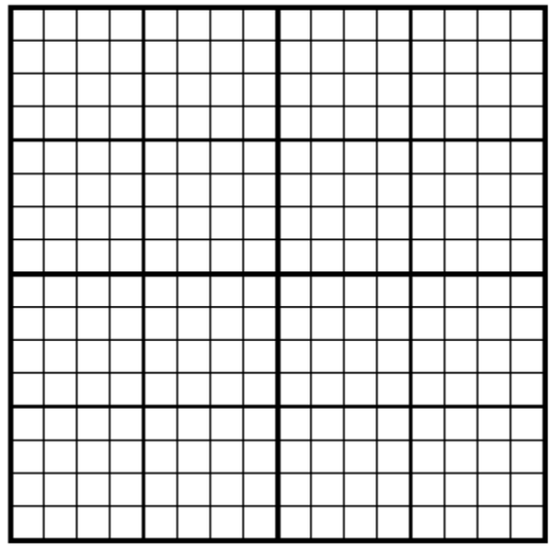


# bounding box counts [alternative]

# Initialize a Grid to hold data

```
lonMin = -74.1 #minimum longitude
lonMax = -73.7
lonStep = 0.0025 #defines cell size

latMin = 40.6  #minimum latitude
latMax = 41.0
latStep = 0.0025 #defines cell size

latLen =  int ((latMax - latMin) / latStep) +1   #number of cells on the y-axis
lonLen =  int ((lonMax - lonMin) / lonStep) +1 #number of cells on the x-axis

#Cell counts for each source of geo-data
FSQcellCount = np.zeros ((latLen, lonLen))
AIRcellCount = np.zeros ((latLen, lonLen))
TAXIcellCount = np.zeros ((latLen, lonLen))
```

GridCounts.py



# Loading 3 geo-data layers

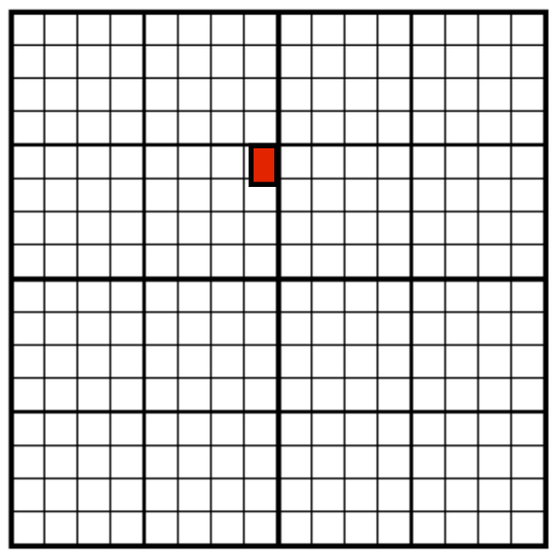
GridCounts.py

```
######## LOADING COORDS FROM 3 GEO LAYERS ##########
airbnb_coords = []

with open('listings_sample.csv') as csvfile:
        reader = csv.DictReader(csvfile)
        for row in reader:
                airbnb_coords.append([float(row['latitude']), float(row['longitude'])])

print 'Number of Airbnb listings: ' + str(len(airbnb_coords))



#reading Foursquare venue data #
foursquare_coords = []
with open('venue_data_4sq_newyork_anon.csv') as csvfile:
        reader = csv.DictReader(csvfile)
        for row in reader:
                foursquare_coords.append([float(row['latitude']), float(row['longitude'])])

print 'Number of Foursquare listings: ' + str(len(foursquare_coords))

#reading Taxi journey coords #
taxi_coords = []
with open('taxi_trips.csv') as csvfile:
        reader = csv.DictReader(csvfile)
        for row in reader:
                taxi_coords.append([float(row['latitude']), float(row['longitude'])])

print 'Number of Yellow Taxi journeys: ' + str(len(taxi_coords))
```

# Count occurrences per cell

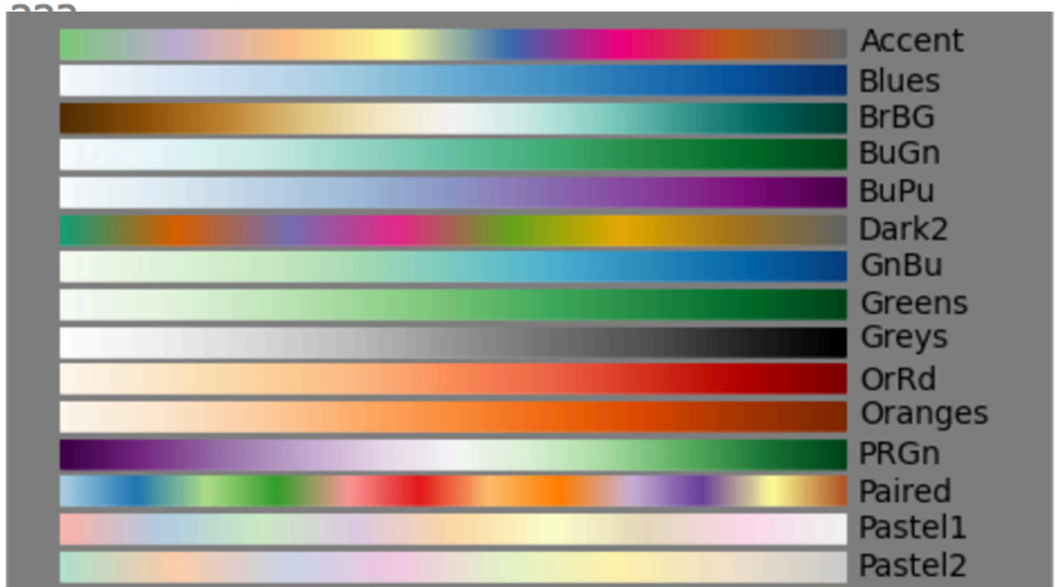
```
all_coords = [foursquare_coords, airbnb_coords, taxi_coords]
for i in range(0, 3):
        current_coords = all_coords[i]

        for coords in current_coords:
                lat = coords[0]
                longit = coords[1]

                #if outside the grid then ingore point
                if (lat < latMin) or (lat > latMax) or (longit < lonMin) or (longit > lonMax):
                   continue

                #identify cell where points belongs too
                cx = int ((longit - lonMin) / lonStep)
                cy = int((lat - latMin) / latStep)

                if i == 0:
                        FSQcellCount[cy, cx] += 1
                elif i == 1:
                        AIRcellCount[cy, cx] +=1
                else:
                        TAXIcellCount[cy, cx] +=1
```

