GA APPROACH TO CONSTRUCT EMS IMPLEMENTATION MODEL FOR AMBULANCES REDEPLOYMENT PROBLEM

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ABSTRACT

This paper develops modified MEXCLP model, MEXCLP-DS, considering double standard coverage constraint and using Generic Algorithms (GAs) to solve ambulances redeployment problem. Finally, the result shows that GAs yields 95.59 % satisfactory solutions, that is, provide twenty-eight demand points sufficient coverage of emergency medical services in five minutes while locating only four facilities. However, we suggest clustering the six uncovered demand points into three groups and three more ambulances in each group to achieve 100% coverage, if the budget is sufficient.
Keywords: genetic algorithm, emergency medical service (EMS), location problem.

INTRODUCTION

The main objective of emergency medical services (EMS) is to save lives, but the potential of such systems to reduce mortality is related to paramedics training and the arriving time for a paramedic team to arrive on scene. EMS managers are faced with one main problem: redeployment problem. The redeployment problem consists of relocating available ambulance to the potential location sites when calls are received. Basically, the redeployment problem can be viewed as an ambulance location problem. Ambulances are assigned to potential sites to provided adequate coverage. Over the past three decades, several coverage models have been put forward for the ambulance location coverage problem [2] [5] [6][10][11]. The objectives of this research focus on developing modified MEXCLP model [5], considering double standard coverage constraint and use Generic Algorithms (GAs) to solve double standard coverage ambulance location problem with probabilistic situation.

FORMULATION OF PROPOSED MODEL: MEXCLP-DS

Maximize
$$\sum_{i=1}^{l}\sum_{j=1}^{m} d_j \left(1-p\right) p^{l-1} y_{ij} h \qquad (1)$$

Subject to
$$\sum_{i=1}^{l}\sum_{j=1}^{m} d_i y_{ij} h \geq \alpha \sum_{i=1}^{l}\sum_{j=1}^{m} d_j h \qquad (2)$$

$$\sum_{k=1}^{n} x_k \geq \sum_{i=1}^{l} y_{ij} \qquad (3)$$

$$\sum_{k=1}^{n} x_k \leq l \qquad (4)$$

$$x_k = \text{Integer} \qquad (5)$$

$$y_{ij} \in \{0,1\} \qquad (6)$$

$y_{ij} = 1$ if node j is covered by at least I facilities,

$y_{ij} = 0$ if node j is covered by less than I facilities.

Where i = the number of vehicles, j = the demand point, k = the number of potential facility sites, d_j = population at demand node, h = the probability of call occurred, l = total amount of vehicles, α = the proportion of the covered demand node, x_k = the number of vehicles placed in node k

The objective function (1) maximizes the expected number of demands that can be covered; constraint (2) ensures that a proportion α of the demand is covered. Constraint (3) computes the number of times node j is covered. Constraint (4) specifies the total amount of ambulance equals to p.

EXPERIMENT AND RESULT

We randomly select 36 demand points in Taipei administrative division and calculate population size in each demand point h*N. The probability of a call (h) is generated by applying uniform distribution within the range of 0~0.02. N denotes original population size.

Table1. Population size in each demand point

Demand point	Population size	Demand point	Population size	Demand point	Population size
1	265	13	31	25	312
2	37	14	518	26	182
3	369	15	391	27	32
4	2136	16	447	28	35
5	1057	17	112	29	183
6	1681	18	379	30	230
7	14	19	1434	31	12
8	350	20	1353	32	642
9	1289	21	1224	33	401
10	97	22	14	34	159
11	182	23	235		
12	95	24	1551		

We apply K-mean to find the number and the location of facilities. The demand point is said to be member of the cluster while the distance between the demand point and the center of the cluster is less than 5.3 km.

Table2. The number and the location of facilities

	Center of the cluster		Member of the cluster (demand point)
Cluster	x-axis	y-axis	
1	6.35	16.77	1,2,13,14,25,27
2	9.66	5.8	12,21,22,24,31
3	6.87	9.75	3,4,5,7,8,9,15,16,17,19,20,26,30,32
4	13.98	11.09	6,10,11,18,23,28,29,33,34

Schaffer et al. (1989) suggested that crossover rate could be 0.75~0.95 and mutation rate could be 0.005~0.01. Therefore, the parameters of GAs in our paper are as follows: crossover rate are 0.7, 0.8 and 0.9 separately; and Mutation rate are 0.004, 0.006, 0.008 and 0.01 separately. We use Evolver 4.0 to compute the result; each combination is executed 30 times, and the best combination occurs while crossover rate is 0.8 and mutation rate is 0.01, therefore, we choose this combination as our GAs setting and compute the result of our proposed model.

The result shows that 28 demand points, totally16679 population are covered by locating 4 facilities, and 6 demand points remain uncovered, 1, 2,12,13,29 and 34 respectively. The total number of population covered amounts to 95.59% and reach the standard of EMS. We suggest clustering uncovered demand points into three groups and locating facilities to achieve 100% coverage; 1, 2, 13 in a group, 29, 34 in a group, and 12 in a group.

Table3. The result of facilities location and population size covered

Facilities location	x-axis	y-axis	Demand points	Population size covered
1	8.491	13.956	3,5,14,16,25,27	2735
2	12.227	5.8	21,22,24,33	3190
3	6.314	9.415	4,7,8,9,15,17,19,20,26,30,31,32	8145
4	12.976	11.09	6,10,11,18,23,28	2609
Total amount of population covered				16679

CONCLUSIONS

Based on MEXCLP model and the idea of double standard in DSM model, we propose MEXCLP-DS model, which compute the best location of facilities in Taipei to supply sufficient coverage of emergency medical services. Follows are conclusions in this paper:

1. We can provide sufficient coverage of emergency medical services while locating only 4 facilities. Amounts of ambulance in each facilities are 8, 7, 17, and 8 respectively.
2. There are 6 points remain uncovered, we suggest clustering uncovered demand points into three groups and locating facilities to achieve 100% coverage, if the budget is sufficient; 1, 2, 13 in a group, 29, 34 in a group, and 12 in a group, or locating 3 more ambulances in each group.
3. We assume number of ambulances and probability of a call are known, we suggest acquiring real world data to computed correct probability of a call.
4. We suggest applying the least cost model to compute number of ambulances on each facility for further research.

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