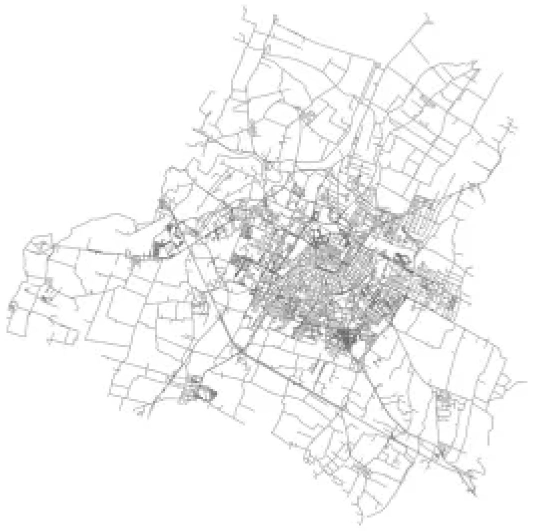
OSMnx: Python for Street Networks

Check out the journal article about OSMnx.

OSMnx is a Python package for downloading administrative boundary shapes and street networks from OpenStreetMap. It allows you to easily construct, project, visualize, and analyze complex street networks in Python with NetworkX. You can get a city's or neighborhood's walking, driving, or biking network with a single line of Python code. Then you can simply visualize cul-de-sacs or one-way streets, plot shortest-path routes, or calculate stats like intersection density, average node connectivity, or betweenness centrality. You can download/cite the paper here.

In a single line of code, OSMnx lets you download, construct, and visualize the street network for, say, Modena Italy:

```python
import osmnx as ox
ox.plot_graph(ox.graph_from_place('Modena, Italy'))
```



(Note that this blog post is not updated with every new release of OSMnx. For the latest, see the official documentation and examples.)

Installing OSMnx

OSMnx is on GitHub and you can install it with conda:

```
conda install -c conda-forge osmnx
```

Or with pip:

```
pip install osmnx
```

If you are pip installing OSMnx, install geopandas and rtree first. It's easiest to use conda-forge to get these dependencies installed. If you're interested in OSMnx but don't know where to begin, check out this guide to getting started with Python.

How to use OSMnx

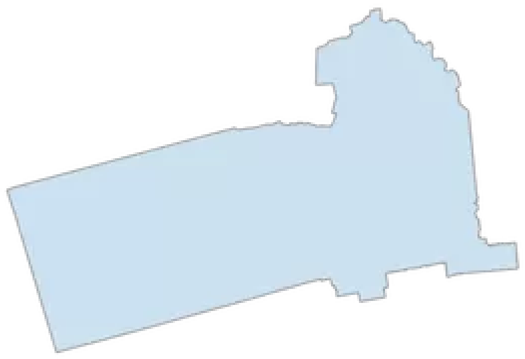
There are several examples and tutorials in the examples repo. I'll demonstrate 5 use cases for OSMnx in this post:

1. Automatically download administrative place boundaries and shapefiles
2. Download and construct street networks
3. Correct and simplify network topology
4. Save street networks to disk as shapefiles, GraphML, or SVG
5. Analyze street networks: routing, visualization, and calculating network stats

1. Get administrative place boundaries and shapefiles

To acquire administrative boundary GIS data, one must typically track down shapefiles online and download them. But what about for bulk or automated acquisition and analysis? There must be an easier way than clicking through numerous web pages to download shapefiles one at a time. With OSMnx, you can download place shapes from OpenStreetMap (as geopandas GeoDataFrames) in one line of Python code – and project them to UTM (zone calculated automatically) and visualize in just one more line of code:

```
import osmnx as ox
city = ox.gdf_from_place('Berkeley, California')
ox.plot_shape(ox.project_gdf(city))
```



You can just as easily get other place types, such as neighborhoods, boroughs, counties, states, or nations – any place geometry in OpenStreetMap:

```
place1 = ox.gdf_from_place('Manhattan, New York City, New York, 
place2 = ox.gdf_from_place('Cook County, Illinois')
place3 = ox.gdf_from_place('Iowa, USA')
place4 = ox.gdf_from_place('Bolivia')
```

Or you can pass multiple places into a single query to construct a single shapefile from their geometries. You can do this with cities, states, countries or any other geographic entities and then save as a shapefile to your hard drive:

```
places = ox.gdf_from_places(['Botswana', 'Zambia', 'Zimbabwe'])
places = ox.project_gdf(places)
ox.save_gdf_shapefile(places)
ox.plot_shape(ox.project_gdf(places))
```

2. Download and construct street networks

To acquire street network GIS data, one must typically track down Tiger/Line roads from the US census bureau, or individual data sets from other countries or cities. But what about for bulk, automated analysis? And what about informal paths and pedestrian circulation that Tiger/Line ignores? And what about street networks outside the United States? OSMnx handles all of these uses.