GridCounts.py

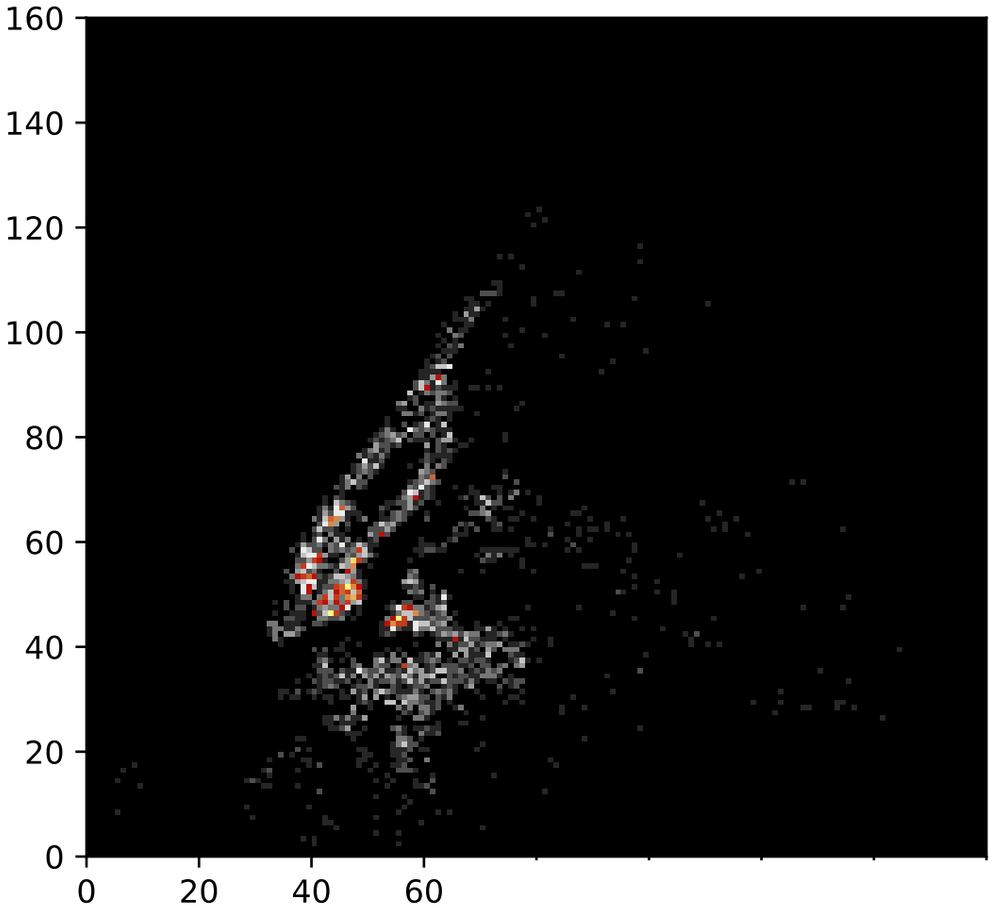


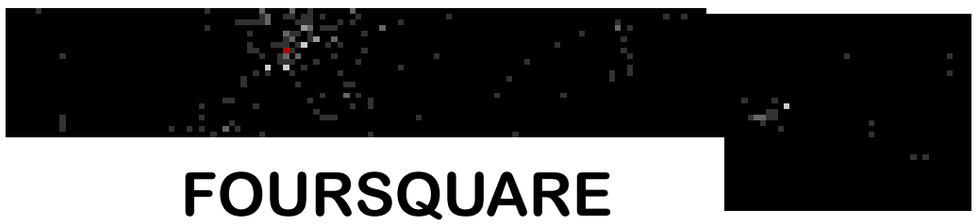
# SciPy: Cookbook/ Matplotlib/ Show_colormaps

```
204  #### PLOT MAPS #####
205
206  cdict = {'red': ((0.0, 0.0, 0.0),
207                   (0.5, 1.0, 0.7),
208                   (1.0, 1.0, 1.0)),
209           'green': ((0.0, 0.0, 0.0),
210                     (0.5, 1.0, 0.0),
211                     (1.0, 1.0, 1.0)),
212           'blue': ((0.0, 0.0, 0.0),
213                    (0.5, 1.0, 0.0),
214                    (1.0, 0.5, 1.0))}
215  mapIndex=0
216  for cellCount in [AIRcellCount,FSQcellCount,TAXIcellCount]:
217      my_cmap = plt.matplotlib.colors.LinearSegmentedColormap('my_colormap',cdict,256)
218      mapIndex +=1
219      plt.pcolor(cellCount,cmap=my_cmap)
220      plt.colorbar()
221      plt.savefig('map' + str(mapIndex) + '.pdf')
222      plt.close()
```




