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مقاله نویسی علوم انسانی

Inverse of Backup 2-Median Problems with Variable Edge Lengths and Vertex Weight on Trees and Variable Coordinates on the Plane

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Abstract: In this paper we consider the inverse of backup 2-median problem. In this problem, a set of weighted points are given and we should change some parameters of the problem such as weights of vertices and edges and coordinates of points such that the two given points be the backup 2-median. We present mathematical models for inverse backup 2-median problems on graphs. In the case that the underlying network is a tree, linear models are presented for the problem with variable edges and weight of vertices. We also consider the continuous case of the problem with variable coordinates of vertices on the plane. In this case, we solve the model by PSO and a hybrid improved PSO methods. Computational results are compared for the varying amounts of parameters.

Keywords: Facility Location, Reverse Optimization, Backup 2-Median, Meta-Heuristic

Introduction: The inverse and backup location facility problems are two important branches of location theory that have been interested by many researchers in the recent decades. Let *n* weighted points be given in the plane or on a graph. The inverse median models investigate to change some parameters of problem such as coordinates, edge lengths and vertex weights such that the given facilities be the median points. For more information about inverse location problems see Burkard et al. (2004). On the other hand, in the backup median problems supposed that some facilities may failed. Therefore the other facilities should serve the clients. The backup 2-median problem on trees has been considered by Wang et al. (2009). Fathali (2014) investigated the backup multi-facility location problem on the plane.

In this paper we consider the combination of inverse location and backup facility location problems. We want to change coordinates, weight of vertices or length of edges with minimum cost such that the given facilities be backup median facilities.

Materials and Methods:

2. inverse Backup 2-Median On Trees: Let *T=(V,E)* be a tree with *n* vertices. Each vertex $v_i \in V$ has a nonnegative weight w_i. Let $d(u,v)$ be the distance between two points u and v, m_1 and m_2 be the two given vertices in *T* which are assumed the location of facilities. Each facility may fail with a probability ρ. For any vertex v_i, suppose that the cost of increasing and decreasing per unit of w_i is c_i^+ and c_i^-, respectively. Let p_i and q_i be the amounts by which the weight w_i is increased and

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decreased, respectively. Then, the model of inverse backup 2-median problem can be written as follows.

$$\min \sum_{i=1}^{n} (c_i^+ p_i + c_i^- q_i)$$

$$s.t.$$

$$(1-\rho)\sum_{i=1}^{n} \hat{w}_i d(v_i, \{m_1, m_2\}) + \rho \sum_{i=1}^{n} \hat{w}_i d(v_i, m_1) + \rho \sum_{i=1}^{n} \hat{w}_i d(v_i, m_2) \le (1-\rho)\sum_{i=1}^{n} \hat{w}_i d(v_i, \{u_j, u_k\}) + \rho \left(\sum_{i=1}^{n} \hat{w}_i d(v_i, u_j) + \sum_{i=1}^{n} \hat{w}_i d(v_i, u_k) \right); \forall u_j, u_k \in V$$

$$\hat{w}_i = w_i + p_i - q_i, i = 1, \ldots, n.$$

$$p_i, q_i \ge 0, i = 1, \ldots, n.$$

Using some properties of backup 2-median problem on trees, this model can be converted to a linear programming model.

3. Inverse Backup 2-Median on The Plane: In this section we consider the inverse backup 2-median on the plane. Let *n* points $X_1, \ldots, X_n$ be given in the plane. Let we have a limited budget B, to change the parameters. Then we want to modify the coordinate of given points such that the two points m_1 and m_2 be close to backup 2-median. With the same notation of inverse backup 2-median on trees, the model of inverse backup 2-median problem on the plane can be written as follow.

$$\Omega_1 :$$

$$\min (1-\rho)\sum_{i=1}^{n} \left(w_i \min_{t=1,2} \{ d(\hat{X}_i, m_t) \} \right) + \rho \sum_{i=1}^{n} \left(w_i d(\hat{X}_i, m_1) + d(\hat{X}_i, m_2) \right)$$

$$s.t.$$

$$\hat{X}_i = X_i + p_i - q_i, \quad i = 1, \ldots, n$$

$$\sum_{i=1}^{n} (c_i^+ p_i + c_i^- q_i) \le B,$$

$$p_i, q_i \ge 0, i = 1, \ldots, n$$

Results and Discussion: Two Particle Swarm Optimization (PSO) methods have been applied to solve the inverse backup 2-median problem on the plane. Table 1, shows the results with varying norms *p*, which obtained by running the two PSO methods on a problem with 80 points.

Table 1. The results of two PSO models for BR2MP with n=80, B=700 and $\rho = 0.5$

p	F_{pso}	F_{ipso}	$CPU - Time_{pso}(s)$	$CPU - Time_{ipso}(s)$
1	5.81E+03	5.64E+03	676.09	481.06
2	4.71E+03	4.65E+03	353.89	378.37
5	4.19E+03	3.75E+03	526.14	462.06
10	3.83E+03	3.39E+03	362.328	657.44

Conclusion: In this paper we investigated the backup 2-median problem with variable edge lengths and vertices weights on trees. The problem with variable coordinates on the plane is also considered. The models of mentioned problems and computational results which obtained by two PSO methods are presented.

References

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