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Research Article

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The optimization of emergency resource-mobilization based on harmony search algorithm

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ABSTRACT

This paper establishes an optimization model of emergency resource-mobilization based on the principle of the shortest time and minimum cost, which is an objective function. In order to calculate this optimization problem, harmony search algorithmic is used to solve the problem. Experimental results show our proposed method is effective and efficient for solving the multi-objective optimization problem.

Key words: harmony search; multi-objective optimization; emergency resources mobilization

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INTRODUCTION

Emergency resource-mobilization composes of many kinds of emergency resources and emergency units. And the distribution of various emergency units is independent and irregular. Emergency resources of all emergency units are limited. The distance between emergency units and point is different. Therefore, speed and cost of resource-mobilization affect the schemes directly.

At present, research on resource scheduling is mostly limited to the constraints of scheduling model and route choice, and for large scale problems, there is less solving algorithm of many cases. In case of emergency points less, exhaustive method can generally obtain the optimal solution of the problem. However, when more emergency resources participate, exhaustive method solves this kind of problems hopeless. So we employ the heuristic optimization algorithm to solve this problem.

Harmony search algorithm [8] is a new heuristic search algorithm and has successfully been applied to the structure optimization design, traffic path planning and the slope stability analysis, etc. Research shows that the algorithm in discrete optimization problems is better than the ant colony algorithm, genetic algorithm performance. The experimental results show that harmony search algorithm has better performance in solving such problems.

ESTABLISH THE OBJECTIVE FUNCTION

Let $S_1, S_2, \ldots$, and S_n are alternative resource supply point, x_{ij} is the jth($j = 1, 2, \ldots, m$) effective rescue resources of S_i. (i= 1, 2, …, n).

Assuming that, in a mobilization of resources, the demand value of jth is a_j, and $\sum_{i=1}^{n} x_{ij} \geq a_j$, From the n available resources to provide emergency resources in selected j p_i (p_i<= n) resource points involved in raising, And meet the "raise the shortest time" and "to raise the cost of at least" two goals.

If the time from raise resources point S_i to place A is t_i ($t_i > 0$), and $t_1 < t_2 < < t_n$. According to "raise the shortest time", then can establish the objective function is:

$$f_1^{'} = \min T(x) = \max_{i=1,2,\ldots,\ n}(t_i)$$

If we consider the cost of raising resources, namely, raise the need another key objective conditions: rescue resources to raise the minimum cost. From the resources point set S_i to raise emergency resource j to reach the unit cost of the rally point A required for c_{ij}, the lowest cost j kind of rescue resources spent at the:

$$C_j = \sum_{n=1}^{n} c_{ij} y_{ij}$$

"The objective function is to meet the minimum fee" for the:

$$f_2^{'} = MIN(C_j) = MIN \sum_{n=1}^{n} c_{ij} y_{ij}$$

In the solving process, according to "raise the minimum cost" of this goal, can be converted to "raise the minimum" problem, in order to meet the various emergency resource mobilization of resources, making out at least some.

HARMONY SEARCH ALGORITHM

Harmony search (Harmony Search, HS [8-12]) algorithm is a new intelligent algorithm in 2001 of a South Korean scholar Geem Z proposed by W et al. The three main parameters of the algorithm, namely the harmony memory considering probability HMCR (Harmony memory considering rate), PAR (Pitch adjusting rate trimming probability), the pitch adjusting bandwidth BW (band width) .The basic steps of harmony search algorithm is as follows:

Step1: Setting of parameters

① The number of variables : N;
② Range of each variable;
③ Maximum iterations: Tmax;
④ Size of harmony memory : HMS;
⑤ Harmony memory consideration rate: HMCR;
⑥ Pitch adjusting rate: PAR;
⑦ Bandwidth: bw.

Step2: Initializing the harmony memory (HM) randomly, the HM is as follows,

$$HM = \left[\begin{array}{c|c} x^1 & f(x^1) \\ x^2 & f(x^2) \\ \vdots & \vdots \\ x^{HMS} & f(x^{HMS}) \end{array}\right] = \left[\begin{array}{cccc|c} x_1^1 & x_2^1 & \cdots & x_N^1 & f(x^1) \\ x_1^2 & x_2^2 & \cdots & x_N^2 & f(x^2) \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ x_1^{HMS} & x_2^{HMS} & \cdots & x_N^{HMS} & f(x^{HMS}) \end{array}\right]$$

Step 3: improvising the new Harmony.