GridCounts.py

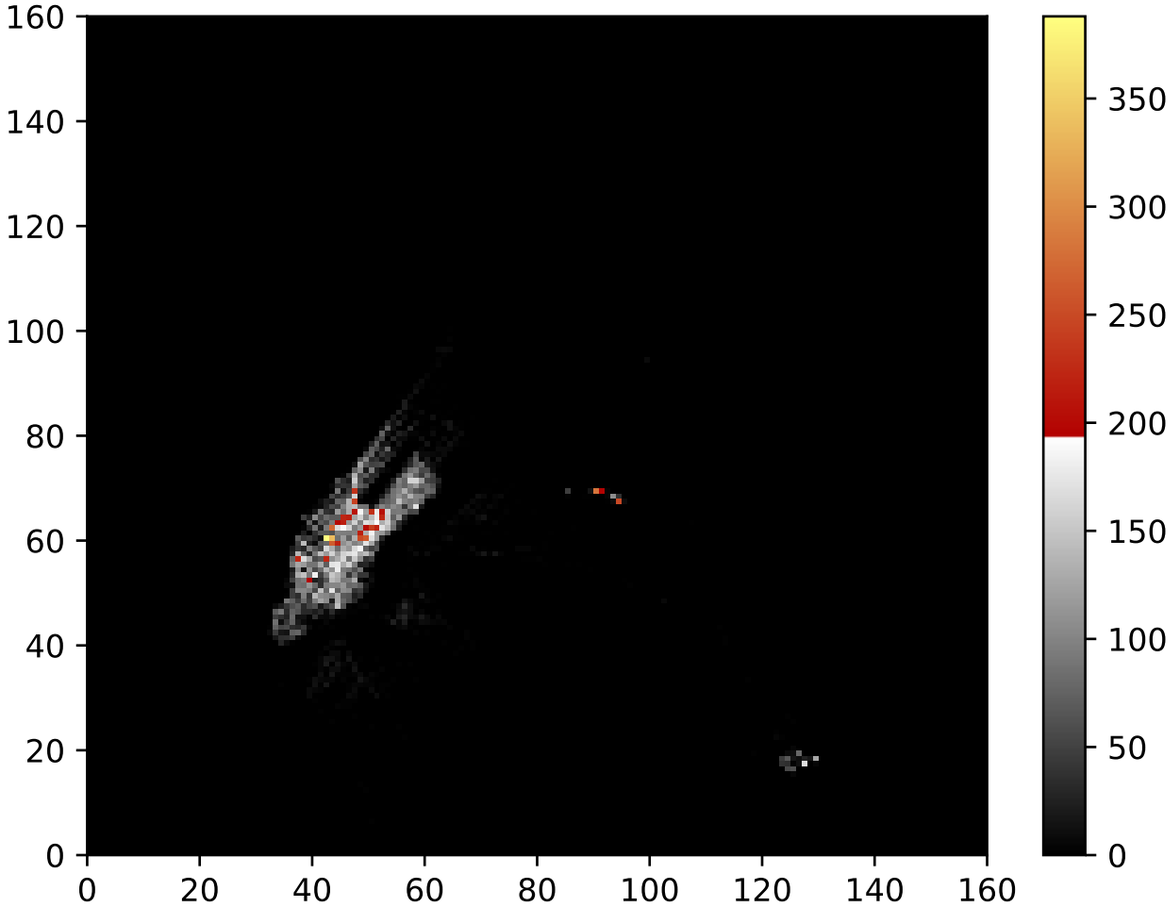


FOURSQUARE

AIRBNB

TAXIS



# place networks

# Loading Foursquare places data

```
### READ FOURSQUARE VENUES DATA ###
node_data = {}
with open('venue_data_4sq_newyork_anon.csv') as csvfile:
  reader = csv.DictReader(csvfile)
  for row in reader:
    latit = float(row['latitude'])
    longit = float(row['longitude'])
    place_title = row['title']
    node_id = int(row['vid'])
    node_data[node_id] = (place_title,latit,longit)
```

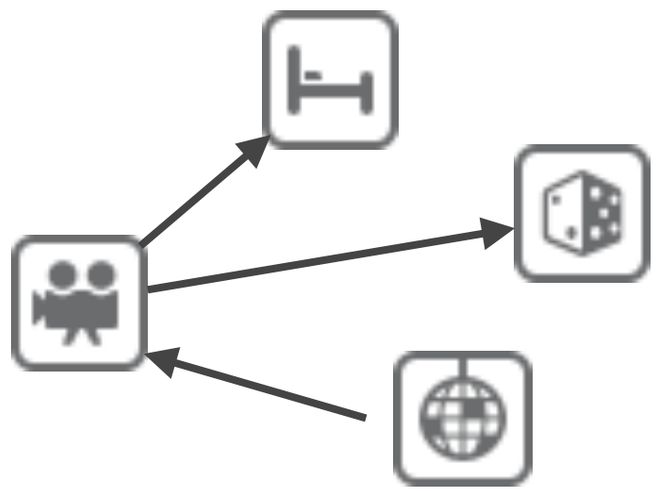
network_analysis.py

venue_data_4sq_newyork_anon.csv

# Generating a Place Network

Let's load a New York's Network of Places : it's a directed graph with places as nodes.