OSMnx lets you download street network data and build topologically-corrected street networks, project and plot the networks, and save the street network as SVGs, GraphML files, or shapefiles for later use. The street networks are directed and preserve one-way directionality. You can download a street network by providing OSMnx any of the following (demonstrated in the examples below):

- a bounding box
- a lat-long point plus a distance
- an address plus a distance
- a polygon of the desired street network's boundaries
- a place name or list of place names

You can also specify several different network types:

- 'drive' – get drivable public streets (but not service roads)
- 'drive_service' – get drivable public streets, including service roads
- 'walk' – get all streets and paths that pedestrians can use (this network type ignores one-way directionality)

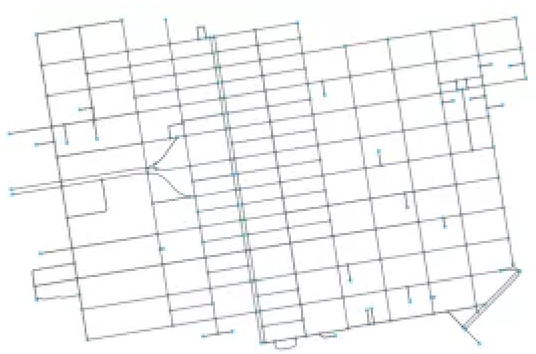
- 'bike' – get all streets and paths that cyclists can use
- 'all' – download all (non-private) OSM streets and paths
- 'all_private' – download all OSM streets and paths, including private-access ones

You can download and construct street networks in a single line of code using these various techniques:

2a) street network from bounding box

This gets the drivable street network within some lat-long bounding box, in a single line of Python code, then projects it to UTM, then plots it:

```
G = ox.graph_from_bbox(37.79, 37.78, -122.41, -122.43, network_t
G_projected = ox.project_graph(G)
ox.plot_graph(G_projected)
```

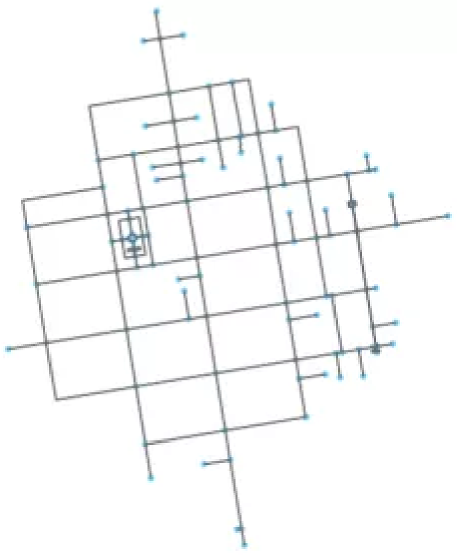


You can get different types of street networks by passing a *network_type* argument, including driving, walking, biking networks (and more).

2b) street network from lat-long point

This gets the street network within 0.75 km (along the network) of a latitude-longitude point:

```
G = ox.graph_from_point((37.79, -122.41), distance=750, network_
ox.plot_graph(G)
```

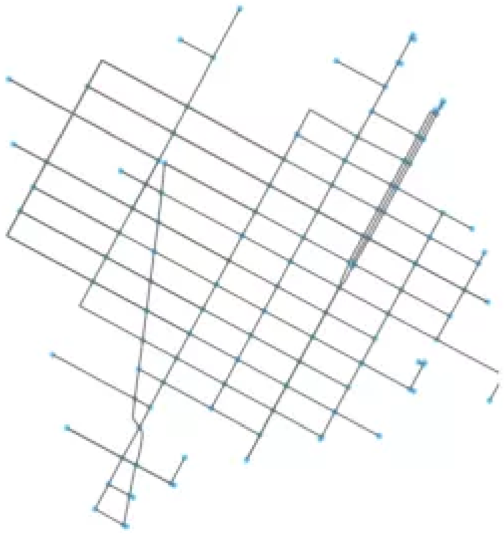


You can also specify a distance in cardinal directions around the point, instead of along the network.

2c) street network from address

This gets the street network within 1 km (along the network) of the Empire State Building:

```
G = ox.graph_from_address('350 5th Ave, New York, New York', netw
ox.plot_graph(G)
```

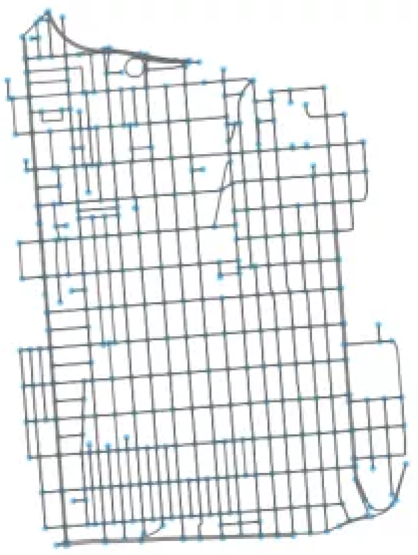


You can also specify a distance in cardinal directions around the address, instead of along the network.

2d) street network from polygon

Just load a shapefile with geopandas, then pass its shapely geometry to OSMnx. This gets the street network of the Mission District in San Francisco:

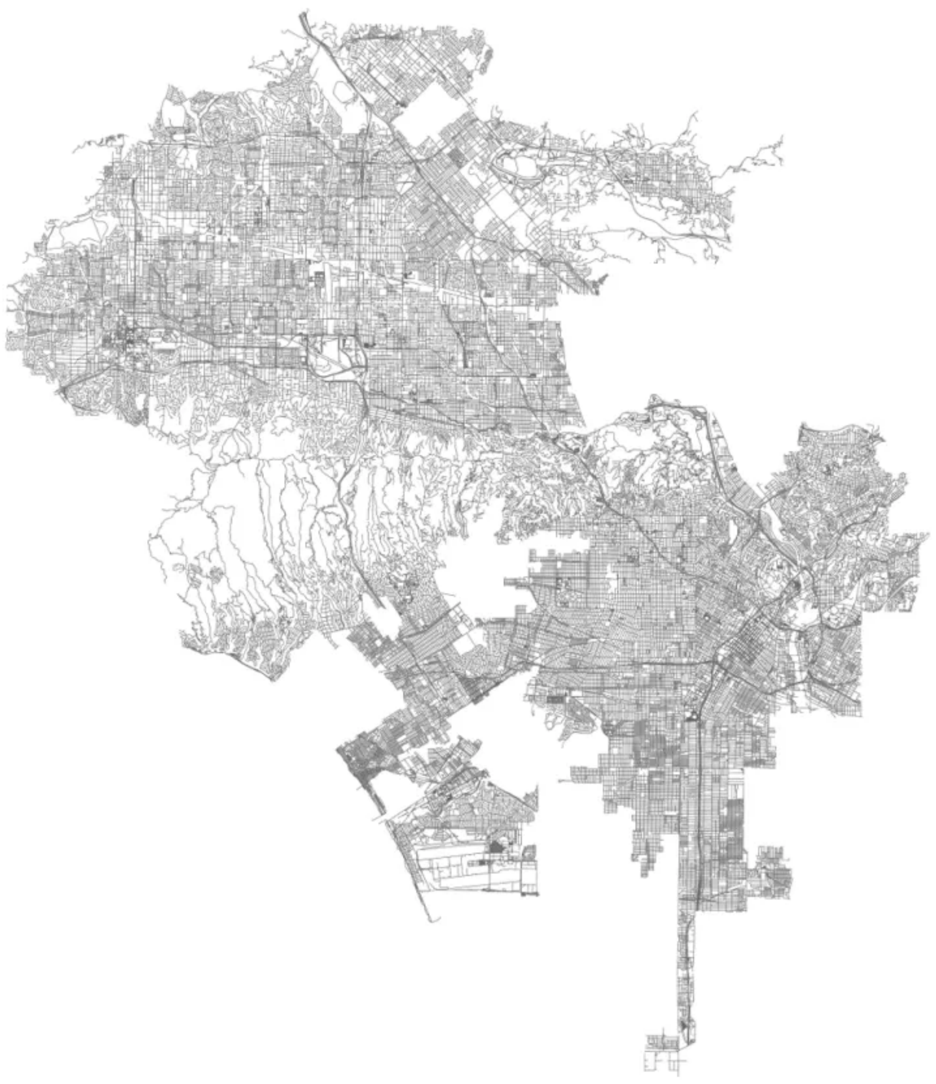
```
G = ox.graph_from_polygon(mission_shape, network_type='drive')
ox.plot_graph(G)
```



2e) street network from place name

Here's where OSMnx shines. Pass it any place name for which OpenStreetMap has boundary data, and it automatically downloads and constructs the street network within that boundary. Here, we create the driving network within the city of Los Angeles:

```
G = ox.graph_from_place('Los Angeles, California', network_type=
ox.plot_graph(G)
```



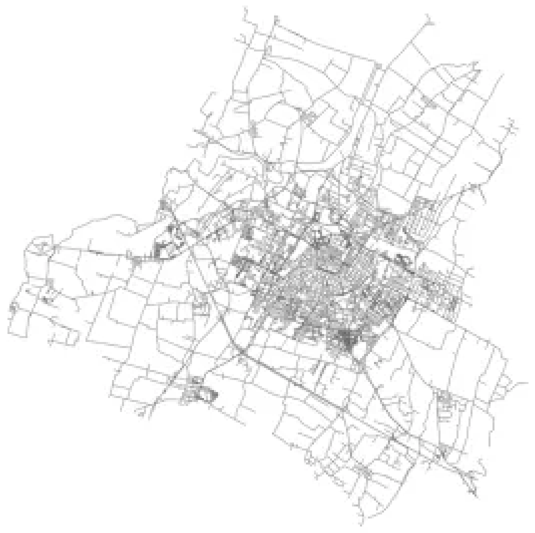
You can just as easily request a street network within a borough, county, state, or other geographic entity. You can also pass a list of places (such as several neighboring cities) to create a unified street network within them. This list of places can include strings and/or structured key:value place queries:

```python
places = ['Los Altos, California, USA',
          {'city':'Los Altos Hills', 'state':'California'},
          'Loyola, California']
G = ox.graph_from_place(places, network_type='drive')
ox.plot_graph(G)
```

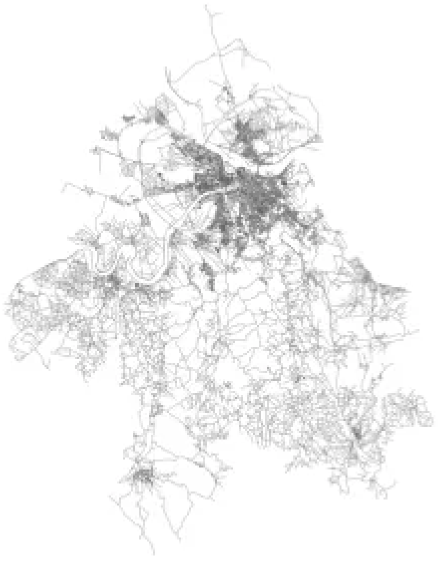
2f) street networks from all around the world

In general, US street network data is fairly easy to come by thanks to Tiger/Line shapefiles. OSMnx makes it *easier* by making it available with a single line of code, and *better* by supplementing it with all the additional data from OpenStreetMap. However, you can also get street networks from anywhere in the world – places where such data might otherwise be inconsistent, difficult, or impossible to come by:

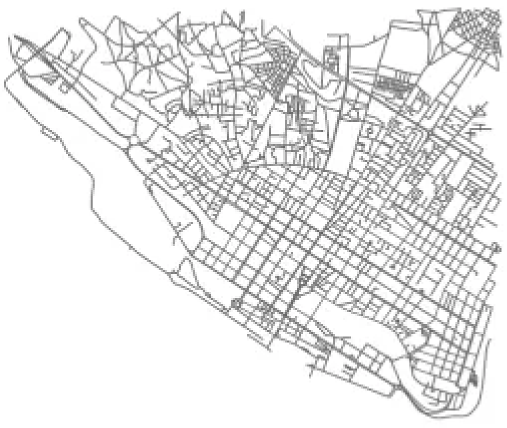
```
G = ox.graph_from_place('Modena, Italy')
ox.plot_graph(G)
```



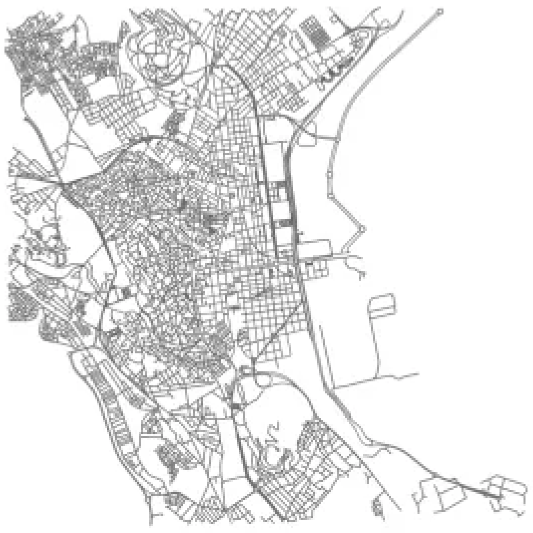
```
G = ox.graph_from_place('Belgrade, Serbia')
ox.plot_graph(G)
```



```
G = ox.graph_from_address('Maputo, Mozambique', distance=3000)
ox.plot_graph(G)
```



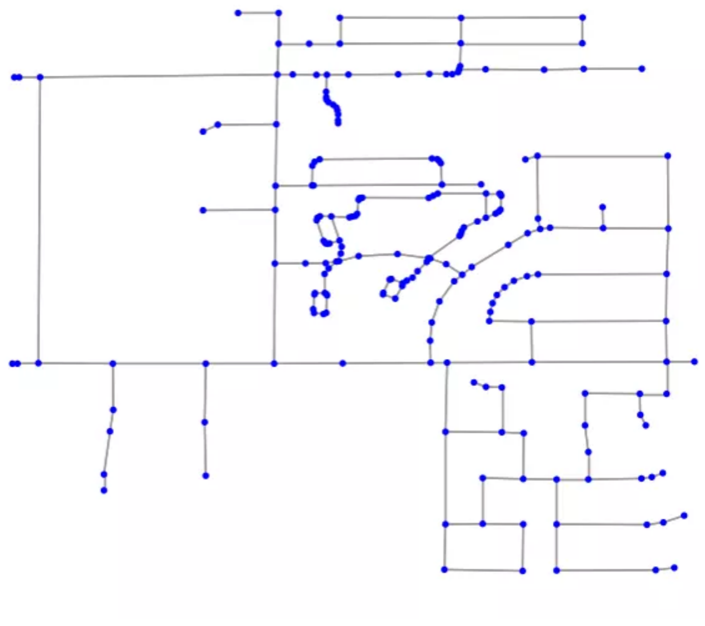
```
G = ox.graph_from_address('Bab Bhar, Tunis, Tunisia', distance=3(
ox.plot_graph(G)
```



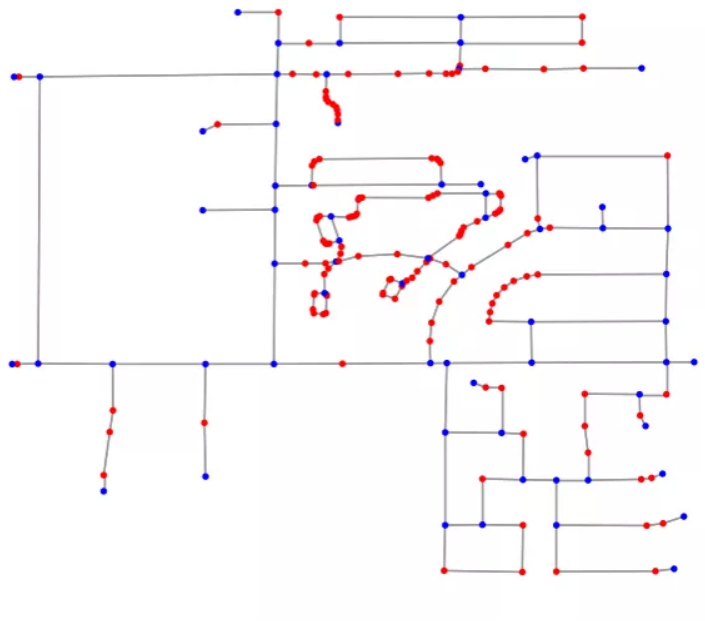
3. Correct and simplify network topology

Simplification is done by OSMnx automatically under the hood, but we can break it out to see how it works. OpenStreetMap nodes can be weird: they include intersections, but they also include all the points along a single street segment where the street curves. The latter are not nodes in the graph theory sense, so we remove them algorithmically and consolidate the set of edges between "true" network nodes into a single edge.

