MULTI-FACILITY LOCATION PROBLEMS WITH THE PRESENCE OF BARRIERS

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ABSTRACT

A constructive heuristic method is introduced to solve the multi-facility location problems in the presence of convex polygonal barriers. Potential locations for the facilities can be anywhere in the space except in the interior of the barriers. Also the Euclidean distance travelled cannot cross the interior of the barriers. The method guides the initial chosed location away from the barriers and the Weisgal procedure then improve the location position subject to the user locations and the corner points of the barriers. The preliminary results are presented based on benchmark problems.
***Keywords**:* Heuristic, multi-facility location problem

INTRODUCTION

In this study, we are given a set of users, located at n fixed points, with their respective demands. We are required to locate M facilities in continuous space to serve these n users, and to find the allocation of these users to these M facilities. The objective is to minimize the sum of transportation costs. This continuous location-allocation problem can be formulated as follows:

$$\text{Minimize } \sum_{i=1}^{M}\sum_{j=1}^{n} x_{ij}\, d\left(X_i, a_j\right) \tag{1}$$

subject to

$$\sum_{i=1}^{M} x_{ij} = w_j, \quad j = 1, \ldots, n \tag{2}$$

$$X_i = \left(X_i^1, X_i^2\right) \in S \subset \Re^2, \quad i=1,\ldots, M \tag{3}$$

$$x_{ij} \geq 0, \quad i = 1, \ldots M; \quad j = 1,\ldots, n \tag{4}$$

where M is the number of facilities to be located, S is the feasible region to be considered, x_{ij} is the quantity assigned from facility i to customer j, $i = 1, \ldots M$; $j = 1, \ldots, n$, $d\left(X_i, a_j\right)$ is the Euclidean distance between facility i and customer j, $a_j = (a_j^1, a_j^2) \in \Re^2$ is the location of customer j, $X_i = (X_i^1, X_i^2)$ are coordinates of facility i, w_j is the demand, or weight, of customer j.

The objective function (1) is to minimize the sum of the transportation costs. Constraints (2) guarantee that the total demand of each customer is satisfied. Constraints (3) describe the restricted regions and constraints (4) refer to the non-negativity of the decision variables.

There is however a shortage of papers on the facility location problem with barriers. This problem is the constrained Weber problem which is also known as the Weber problem in the presence of forbidden regions and/or barriers to travel. This was initially investigated by Katz and Cooper [1]. They considered a Weber problem with the Euclidean metric and with one circular barrier. A heuristic algorithm was suggested that is based on a sequential unconstrained minimization technique for nonlinear programming problems. Hansen et al. [2] provided an algorithm for solving the location problem when the set of feasible points is the union of a finite number of convex polygons. Other studies include Aneja and Parlar [3] and Butt and Cavalier [4] who developed heuristics for the median problem with *lp* distance and barriers that are closed polyhedra. Batta, Ghose, and Palekar [5] obtained discretization results for median problems with l_1-distance and arbitrarily shaped barriers by transforming these problems into equivalent network location problems. Their results were generalized by Hamacher and Klamroth [6] for arbitrary

block norms, although it is not possible to transform these problems to the analogous network location problems. Bischoff and Klamroth [7] proposed a genetic algorithm based solution to the problem.
Our aim is to introduce a constructive heuristic as an efficient method to solve this typical problem of facility location-allocation.

PROPOSED METHOD

The proposed constructive heuristic method is outlined as follows:

Step 1 The initial locations of the facilities are chosen randomly from the region under consideration.

Step 2 If the initial location lies in the barrier, shift the location to the nearest corner point of the barrier.

Step 3 Assign each of the users to the nearest facility found in Step 2. Some distances from the users to the facilities may not be direct because of the barriers. A computational technique needs to develop to check the nearest distance through the corner point of the barrier as the intermediate point.

Step 3 Improve the location using Weiszfeld's procedure (Cooper [8] and Gamal and Salhi [9]).

Step 4 Repeat Step 1 to Step 3 several times and record the best solution

NUMERICAL EXAMPLES

Consider the problem of finding the best locations for two facilities to serve 18 users with the present of two convex polygonal barriers as depicted in Figure 1.

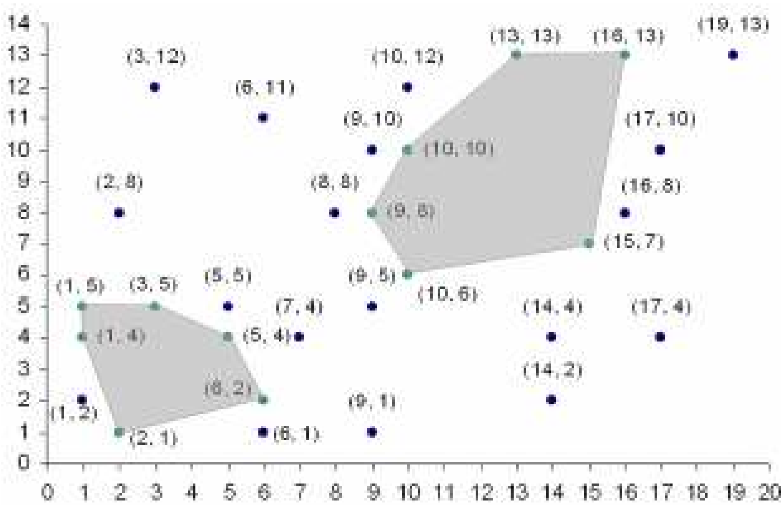

Figure 1 Locations of 18 users with two barriers

The best locations for the two facilities found using the proposed heuristic method may be seen in Figure 2; *i.e.* at points (6.48 , 6.61) and (16.09 , 7.63).

FUTURE WORK

We have put forward the outline of the constructive heuristic method to solve the multi-facility location problems in the presence of convex polygonal barriers. Also we will develop a genetic algorithm (GA) based method to cope with this type of location problem by adopting the GA method by Salhi and Gamal [10]. Algorithm developed will be tested on some benchmark problems and the results will compared with the ones found so far in the literatures.

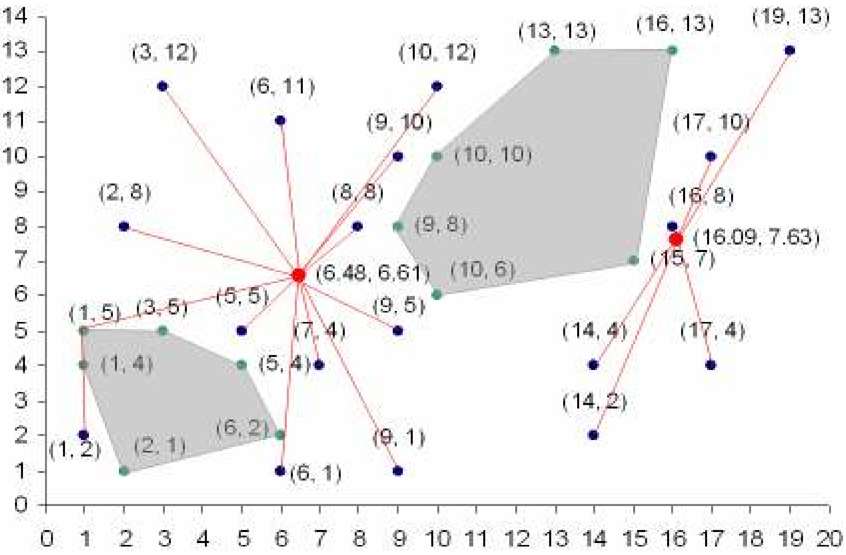

Figure 2 The best location for the two facilities to serve the 18 users

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