## Place Network



**Connect two places if a user transition has been observed between them!**

```
### LOAD NETWORK FROM FILE ###
nyc_net = nx.read_edgelist('newyork_net.txt',create_using=nx.DiGraph(), nodetype = int)

# some simple stats
N,K = nyc_net.order(), nyc_net.size()
avg_deg = float(K)/N

print "Loaded New York City Place network."
print "Nodes: ", N
print "Edges: ", K
print "Average degree: ", avg_deg
```

newyork_net.txt

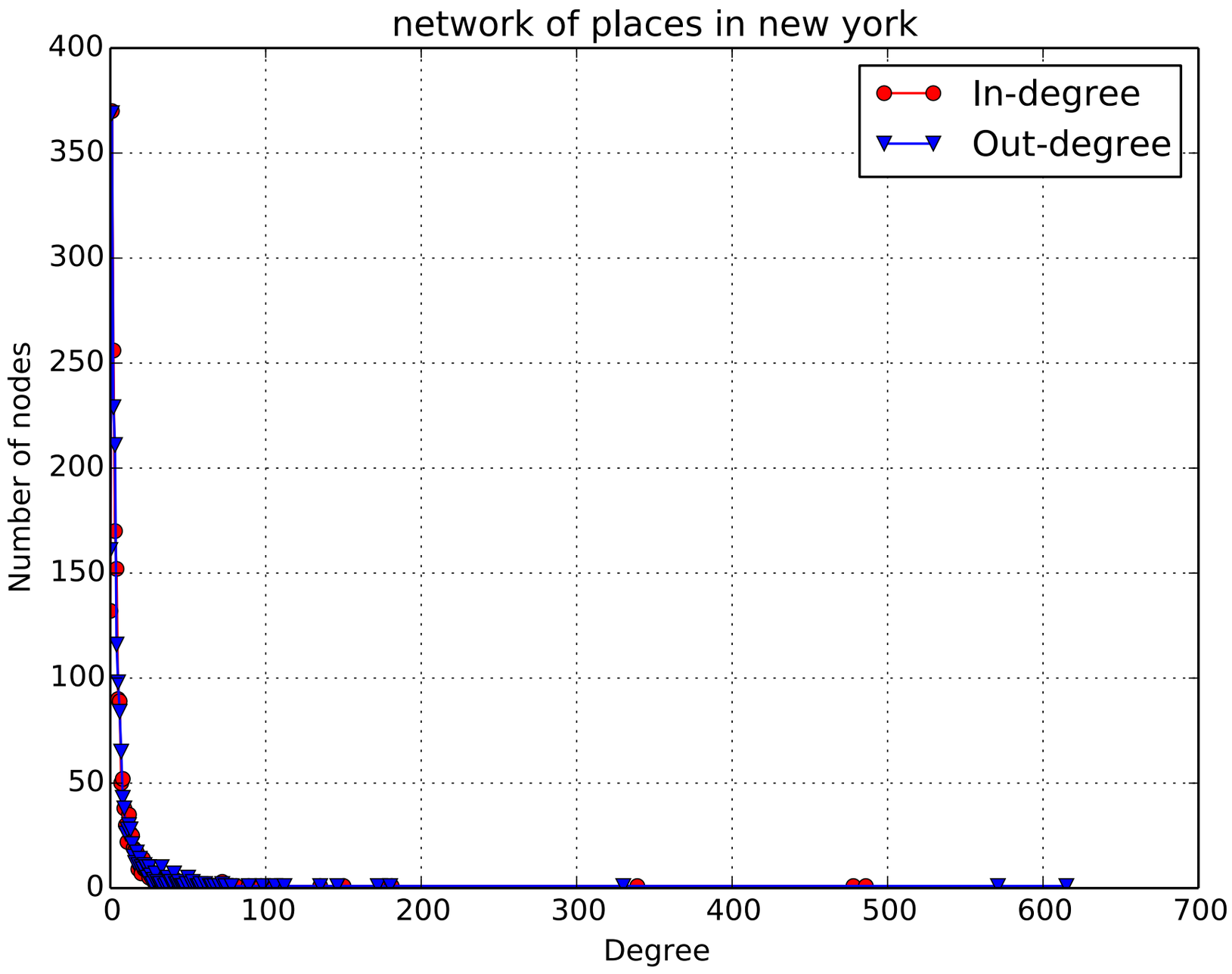
network_analysis.py

# Getting Degree Distributions

```
in_degrees  = nyc_net.in_degree() #Get degree distributions (in- and out-)
in_values = sorted(set(in_degrees.values()))
in_hist = [in_degrees.values().count(x) for x in in_values]
out_degrees  = nyc_net.out_degree()
out_values = sorted(set(out_degrees.values()))
out_hist = [out_degrees.values().count(x) for x in out_values]

# plot degree distributions
logScale = True #set this True to plot data in logarithmic scale
plt.figure()
if logScale:
  plt.loglog(in_values,in_hist,'ro-') # red color with marker 'o'
  plt.loglog(out_values,out_hist,'bv-') # blue color with marker 'v'
else:
  plt.plot(in_values,in_hist,'ro-') # red color with marker 'o'
  plt.plot(out_values,out_hist,'bv-') # blue color with marker 'v'
plt.legend(['In-degree','Out-degree'])
plt.xlabel('Degree')
plt.ylabel('Number of nodes')
plt.title('network of places in new york')
plt.grid(True)
if logScale:
  plt.xlim([0,2*10**2])
  plt.savefig('nyc_net_degree_distribution_loglog.pdf')
else:
  plt.savefig('nyc_net_degree_distribution.pdf')
plt.close()
```

