P-median Model

Functions : load, choropleth, auto.shading, choro.legend, allocations, match, star.diagram

Data Files: EN.RData

Buffalo and Niagara counties has been carved up into 297 zones. You have been asked to locate 5 air pollution monitoring stations using the P-median location model. The R function `allocations` in the package of *tbart* can be used to set up a P-median problem and the results will be visualized using functions in *GISTools* package in R. A data file required in this class can be downloaded from the UBlearns. File `EN.RData` contains all the necessary data for this lab. Download the file and load into R workspace.

P-median model setup and run

1. Load the data and change the working directory where the downloaded data file is located.

```
> load('EN.RData')
> setwd(' ... ')
> set.seed(12345)
```

2. Make maps of the study area shaded by the population density and the daily variability of $PM_{2.5}$ in the year of 2011. The two variables are respectively named as *pop.den, pm25.std* in the spatial polygon data frame (*en.county*). Overlay the maps with background image retrieved from OpenStreet Map (Please see the tutorial). ** No need to hand in the output of Q.1. However, please make a comment on the distribution of population and PM2.5 concentrations.

3. Solve the p-median problem when p value is ranged from 3 to 15 stations ($p = 3, 4, ..., 15$). Develop a tradeoff of the weighted distance (= objective value) versus the number (p) of facilities being located, where the value of p ranges from 1 to 10. Plot the tradeoff curve of values, Y axis for weighted distance and X axis for p. Along with the tradeoff curve, report the solutions for each value of p in terms of weighted distance and the sites selected for facilities. Is there any site which is consistently identified as facilities? Hand in the spider diagram for $p = 6$. **Hint: in order to see the objective function, you need to use an option (*verbose* = *T*) in the allocations function.

   Your report must include

   (a) a graph of Weighted distance versus P- values (20 points)

   (b) a map of spider diagram of solution when p = 6 over the background map of OpenStreet map and choropleth map of allocation distance. (30 points)

4. For the $p = 5$ solution, the best solution uses sites 18, 49, 121, 159, 230

   a. undergraduate: Solve the p-median problem using `allocations` in order to find the best solution which must involve sites 1 and 100 (50 points).

b. graduate: Solve the p-median problem using `allocations` in order to find the best solution which does not involve using all five of these sites (10 points)

How does the best 5 facility solution compare to the one that doesnt use all of the best sites, in terms of weighted distance, and in terms of sites used? Map these two solutions using the spider diagram and report the id of five sites for each solution.

5. For the $p = 5$ solution, find the best solution which takes into account the population density of each demand zone. Make the spider diagram of the solution with population density as a weight and compare these maps with the solution based on Euclidian distance (above). (40 points for graduate students only).

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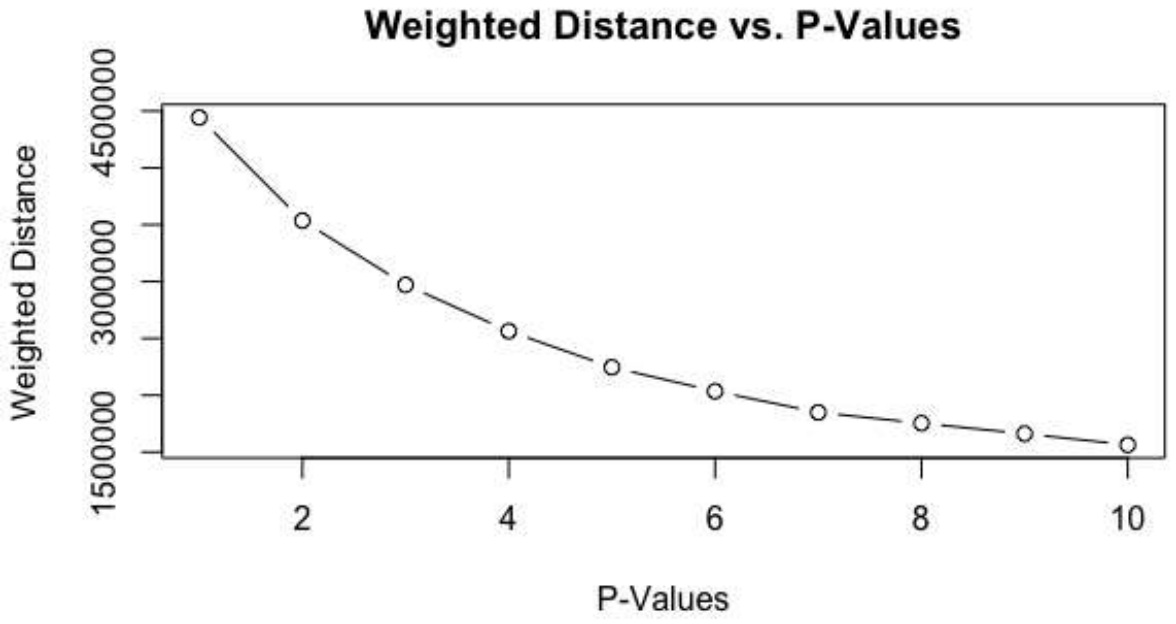
GEO482 – Location Analysis
Lab 2 – P-Median

2. After creating the two maps for population density and air pollution, looking at the population map we can see that the vast majority of people live in and around the urban core of Buffalo. And looking at the air pollution map, the majority of air pollution is located north of Buffalo, with the heaviest concentrations in Niagara County and Niagara Falls.

3. p=3: (55 287 178)
   p=4: (18 17 284 178)
   p=5: (18 49 288 245 159)
   p=6: (14 17 296 246 159 137)
   p=7: (14 49 225 275 88 159 124)
   p=8: (14 49 224 297 167 195 183 197)
   p=9: (14 49 207 275 83 181 148 89 195)
   p=10: (14 49 13 276 210 156 195 125 104 197)
   p=11: (14 49 13 76 210 173 195 184 281 104 140)
   p=12: (14 49 31 188 292 274 156 149 125 119 195 147)
   p=13: (14 49 13 188 76 210 156 181 184 281 119 195 140)
   p=14: (14 49 13 188 76 210 156 181 125 281 119 195 147 241)
   p=15: (14   2 49 13 188 76 210 156 181 125 281 119 195 147 241)



4. The solution set when fixing sites 1 and 100 is (1 17 100 284 178).