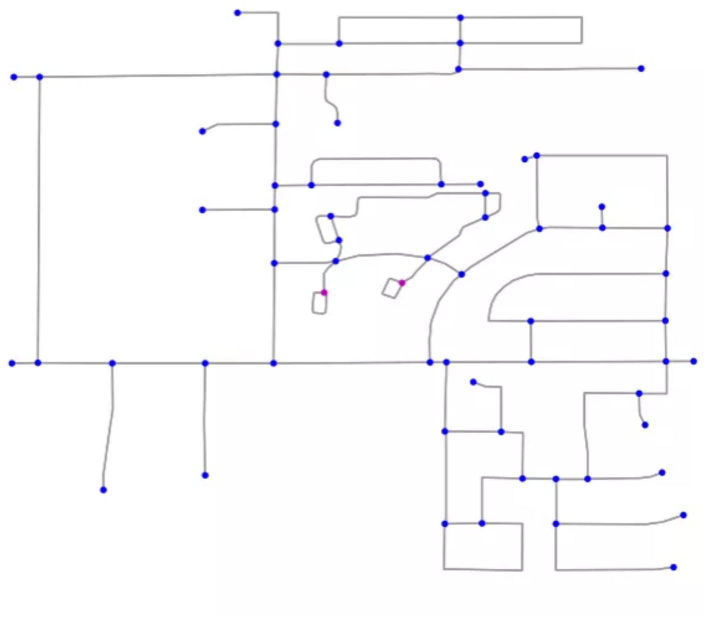
When we first download and construct the street network from OpenStreetMap, it looks something like this:



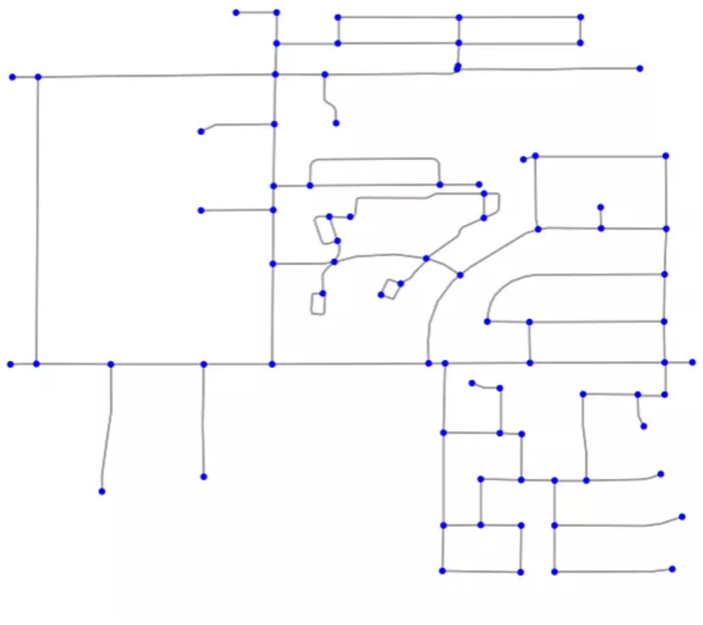
We want to simplify this network to only retain the nodes that represent the junction of multiple streets. OSMnx does this automatically. First it identifies all non-intersection nodes:



And then it removes them, but faithfully maintains the spatial geometry of the street segment between the true intersection nodes:

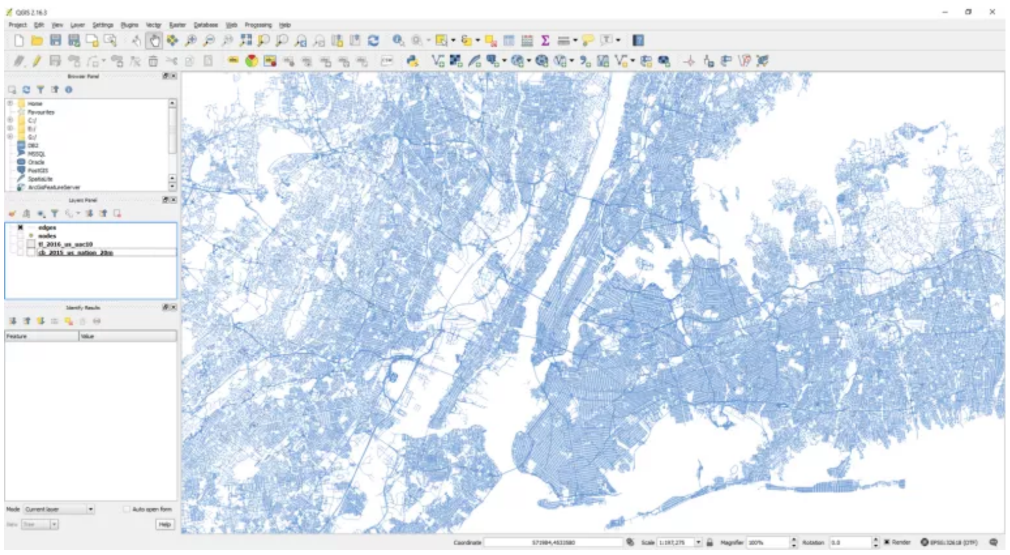


Above, all the non-intersection nodes have been removed, all the true intersections (junctions of multiple streets) remain in blue, and self-loop nodes are in purple. There are two simplification modes: strict and non-strict. In strict mode (above), OSMnx considers two-way intersections to be topologically identical to a single street that bends around a curve. If you want to retain these intersections when the incident edges have different OSM IDs, use non-strict mode:

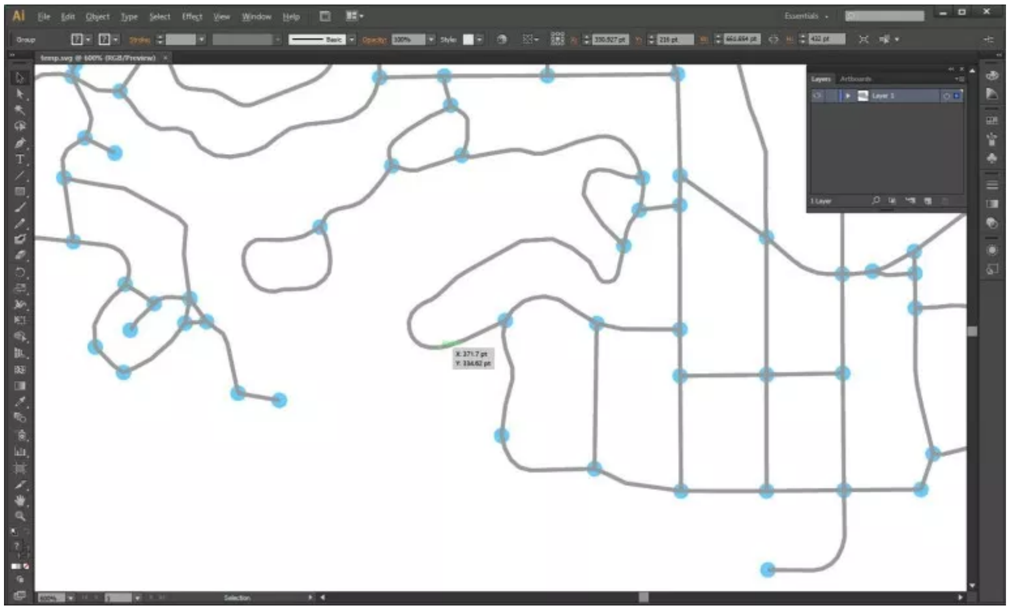


4. Save street networks to disk

OSMnx can save the street network to disk as a GraphML file to work with later in Gephi or networkx. Or it can save the network (such as this one, for the New York urbanized area) as ESRI shapefiles to work with in any GIS:



OSMnx can also save street networks as SVG files for design work in Adobe Illustrator:



You can then load any network you saved as GraphML back into OSMnx to calculate network stats, solve routes, or visualize it.

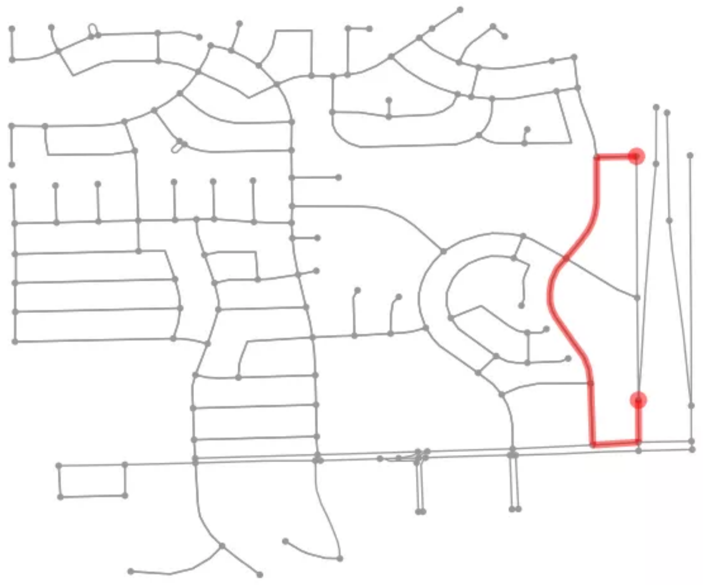
5. Analyze street networks

Since this is the whole purpose of working with street networks, I'll break analysis out in depth in a future dedicated post. But I'll summarize some basic capabilities briefly here. OSMnx is built on top of NetworkX, geopandas, and matplotlib, so you can easily analyze networks and calculate spatial network statistics:

```
G = ox.graph_from_place('Santa Monica, California', network_type
basic_stats = ox.basic_stats(G)
print(basic_stats['circuity_avg'])
extended_stats = ox.extended_stats(G, bc=True)
print(extended_stats['betweenness_centrality_avg'])
```