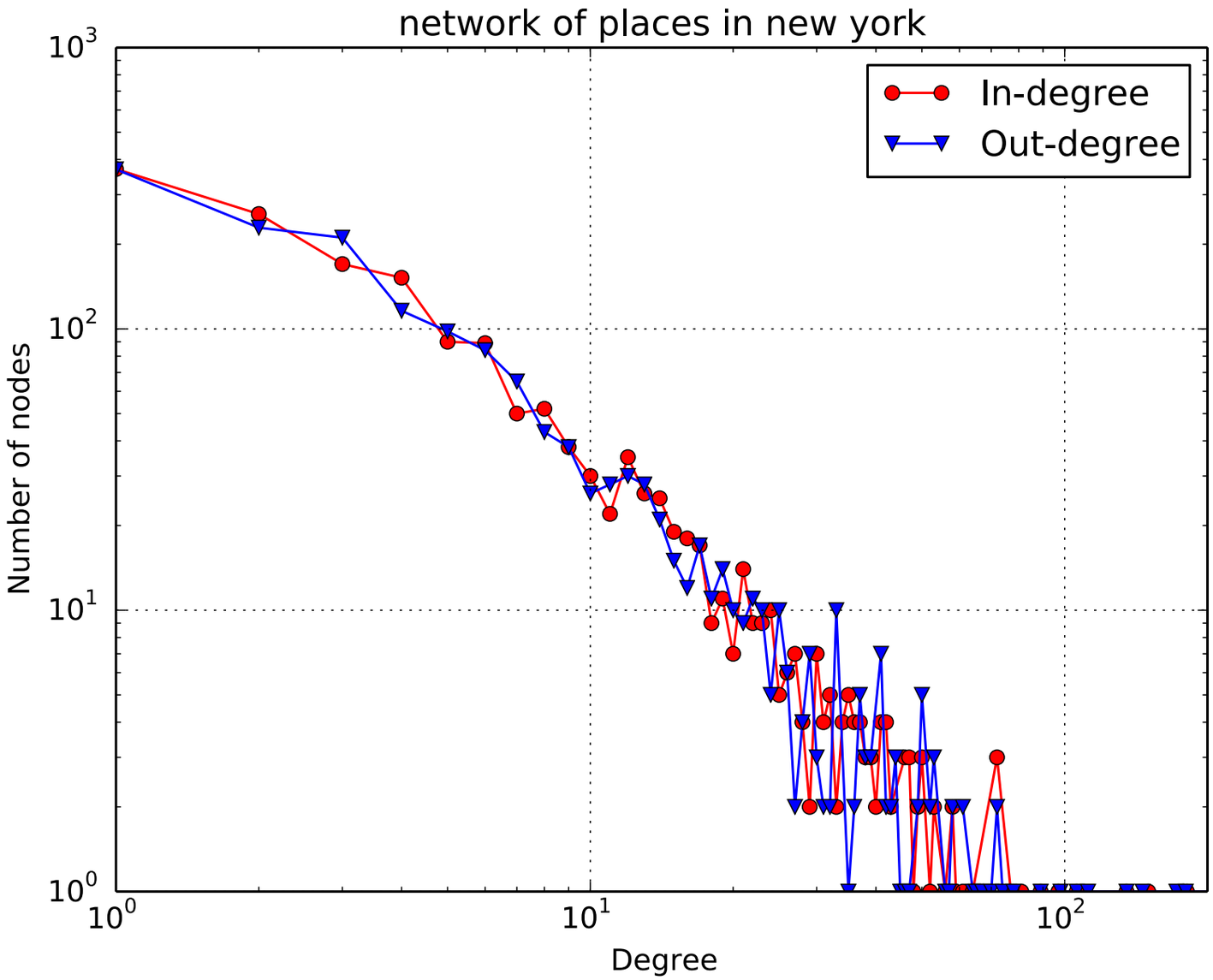
network_analysis.py

# Degree Distribution




**OOPS! We can’t see much this way, can’t we?**

# Logarithmic beauty!




**Change scale of x,y axis by replacing**
**plt.plot(in_values,in_hist,'ro-') # in-degree**
**with**
**plt.loglog(in_values,in_hist,'ro-') # in-degree**

# Triadic Formations in Networks

We can get the clustering coefficient of individual nodes or of all the nodes (but the first we convert the graph to an undirected one).

