Investigating multi-purpose allocation status of the fire stations with Vector Assignment Ordered Median Problem model in GIS environment

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Abstract

Location and allocation analysis is one of the most important network and useful analyzes in GIS. This analysis involves various models that, each model is used to solve various problems. Recently, a new model called VAOMP (Vector Assignment Ordered Median Problem) has been developed that, it can solve many different problems. Given that, the location and allocation problems are very difficult, it is almost impossible to solve them in exact methods. Therefore, the present research intends to solve the allocation problem of the population to existing fire stations. The VAOMP model and the Genetic and Simulated Annealing algorithms with three goals such as minimizing the arrival time to demands, minimizing distance and maximizing the coverage of each station, solved the problem. The results of this research showed that the Genetic algorithm produces more qualitative solutions in shorter time, while 10 stations in the 21st and 22nd districts of Tehran are not sufficient to serve the total demands in the study area and 55240 people without services will remain and at least, 13 stations in the region should be created.

Introduction

The optimal location of the facilities and the optimal allocation of citizens to these facilities are very important problems. Because, if the location of a facility is not appropriate, it cannot be able to provide the optimal services to

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the demands (Shamsul Arifin, 2011). So, making an incorrect decision about the location of the facility would lead to improper use of the land, damage to the land and the loss of its construction costs. Therefore, the present study for solving the optimal allocation problem of population to the fire stations in the study area, and examining the number of people without services, uses from GIS for analysis, data preparation and output display (Church, 2002).

Materials and Methods

First, the data are prepared and entered to GIS environment. Then some analyzes are performed on prepared data. As mentioned, the three objectives of this research are include: 1. Minimizing the distance between the demand and fire stations. 2. Minimizing the arrival time to demand from fire stations. 3. Maximizing the coverage of the fire stations (Bolouri et al., 2018). These goals are combined with a weighted linear summation (Erkut et al., 2008). The VAOMP model (Lei and Church, 2014; Lei et al., 2016) is developed using two Genetic algorithms and Simulated Annealing algorithms. The optimal parameters are determined for each algorithm by sensitivity analysis and ultimately, the model is run. If the number of the existing fire stations is not enough for servicing to demands then, the relocation and reallocation will be performed to identify the minimum number of stations in the area.

Results and Discussion

After analyzing, to determine the best parameters for each algorithm and the implementation of the algorithms in the study area, by comparing the results of both algorithms and the convergence diagram of each algorithm, the validity of the model was investigated. Efficiency and effective implementation of each algorithm depend on its parameters. Although, these parameters can accept different values, for simplicity of the process, the defined values were considered for them.

Conclusions

The results of the model application in the region showed that the number of existing stations for servicing to the population in the region was insufficient and 55240 people remained without services, so by relocating-reallocating and adding a number of the candidate stations to the problem space, it was determined that, at least 13 stations needed for optimal service of the fire stations in the region, while the Genetic algorithm produced more qualitative solutions in a shorter time.

Keywords: location and allocation, fire station, VAOMP, GIS, Genetic and Simulated Annealing algorithm

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