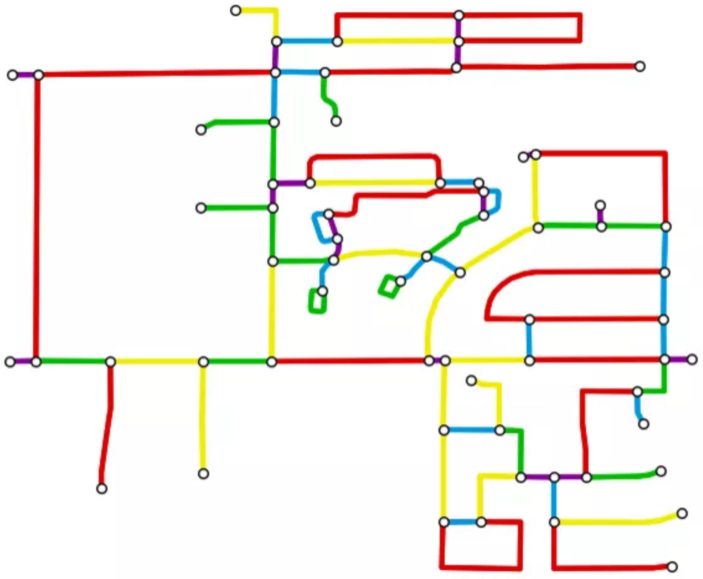
The stats are broken up into two functions: basic and extended. The extended stats function also has optional parameters to run additional advanced measures. You can also calculate and plot shortest-path routes between points, taking one-way streets into account:

```
G = ox.graph_from_address('N. Sicily Pl., Chandler, Arizona', di
route = nx.shortest_path(G, origin, destination)
ox.plot_graph_route(G, route)
```



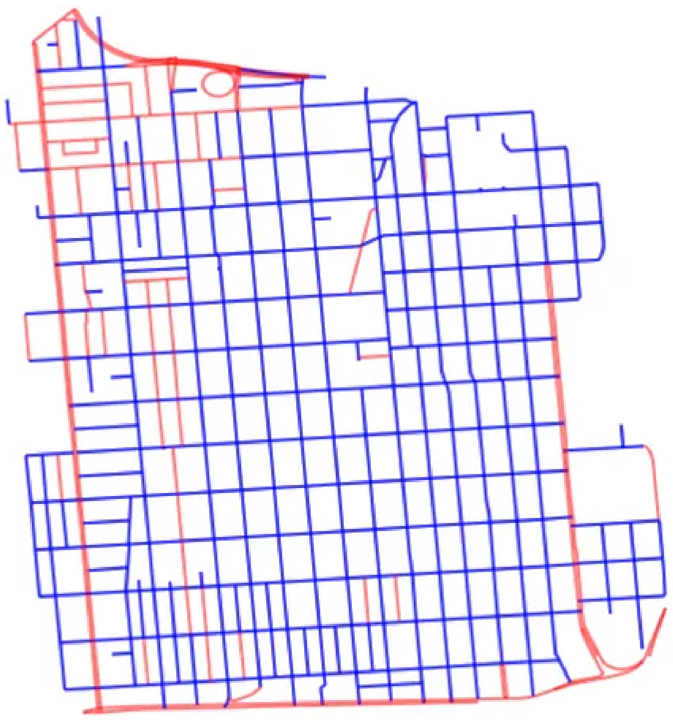
OSMnx can visualize street segments by length to provide a sense of where a city's longest and shortest blocks are distributed:

```
ec = ox.get_edge_colors_by_attr(G, attr='length')
ox.plot_graph(G, edge_color=ec)
```



OSMnx can easily visualize one-way vs two-way edges to provide a sense of where a city's one-way streets and divided roads are distributed:

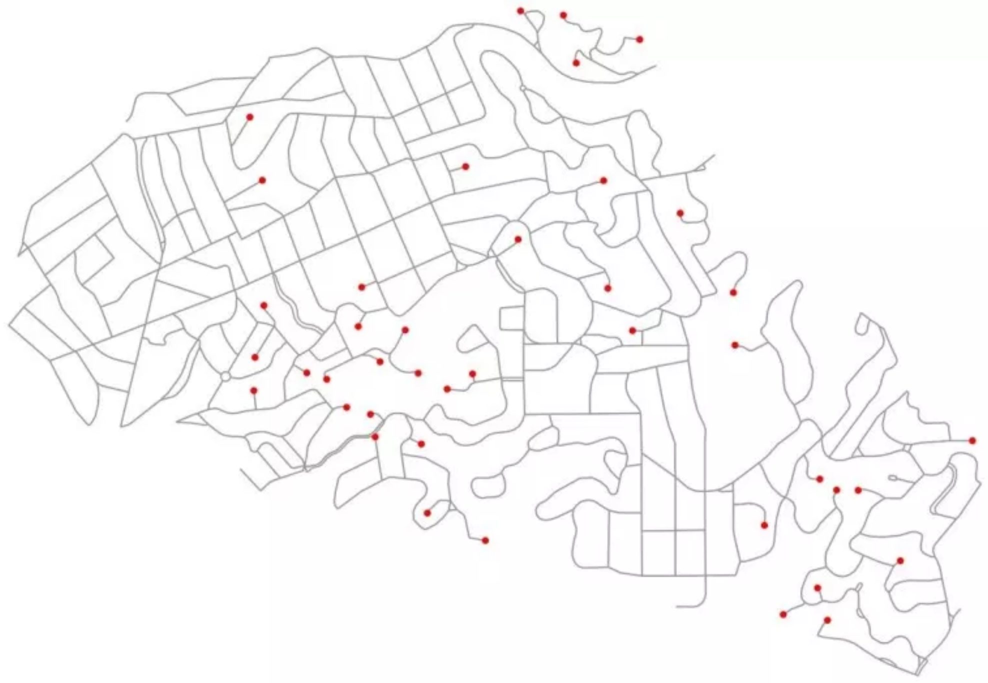
```
ec = ['r' if data['oneway'] else 'b' for u, v, key, data in G.ed
ox.plot_graph(G, node_size=0, edge_color=ec)
```