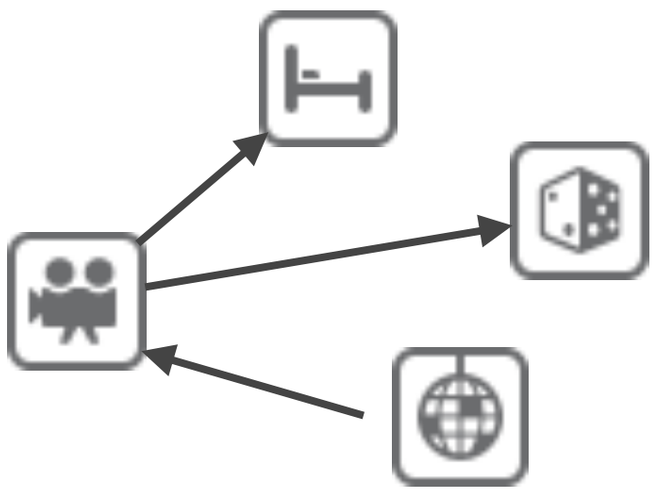
```
# Symmetrize the graph for simplcity
nyc_net_ud = nyc_net.to_undirected()

# We are interested in the largest connected component
nyc_net_components = nx.connected_component_subgraphs(nyc_net_ud)
nyc_net_mc = nyc_net_components[0]

# Graph statistics for the main component
N_mc, K_mc = nyc_net_mc.order(), nyc_net_mc.size()
avg_deg_mc = float(2*K_mc)/N_mc
avg_clust = nx.average_clustering(nyc_net_mc)

print ""
print "New York Place Network graph main component."
print "Nodes: ", N_mc
print "Edges: ", K_mc
print "Average degree: ", avg_deg_mc
print "Average clustering coefficient: ", avg_clust
```

network_analysis.py

# Node Centralities

Now, we will extract the main connected component; then we will compute node centrality measures.

```
# Betweenness centrality
bet_cen = nx.betweenness_centrality(nyc_net_mc)
# Degree centrality
deg_cen = nx.degree_centrality(nyc_net_mc)
# Eigenvector centrality
eig_cen = nx.eigenvector_centrality(nyc_net_mc)
```



network_analysis.py

# Most Central Nodes

First we introduce a utility method: given a dictionary and a threshold parameter, the top-K elements of the dictionary are returned according to element values.

```
def getTopDictionaryKeys(dictionary,number):
        topList = []
        a = dict(dictionary)
        for i in range(0,number):
                m = max(a, key=a.get)
                topList.append([m,a[m]])
                del a[m]

    return topList
```

We can then apply the method on the various centrality methods available. Below we extract the top-10 most central nodes for each case.

```
top_bet_cen = getTopDictionaryKeys(bet_cen,10)

top_deg_cen = getTopDictionaryKeys(deg_cen,10)

top_eig_cent = getTopDictionaryKeys(eig_cen,10)
```

network_analysis.py

# Interpretability Matters

```
print 'Top-10 places for betweenness centrality.'
for [node_id, value] in top_bet_cen:
  title = node_data[node_id][0]
  print title
print '------'

print 'Top-10 places for degree centrality.'
for [node_id, value] in top_deg_cen:
  title = node_data[node_id][0]
  print title
print '------'

print 'Top-10 places for eigenvector centrality.'
for [node_id, value] in top_eig_cent:
  title = node_data[node_id][0]
  print title
print '------'
```

network_analysis.py

# Most Central Nodes

**Betweenness Centrality**

**Top - 10**
JFK Airport
LaGuardia Airport (LGA)
Madison Square Garden
Empire State Building
Frying Pan
The Garden at Studio Square
Chelsea Clearview Cinemas
230 Fifth Rooftop Lounge
33rd St PATH Station
Tiffany & Co.

**Degree Centrality**

**Top - 10**
JFK Airport
LaGuardia Airport (LGA)
Madison Square Garden
Empire State Building
Frying Pan
230 Fifth Rooftop Lounge
Chelsea Clearview Cinemas
The Garden at Studio Square
Tiffany & Co.
**Central Park West**

**Eigenvector Centrality**

**Top - 10**
JFK Airport
LaGuardia Airport (LGA)
Madison Square Garden
Frying Pan
Empire State Building
**230 Fifth Rooftop Lounge**
Chelsea Clearview Cinemas
Tiffany & Co.
Central Park West
The Garden at Studio Square

