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Editors

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Recurrent Process on Appointing an Aid Site: A Case for Airports

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Abstract

Mathematical models have been used for many decades in order to improve the infrastructure design of transportation facilities. In this study, locational best fit airport infrastructure is determined for providing an urgent assistance in case of an emergency requirement throughout the country. The data are supplied from civil airports in Turkey. In order to solve the problem, the mathematical models such as Weber Problem solution methodology is applied for assessing the results. Moreover, the limitations such as distance costs and also the weights of the regional airports such as the passenger counts and the approximate physical size of the airport field are taken into account. Optimizing the circumstance, the economic losses are aimed to be lower, and thus the financial improvement is targeted by the application of the mathematical model and the implementation of its results.

KEYWORDS: Airport, Iterative model, Location appointment, Recurrent algorithm, Weber problem

Introduction

Many research show that mathematical methodologies solve the problems of transportation activities such as discovering the directions with similarities and inferring the paths [1], [2], [3]. Accordingly, with the help of mathematical models, many policies are developed for better transportation activities at a specific region [4].

The concern in this study is to provide immediate air support in case of an emergency situation at any airport within the country. The aim is to determine the location of one large facility for storing the emergency necessities such as health-care equipment and professionals. Hence, the motivation of this aim is satisfied by decreasing the cost of immediate access to an unforeseen disaster. There are applications in the literature which consider the number of airplanes to determine the location of a support facility [5], [6]. Those research took the number of airplanes landed to the airport (i.e. the number of airplanes used the airport for landing and takeoff) as an indication of airport weights. However, since the number of lives are not taken into account for this kind of particular study (e.g. appointing an aid site), this research introduces the number of passengers used the airports rather than the number of airplanes occupied the airports. Therefore, this study aims at deciding on the most convenient transportation location in the case of an intervention, by considering the number of travelers at airports. To achieve the goal, a single point facility location is located by the techniques in the literature to solve the case such that a facility location is determined for a specific industry [7].

One of the best mathematical technique for finding a single facility location in two-dimensional space is called the Weber Problem (WP) [8], [9]. Because the weights of airports (i.e. the number of passengers used the specific airports and the estimated physical sizes of the airport terrains), an iterative technique has to be applied to get the optimum location. One of the most authoritative mathematical method for assessing the optimal facility location is the Weiszfeld method or algorithm (WM) for implementation [10], [11]. Hence, transportation information is analyzed by the help of WP and WM in this research.

Methodology

The operation research problem of WP is an optimization of a location. The main goal on this problem is to minimize the Euclidean distances which are weighted by some kind of costs, to find an optimal location meeting the requirements of all other demand locations [9], [11]. The explanation of WP is as follows.

$$\min \sum_{j=1}^{n} w_j |\bar{x} - \bar{x}_j| \tag{1}$$

based on $\bar{x} = (x, y)$ and $\bar{x}_j = (x_j, y_j)$. Moreover, the demand points $\bar{x}_j$ are members of the surface of E^2. Consequently, the optimization explanation (1) ascertains the most appropriate place of $\bar{x}$. To solve the mathematical problem of WP, a powerful method is introduced in the following.

A successful iterative methodology of Weiszfeld Method or Weiszfeld Algorithm (WM) can confidently solve WP with by utilizing the software of LINGO [10], [12], [13]. The mathematical location allocation problem is dealt with WM which optimizes the weights in terms of the demands. Hence, the following WM description can be implemented in this study.

$$\min \sum_{i=1}^{n} a_i D_i \tag{2}$$

so that $a_i D_i$ in the formulation (2) is the weight times the distance which means the Euclidean cost (e.g. the distance) which is weighted for the location of final site location (X_f, Y_f). n is the number of demand locations requesting service such that affecting the final decision of the site. Additionally the final position of the place must satisfy the mathematical inequality of $(X_f, Y_f) \geq 0$, as the final output must be on the fixed topography.

The computer program applies the methodology of the combination of WP and the recurrent method of WM to the weighted Euclidean costs (e.g. distances) of demand locations at a fixed topography surface. The program runs until the iterations give the same result accordingly. Then the optimization with mathematical iterations stops, and the final outcome can be stated. Because the site of the facility has a weighted importance such as the capacity, physical size of the area, etc., the inputs from WP can be accounted as the inputs for a solution of WM.

Application to the Case Study

First of all, the scope of this case includes not only the number of passengers that visit the airport in the last six months as *parameter-1*, but also the physical size of the airports lands as *parameter-2*. These parameters decide the weight of the airports included in the study. Totally 55 civil airports in Turkey are used in the analysis. *Parameter-1* having a weight of 0.8 is assigned, since the probability of having causalities increases as the number of lives around increases. In this manner, *parameter-2* having a weight of 0.2 is assigned, because the terrain area size is important in order to establish a facility. Required area should be selected as large as possible to store services for emergency situations. Thus, the total weight of the parameters from each demand source as demanding place is equal to 1.00. Additionally, the positional data of all demand sources (i.e. 55 airports) are considered to finalize the location of the aid site. Position information delivers very vital constraint for cost that is labeled as distance for this research.

Major Outcomes

The algorithm with the objective function of (2) that is applied to the data in this research is suitable to be launched in the software of LINGO 17.0 x64.lnk [13]. Therefore, this solver program was operated by a computer having Intel®Core$^{\text{TM}}$ i7-2640M CPU@2.80GHz. The solver processed the data input and provided the result of (0.6956857, 0.5563164) as the optimum solution of (X_f, Y_f) coordinate. This spatial output of 0.6956857 and 0.5563164 serve as 39.85985448° N and 30.34723505° E respectively which belong to $39°51'35.5''$ N, $30°20'50.1''$ E correspondingly, according to the Mercator projection. The solver reported that this result is the local optimum solution with no infeasibilities. However, since the problem here was convex, the output of local optimum was literally the global optimum. Hence the verification of results was done.

Conclusions

Mathematical models are being used to solve several problems of infrastructures in many engineering areas and applications. In our case, the location of the aid site is appointed and proposed by the application of WP which is a mathematical problem, and WM which is a mathematical iterative technique. Spatial results are gained by the evaluation of the parameters of not only the weights but also the costs as distances of demand locations. As mentioned earlier, the weights are considered as the factors of the numbers of passengers visited the airport in the last six months, and the physical areas of the airports. In accordance with the mathematical appraisal in this research, the aid site for the airport throughout the country is proposed to be erected as soon as possible. By taking the outcomes of this study into consideration, making great contribution to the state planning, cutting the budgets of traveling distances and mileage use, and more importantly rescuing lives quicker than earlier times during the interventions are anticipated.

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