Redefining "Betweenness Centrality”

Objectives

1. To explore betweenness centrality, a metric evaluating node importance based on shortest paths in a transportation network.
2. To modify betweenness centrality by integrating real-world travel patterns influenced by population density, offering a more practical measure of node significance.
3. To compare and visualize the outcomes of conventional and modified betweenness centrality.

Methods

Conventional Betweenness Centrality

1. Evaluate node importance using shortest-path routing between all pairs of nodes.
2. Extract a road network within a bounding box (33.86, -84.40, 33.82, -84.34) using the OSMnx library.
3. Compute betweenness scores with edge weights based on road length.
4. Visualize the scores on a map with nodes color-coded to reflect their centrality.

Modified Betweenness Centrality

Adjust the conventional metric to incorporate population density-based travel demand.

1. Retrieve population density data using the U.S. Census Bureau API.
2. Sample origin-destination pairs proportionally to population density.
3. Simulate travel paths using shortest-path algorithms like Dijkstra’s.
4. Count node traversal frequency and assign it as the modified centrality score.
5. Plot and compare results with conventional centrality to highlight differences in node significance.

Outputs

1. **Visualizations**
    - Map of **conventional betweenness centrality**: Nodes color-coded by their theoretical importance within the road network.
    - Map of **population density**: Highlights areas influencing travel demand.
    - **Comparative map**: Displays differences between conventional and modified centrality scores.
2. **Insights**
    - Conventional betweenness emphasizes network structure, while modified metrics reflect practical node usage.
    - High-scoring nodes in the modified metric represent critical hubs for real-world travel, while peripheral nodes often remain less significant.

Key Observations

1. **Conventional Betweenness**
    - Highlights structural hubs and intersections.
    - Scores reflect theoretical connectivity, not influenced by population distribution.
2. **Modified Betweenness**
    - Reflects real-world travel patterns influenced by population density.
    - Identifies nodes with high traffic demand, emphasizing practical significance.
3. **Comparative Insights**
    - Structural hubs often remain important in both metrics.
    - Modified centrality highlights nodes that are practically significant due to travel demand, offering actionable insights for urban planning.