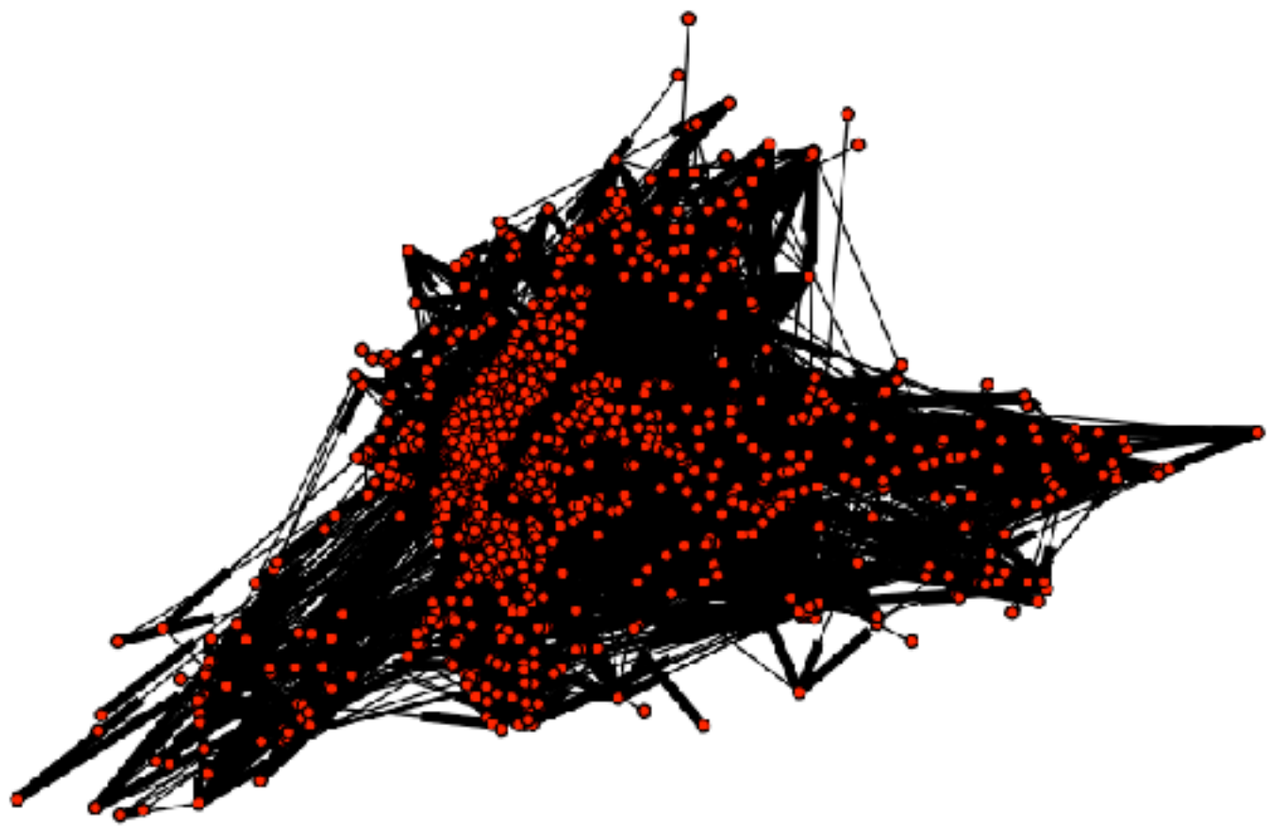
The ranking for the different centrality metrics does not change much, although this may well depend on the type of network under consideration. The results meet ones intuition (if they know New York), yet biases may also exist..

