

## Practical 7 (A) - Compute and visualize shortest route between 2 coordinates using OSMnx.

In urban geospatial analysis, determining the shortest or fastest route between two locations is an important problem in navigation systems, transportation planning, and logistics. OpenStreetMap provides detailed road-level data, including road geometry and attributes, which can be used to model real-world routing scenarios accurately.

OSMnx enables road networks to be represented as graph structures, where routing algorithms can be applied efficiently. In such a graph-based representation:

- Nodes represent intersections, junctions, or points where roads meet.
- Edges represent road segments connecting these nodes.

Each road segment (edge) can store multiple attributes such as:

- Length of the road segment
- Speed of travel
- Estimated travel time
- Road direction and type

To compute a route, the road network for a selected city is first downloaded using OSMnx. The network is restricted to drivable roads to ensure realistic vehicle routing. Speed and travel time attributes are then added to the edges based on available road data.

The cost of traversing each road segment is defined using an edge weight. When travel time is used as the weight, it is computed as:

- **Travel Time = Road Length / Speed**

Since routing algorithms operate on nodes, the given geographic coordinates (latitude and longitude) of the origin and destination are mapped to their nearest nodes in the road network. Once these nodes are identified, shortest path algorithms are applied to compute the optimal route between them by minimizing the total edge weight.

## **Practical 7 (B) - Quantifying Urban Density: Calculating Building Coverage Ratio (BCR) using OSM.**

Urban density is an important indicator used in urban planning, land-use analysis, and sustainable city development. One commonly used metric to measure urban density is the Building Coverage Ratio (BCR), which represents the proportion of land area covered by building footprints within a given region. A higher BCR indicates denser built-up areas, while a lower BCR suggests more open or undeveloped land.

OpenStreetMap provides detailed spatial data related to buildings, including building footprints represented as polygon geometries. These building features can be extracted and analyzed using Python-based geospatial libraries. OSMnx allows users to download building data directly from OpenStreetMap for a specified geographic area, making it suitable for urban density studies.

In geospatial analysis, buildings are represented as polygon features, where each polygon corresponds to the outline of a building. By extracting all building polygons within a defined boundary, the total built-up area can be calculated. The total land area of the selected region is also computed based on the boundary geometry.

The Building Coverage Ratio (BCR) is calculated using the formula:

- **$BCR = (\text{Total Building Area} / \text{Total Land Area})$**

After computing the total building area and land area, the BCR value provides a quantitative measure of urban density for the selected location.

The extracted building footprints and study boundary can be visualized on an interactive map to better understand the spatial distribution of buildings. Such visualization helps in interpreting how buildings are clustered within the area and supports urban planning and infrastructure assessment.