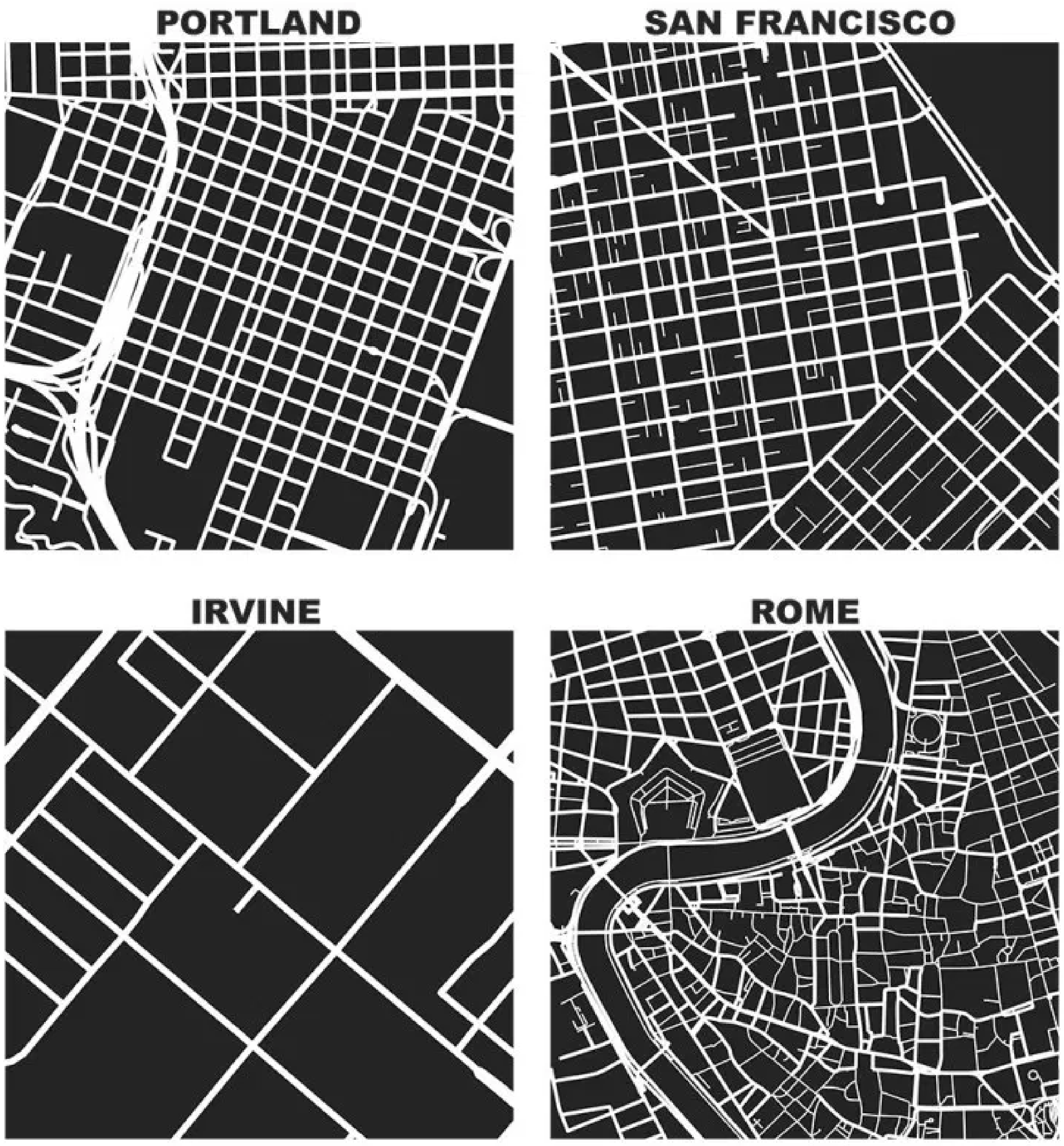
You can also quickly visualize all the cul-de-sacs (or intersections of any other type) in a city to get a sense of these points of low network connectivity:

```
culdesacs = [key for key, value in G.graph['streets_per_node'].i
nc = ['r' if node in culdesacs else 'none' for node in G.nodes()]
ox.plot_graph(G, node_color=nc)
```

Urban planning professor at Northeastern University



Allan Jacobs famously compared several cities' urban forms through figure-ground diagrams of 1 square mile of each's street network in his book *Great Streets*. We can re-create this automatically and computationally with OSMnx:



These Jacobsesque figure-ground diagrams are created completely with OSMnx.

Conclusion

OSMnx lets you download spatial geometries and construct, project, visualize, and analyze complex street networks. It allows you to automate the collection and computational analysis of street networks for powerful and consistent research, transportation engineering, and urban design. OSMnx is built on top of NetworkX, matplotlib, and geopandas for rich network analytic capabilities, beautiful and simple visualizations, and fast spatial queries with R-tree.

OSMnx is open-source and on GitHub. You can download/cite the paper here.

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152 thoughts on “OSMnx: Python for Street Networks”

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rodrigo culagovski

2016-11-10 at 12:08

Congratulations, will be following this to see where it goes.

Armando

2016-11-11 at 06:40

Hi Geoff,
thank you for this great resource!

How can we export the data as a GeoJSON file? Is this possible?
Do you know how can we use this data to build the city blocks from the street network?

Thanks!

gboeing