Notes on Healthcare Facility Location

Various Artists...

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Abstract

We describe an approach based on the facility location optimization problem for identifying the best locations to set up supportive centers for elderly people with dementia/Alzheimer's-related symptoms. **Keywords: Healthcare Facility Location**

1 A Brief Description of our Understanding of The Problem

Assume a geographical region X with a set F of fixed healthcare facilities on X. Assume also a set D of demands by elderly citizens for F. D is defined based on recorded historical data that contains among others the following information:

1. Mobility patterns of elderly. It contains information about the place of departure, the place of arrival and the means to travel from the one point to the other.
2. Comorbidities of the elderly people.
3. Information about the doctor they visited.
4. Demographic data
5. Economic data
6. etc.

Based on this data our goal is to choose a small number of healthcare centers such that elderly citizens would be best served.

In the following we will try to formalize the problem. In doing that, we take into account the following points:

1. The size of the data is prohibitively small to use (advanced) machine learning and AI methods. We prefer to use optimization methods.
2. Due to the small size of the data we could use statistical data to enhance the results.
3. Due to the small size of the F set, we could target at solving the optimization problem for a specific number of chosen facilities in increasing order, e.g., solve for 1, then 2 and then 3 and show the gains in each case.
4. We will optimize for total cost of travelling taking into account that the elderly citizen will move by car. This is related to total distance travelled although this is not always the case.

2 Correlation

3 A Simple Model

We model the problem as a healthcare facility location problem. There is extensive research work on this field; for a rather recent (2017) comprehensive review see [1]. One could further look at more recent literature but from what I have seen the main differences lie at the modeling side and not at the solution side, which means that it is very data-dependent.

In the following, we define the Integer Linear Program (ILP) that provides a solution to a simple problem. Given that this is a correct (albeit incomplete) model, we can experiment and then try to extend it in order to incorporate more features. We do not discuss the solver, for which standard toolboxes can be used.

Sets:

F : the set of candidate locations (these correspond to candidate healthcare facilities)

D : the set of demands (these correspond to known locations from which elderly citizens started their trip to the doctor)

Input Parameters:

d_{ij} : the travel distance/time/cost from demand point $i \in D$ to candidate facility $j \in F$ (this can be estimated by the distance between these two points)

w_i : the demand at point $i \in D$ (this correspond to how many people start from a particular location/area based on historical information or statistical information)

p : the number of facilities to be used from F (since this number is small we may simply iterate)

Decision Variables:

x_j : it is 1 if $j \in F$ is established as a candidate location, and 0 otherwise

y_{ij} : it is 1 if demand point $i \in D$ is assigned to location $j \in F$ (in the case when $p = 1$ this variable makes no sense since all demands will be assigned to the unique chosen facility)

Formulation:

$$\min \sum_{i \in D} \sum_{j \in F} w_i d_{ij} y_{ij} \tag{1}$$

subject to

$$\sum_{j \in F} y_{ij} = 1, i \in D \tag{2}$$

$$\sum_{j \in F} x_j = p \tag{3}$$

$$y_{ij} \leq x_j, i \in D, j \in F \tag{4}$$

$$y_{ij} \in \{0, 1\}, i \in D, j \in F \tag{5}$$

$$x_j \in \{0, 1\}, j \in F \tag{6}$$

Equation 1 states that we want to minimize the total demand-weighted travel distance/time/cost. This is a p-median location approach for the optimization function. Other approaches are also possible - it depends on what we wish to optimize. Constraint 2 states that each demand location is assigned to only one facility location. Constraint 3 specifies the total facilities that will have to be used. Constraint 4 limits the assignments to chosen facilities. Finally, Constraints 5 and 6 impose the integrality of the decision variables.

References

[1] Amir Ahmadi-Javid, Pardis Seyedi, and Siddhartha S. Syam. A survey of healthcare facility location. *Computers & Operations Research*, 79:223–263, 2017.