Converting OpenStreetMap Data to Road Networks for Downstream Applications

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Abstract

We study how to convert OpenStreetMap data to road networks for downstream applications. OpenStreetMap data has different formats. Extensible Markup Language (XML) is one of them. OSM data consist of nodes, ways, and relations. We process OSM XML data to extract the information of nodes and ways to obtain the map of streets of the Memphis area. We can use this map for different downstream applications.

1 Introduction

OpenStreetMap (OSM) [1] is referred to as the Wikipedia of the mapping of the world. People from all over the world contribute to build it. OSM represents the visual representation of the world. In this work, we detail how to convert OSM data to road networks that many downstream applications depend on.

OSM data has many formats, among which XML is a popular choice. OSM data is the collection of nodes, ways, and relations. Nodes contain the location in the WGS84 (World Geodetic Coordinate System 1984) coordinate system specified by a pair of latitude and longitude. way is a collection of nodes (at least two). If we plot all nodes of a way by considering the latitude as the X axis and longitude as the Y axis, a line will be drawn. If the first node and the last node of a way coincide, this way is considered closed. Various attributes can be assigned to each node, way, and relation. The attributes are represented as tags in OSM XML. Each tag is composed of a key and a value. In Fig. 1, we show an example of the raw OSM data in the XML format. The flowchart of this project is shown in Fig. 2. The data of the Memphis area is downloaded from https://extract.bbbike.org/, which packs city-level OSM data.

1https://wiki.openstreetmap.org/wiki/Converting_to_WGS84
2 Nodes and Ways

A node represents a particular location on the surface of the earth that is identified by its latitude and longitude. At a minimum, a node has an ID number and a pair of latitude
and longitude. The shape of a way can then be defined using nodes. The majority of the nodes do not have tags when they are used as intermediate points along ways. A way is an ordered list of at least two nodes that together define a polyline.

2.1 Extracting Node Information

To extract the information of nodes, we use the xml.etree.cElementTree package. This is one of the most popular python packages for parsing XML data. We know that a node consists of id, latitude, and longitude. With the help of the xml.etree.cElementTree package, we parse the node’s information and convert it into the pandas DataFrame. An example is shown in Fig. 3.

| node_id   | lon     | lat     |
|-----------|---------|---------|
| 0         | 116829005 | -90.1938287 | 35.2192446 |
| 1         | 116829007 | -90.1938126 | 35.2189378 |
| 2         | 116829008 | -90.1937054 | 35.2186398 |
| 3         | 116829012 | -90.1921765 | 35.2164748 |
| 4         | 116829015 | -90.190417  | 35.2149453 |

Figure 3: The first four nodes’ information of the OSM data of the Memphis area.

2.2 Extracting Way Information

To extract the information of ways, again, we use xml.etree.cElementTree. A way contains id, the references of its constituting nodes references, and tags. Each tag has a key and a value. In this task, we extract only the highway keys: residential, service, tertiary, track, secondary, primary, tertiary link, secondary link, motorway link, primary link, motorway, trunk link, trunk, footway, construction, pedestrian, proposed, path, raceway, cycleway, living street, steps, abandoned, rest area, corridor, and platform. We put this information into pandas DataFrame for later use. An example is shown in Fig. 4.

2.3 Merging Node and Way Information

Next, we need to merge the node’s information and way’s information to get the final DataFrame. We know that single ways have multiple node references and we want to extract the latitude and longitude for those nodes’ references. Once we are able to do that,
we can plot the latitudes and longitudes according to the ways. Fig. 5 shows the final DataFrame for putting the node and way information together.

### 2.4 Converting the Latitude and Longitude to X and Y Coordinates

The method for identifying a position on the earth is called the coordinate system. We can use for this case latitude/longitude, easting/northing, and X/Y. The coordinate systems are classified into two categories: geographic and projected. A spherical surface is used for the geographic coordinate system and latitude and longitude are used. Our main goal is to plot the Memphis area in 2D, for which we need to convert a sphere into a flat surface. For that, we use the projected coordinate system. In particular, we use the pyproj python library.
3 Results

We conduct a number of experiments to plot the streets of the Memphis area. First, we plot only the motorway and use UTM (Universal Transverse Mercator) zone 15\(^\text{2}\). The plot showing only the motorway can be found in Fig. 6.

Next, we plot motorway, trunk, primary, and secondary ways. The plot is shown in Fig. 7.

Lastly, we plot all ways of Memphis. The map is shown in Fig. 8. Note that the map is slightly tilted towards the left-hand side by using the UTM zone 15 which is the UTM zone for Memphis.

\(^2\)https://www.arcgis.com/apps/View/index.html?appid=7fa64a25ef0d0420896c3336dc238475
4 Conclusion

In this task, we show how to convert OSM data to road networks which are essential for many downstream mobility applications. We also visualize Memphis in various ways showing its consisting roads.

References

[1] OSM. OpenStreetMap. https://www.openstreetmap.org/. Feb. 2022.
Figure 7: The map showing the motorway, trunk, primary, and secondary ways of Memphis.

Figure 8: The map containing all ways of Memphis.