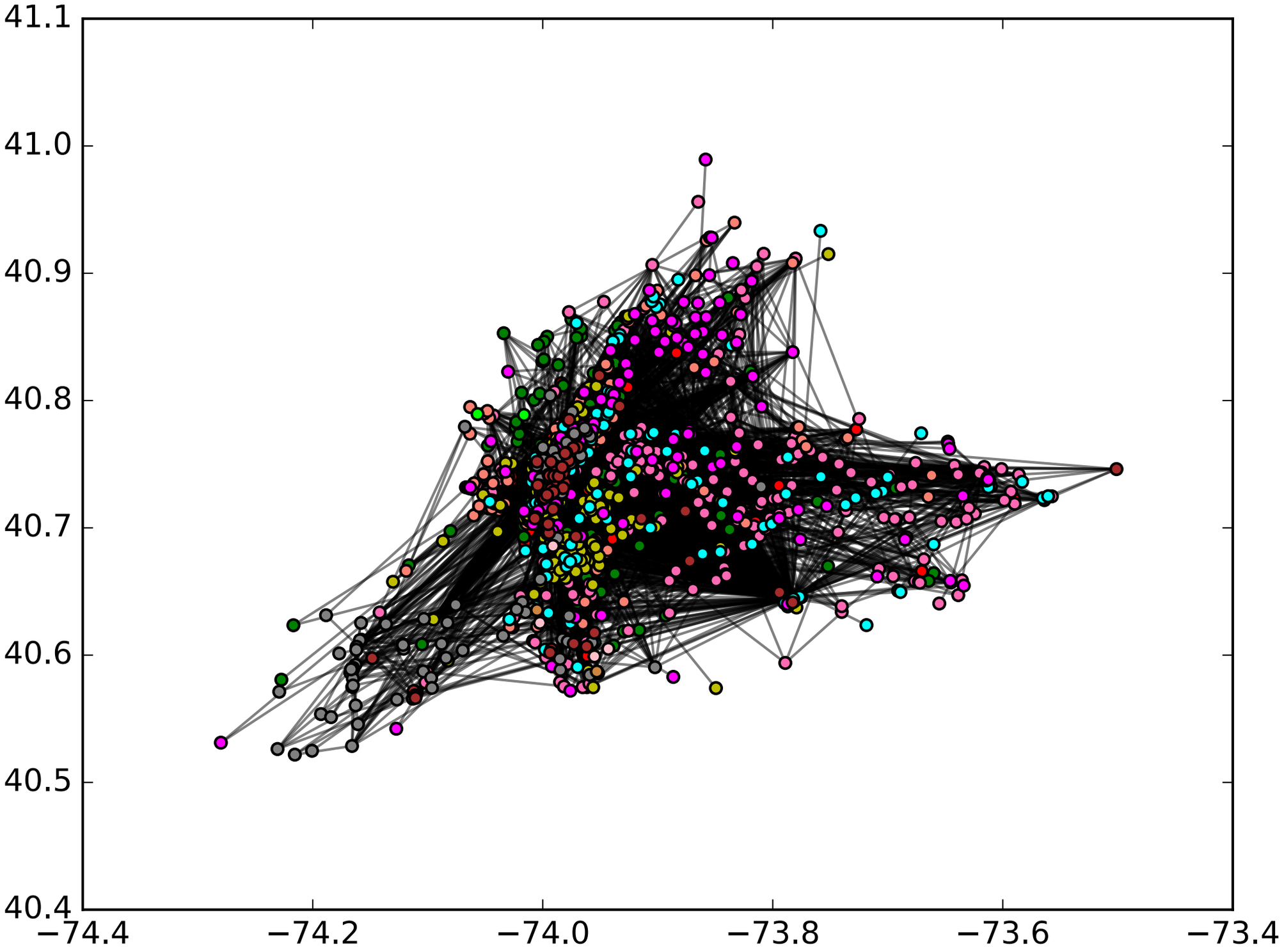
**network_analysis.py**

# Drawing the Graph

```
# draw the graph using information about nodes geographic positions
pos_dict = {}
for node_id, node_info in node_data.items():
  pos_dict[node_id] = (node_info[2], node_info[1])
nx.draw(nyc_net,pos=pos_dict,with_labels=False,node_size=20)
plt.savefig('nyc_net_graph.png')
plt.close()
```

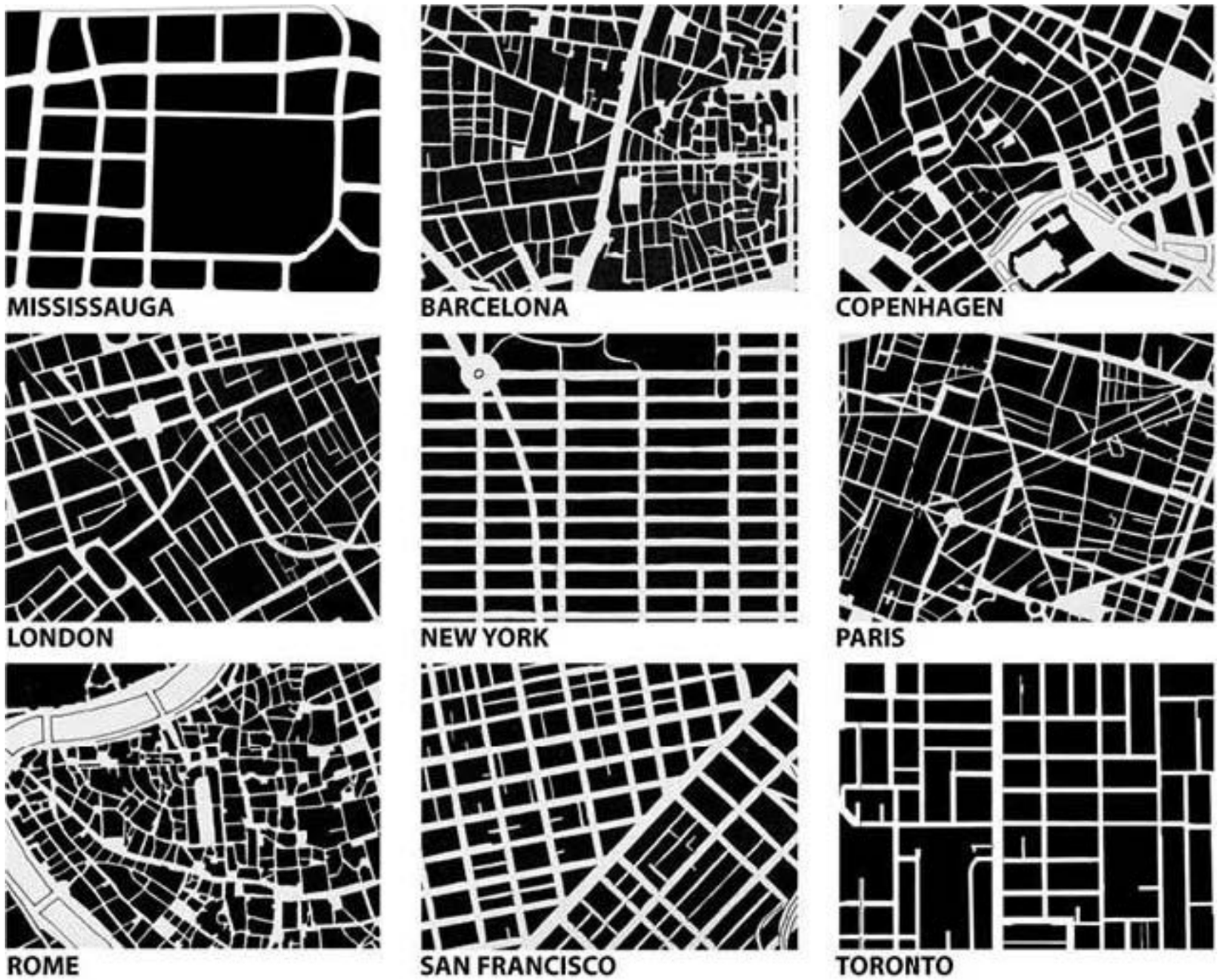
network_analysis.py






Blondel, Vincent D., et al. **"Fast unfolding of communities in large networks."** *Journal of statistical mechanics: theory and experiment* 2008.10 (2008): P10008.

# OSMnx for Street Network Analysis




http://geoffboeing.com/2016/11/osmnx-python-street-networks/

showcasing

deck.gl