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Final Project Write-Up: Providing Elderly Access in Brookline, MA

Abstract

This project will support thesis research on how urban infrastructure affects the mobility and access restraints on elderly citizens in Brookline, MA. It will analyze access to MBTA transit stops in the town, and the effective walking radius to and from these stops. I will use GIS datalayers provided by the Town of Brookline, including topographic data, and generate service area maps to show graphically the extent to which these transit stops serve pedestrians from their homes. A layer of major roads and transit networks will allow the creation of a map of walkable distance; analyzing the slope of the topographic layer will further refine this by adding a raster gradient map that weights steeper terrain to scale at a higher cost (this affects elderly citizens more than younger generations). I will conclude with a general assessment of Brookline's transportation services and how well they accommodate elderly residents, and where specific holes in accessibility exist in the town.

Process

Building the network dataset

I received several street-related datalayers from the Brookline GIS office, but needed only the centerline geometry to produce a network dataset. In ArcCatalog, I enabled the Network Analyst extension, and used the centerline shapefile to create a new network dataset. This automatically created junctions wherever street lines met, and added a length attribute to each line.

This dataset was added to an ArcMap layer. Using the Network Analyst toolbar, I created a new service area, adding the 60+ MBTA bus stops and 10+ MBTA streetcar stops as "facilities". In the options, I chose to generate polygons that captured travel distances of 500 and 1000 meters along roads from the facilities. These represented the differences in what a mobility-restricted person might be able to access on foot, versus someone in relatively good shape. I also generated lines for the actual length of road accessible.

Working with topography

The contour lines provided by Brookline comprised a huge file, as they were quite detailed and included lines for every two meters of elevation. This proved problematic when attempting to convert the contours into a TIN (Triangulated Irregular Network) for analysis, since the computer's memory could not handle such a large conversion. To simplify the work, I cropped the contour lines extending past the town boundaries, and then selected only those lines with Z-values divisible by 10. This substantially reduced the size of the shapefile to at most one-fifth the original size. I also kept lines with Z-values of -1000, as these were probably present to fix certain aspects of the topography at edges of the map.

Using the 3D Analyst toolbar (which also required activating the extension in ArcMap), I interpolated a TIN surface from the contour lines. This surface could be navigated in 3D using ArcView. From the 3D Analyst toolbar, I also processed the TIN into a slope field raster. This created a raster map of the town, with the value at each raster equal to the slope of the land surface in degrees. Using Spatial Analyst, I converted this raster map into vector, creating polygons with the shared attribute of certain slope values.

Applying slope to the network analysis

The slope polygon layer was intersected with the street centerline geometry used previously in the network analysis. The intersection produced the same street geometry as before, but each segment now carried a new attribute: the slope of the polygon or raster that it crossed over. These values, many of which contained decimal degrees, were reclassified to integer. Furthermore, these were reclassified to blocks of ten degrees: all values 0-10 degrees became 1, 10-20 became 2, 20-30 became 3, and so on. This new classification acted as a slope index to weight the difficulty of traversing street segments. Using this new street shapefile, I created a new network dataset. This dataset calculated both a length attribute and an attribute multiplying length by the slope weighting. Thus, a segment of road 200m long but with a slope of 15 degrees was given a weighted length of 400m.

The new network dataset was processed in ArcMap, using the same facilities and polygon distances as the original. Two new polygon service areas, one for 500m and one for 1000m, were created from this dataset.

Map Results

The first map shows the original street network of Brookline, the location of bus and streetcar stops, their route lines, and the polygon service areas. These polygons show that most of the town's area is within one kilometer walking distance to a transit stop, with the exception of the southeast corner of private residential neighborhoods. Within half a kilometer, however, there are significant holes in service area, especially in the center of town.

The second map highlights the length of streets included in this service area calculation. The streetlines are color-coded based on their distance along the path from the nearest facility; lighter lines are further out on the journey. A 100m buffer is added as a slightly more accurate picture of the block area accessible to a pedestrian, as the polygons generated previously are slightly misleading in depicting accessible area within blocks.

The third map shows the TIN created by interpolating the contour lines. The transportation network is overlaid to give a qualitative sense of where terrain might be an overwhelming obstacle to pedestrian mobility.

The fourth map shows the raster and vector maps of slope field. They show that areas of steep slope are scattered in clusters around the town area. The north portion of town is strikingly smooth compared to areas south.

Finally, the fifth map shows the result of the service area analysis, when taking into account the difficulty of traversing steeply sloped roads. The difference in the old service area and the new is not very severe; using my method of weighting does shorten the paths very much. I assume that most streets are comfortably within 0-20 degree slope areas, with some of the more difficult terrain close enough to the facilities that alternate, easier routes can extend farther, or simply outside the original service area to begin with.

By this analysis, the serious holes in transit infrastructure are in the southeast and southwest corners of town, where a number of residential streets are far away from bus stops or train stops. When narrowed down to a 500m walking radius, even more holes in service appear, especially in the center of the town area. Terrain matters as well, but the extent to which it affects the service area depends a lot on how it is used to weight cost of travel.

The most glaring weakness of this model is in this weight classification. Dividing up the range of slope degrees into intervals of ten, and using them as a multiplying factor on the length of the roads, was probably not very accurate in simulating an actual walk. Refining this into a realistic weight classification would take some amount of empirical study on mobility and how much harder it actually is to travel a certain distance with various slopes. However, I am convinced that the general practice of using network datasets and service areas is still a superior way of determining how transportation infrastructure actually serves an area, rather than using a simple distance buffer.