The generation of new harmony, $x^{'} = (x_1^{'}, x_2^{'}, \cdots, x_N^{'})$,the new harmony $x_i^{'}$ （i=1,2,…,N） can create through the following three kinds of mechanism: ①The learning and memory; ②the tone tuning;③the random selection of tone.

That is:

$$x_i^{'} = \begin{cases} x_i^{'} \in (x_i^1, x_i^2, \cdots x_i^{HMS}) & \text{If } rand\text{<HMCR} \\ x_i^{'} \in X_i, otherwise; & \end{cases} \quad \text{i=1,2,}\cdots\text{,N}$$

Where X_i denotes the value of the ith variable, rand represents a random uniform distribution on [0,1], For from the harmony database and $x_i^{'}$ tone tuning to the probability of PAR, i.e.:

$$x_i^{'} = \begin{cases} x_i^{'} + rand1 * bw & \text{If } rand1\text{<PAR (Continuous type)} \\ x_i(k+m), m \in \{-1,1\} & \text{If } rand1\text{<PAR (Discrete type)} \\ x_i^{'}, otherwise; & \end{cases} \qquad i=1,2,\cdots,N$$

Where in *rand*1 represents a random uniform distribution on [0, 1], PAR as the pitch adjust probability, BW is tone tuning bandwidth.

Step 4: *Update* memory
Evaluation of the new generation of harmony, if new harmony is better than the worst in the harmony memory harmony, harmony will be updated to the new harmony memory. For example, to find the optimal path, i.e.:
If $f(x^{'}) < f(x^{worst}) = \max_{j=1,2,\cdots,HMS} f(x^{j}),$ then $x^{worst} = x^{'}$

Step 5: if the termination condition is reached, output the optimal solution. Otherwise, go to Step 3.

EXPERIMENTAL SECTION

EXPERIMENTAL SIMULATION
Problem description
Assume that d_1 (=21), d2 (=29), d_3 (=36) are three essential resources in the rescue process, there are 8 resources rescue point (S_1, S_2… S_8). The per cost that j*th* rescue resources is transport to the accident point A is C_{i1}. All cost of resource rescue point is shown in table 1; Reserves of *j*th resources rescue point for the x_{ij}, is shown in Table 2. The shortest time t_i of arriving accident location from resources rescue point is shown in table 3.

Table 1 the cost from resources rescue point to the location of the accident

C_{ij} \ S_i	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
C_{i1}	5	11	8	13	20	29	15	16
C_{i2}	5	10	5	10	17	20	10	8
C_{i3}	4	8	6	10	11	22	15	13

Table 2 the resource reserve scale of resources rescue point

x_{ij} \ S_i	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
x_{1j}	4	2	5	4	2	2	10	11
x_{2j}	6	3	2	6	10	8	4	11
x_3	7	5	7	10	9	6	4	0

Table 3 the shortest time that arrive accident location from resources rescue point

t_i \ S_i	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
t_i	2	4	4	8	26	28	12	18

Solving the problem by HS algorithm
According to table 1, table 2, and table 3, multi target applications to set up to raise model, we employ HS algorithm to solve the emergency resource-mobilization. The HS algorithm is initially applied to solve continuous optimization problems, in solving combinatorial optimization problems, and is used to generate a new post. There may be illegal solutions, resulting in HS algorithm cannot be used, therefore, the application of HS algorithm in combination optimization problems, must realize its discretization.

In the solution process, the key parameters: the probability HMCR=0.8, pitch adjusting probability PAR=0.2, number of maximum iterations MAXITER=1000, tone tuning bandwidth of BW=0.1, and the memory size of HMS=5, solving process as shown in figure 1:

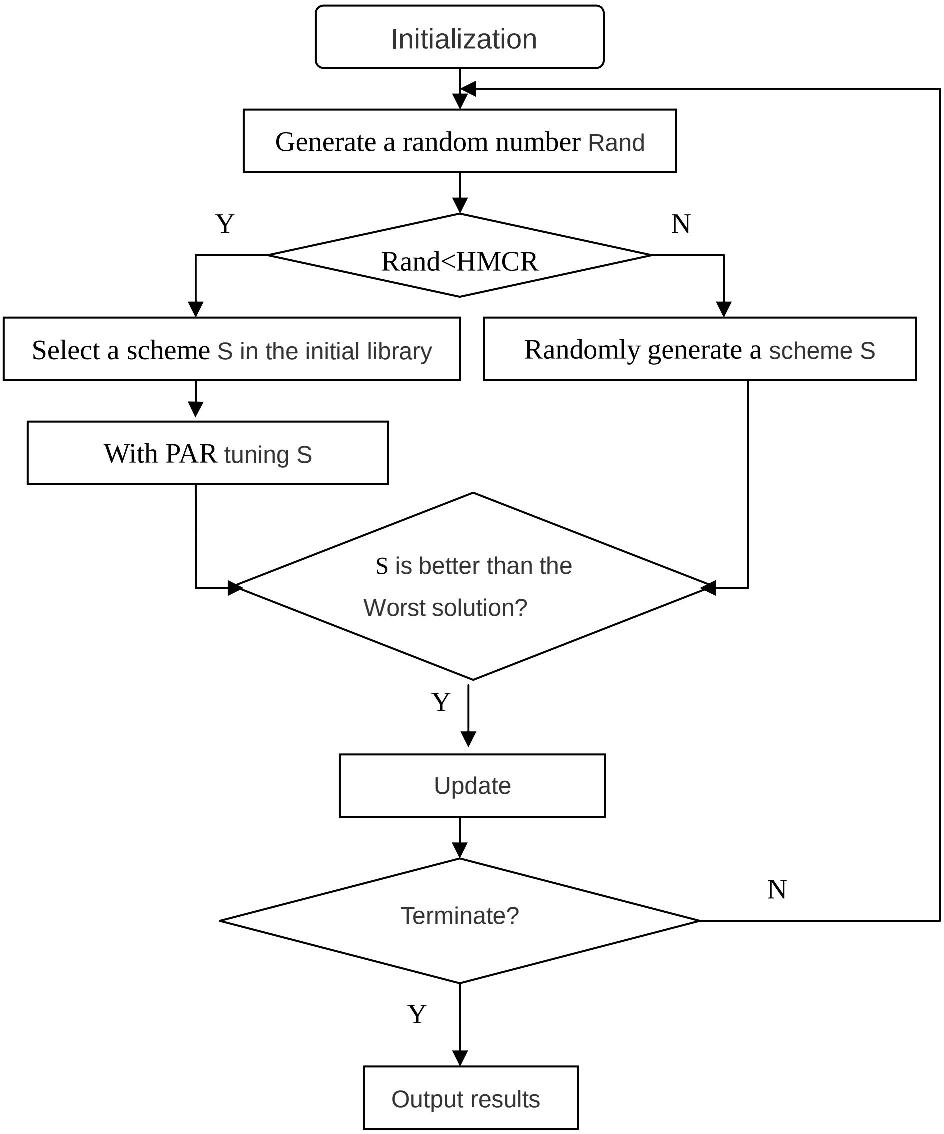

Fig.1 flow char of harmony search algorithm

The results is obtained by using the MATLAB 7 programming algorithm to solve the problems mentioned above, the experimental results are as follows:

Table 4 resource mobilization scheme

C_{i1} / x_i/C_{i1}	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
x_1/C_{i1}	4/5	2/11	5/8	4/13	0/0	0/0	6/15	0/0
x_2/C_{i2}	6/5	0/0	2/5	6/10	0/0	0/0	4/10	11/8
x_3/C_{i3}	7/4	5/8	7/6	10/10	7/11	0/0	0/0	0/0

According to the following table raising scheme, three kinds of resources can be obtained by raising scheme, it as follows,

The scheme for resource d_1: {(S1, 4), (S2, 2), (S3, 5), (S4, 4), (S7, 6)};

The scheme for resource d_2: {(S1, 6), (S3, 2), (S4, 6), (S7, 4), (S8, 11)};

The scheme for resource d_3: {(S1, 7), (S2, 5), (S3, 7), (S4, 10), (S5, 7)}.

The shortest response time t_1 of resource d_1 is MAX (t) =12 (unit time); the lowest cost of d_1 is

4×5+2 ×11+5×8+4 ×13+6×15=224 (unit cost);

The shortest time of resource d_2 is 18 (unit time), the lowest cost of d_2 is 228 (unit cost).

The shortest time of resource d_3 is 26(unit time), the lowest cost of d_3 is 287 (unit cost).

Therefore, in the rescue process, the earliest start time of the emergency rescue should be the maximum response time of three resources, it is 26 (unit time).

CONCLUSION

This paper adopts the harmony search algorithm to solve the problem of emergency resources. The experimental results show that the harmony search algorithm has advantages of fast convergence speed, which is simple and intuitive, less parameters, easy to implement. The method is effective and feasible to solve emergency resources mobilization.

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