Spider network search strategy for p-location problems

Marek Kvet[1] and Jaroslav Janáček[1]

[1]University of Žilina, Faculty of Management Science and Informatics
Univerzitná 8215/1, 010 26 Žilina, Slovakia

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Introduction

In this paper, we introduce a new strategy of heuristic solving method for the generalized min-sum *p*-location problem for EMS designing. The suggested method is based on the path-relinking approach and it makes use of a uniformly deployed set of the problem solutions. The set of solutions represents fixed points of a spider's network. The center of the network is determined by subsequent inspection of the shortest path connecting the current best-found solution and one of the fixed points. The inner nodes of the spider's network are obtained by inspections of paths, which connect neighboring fixed points. When series of the inner network nodes is finished, the connections of the general best-found solution and the inner nodes are inspected to improve the general best-found solution. Then a new series of inner nodes is created by inspecting the links between the neighboring current inner nodes. The process continues until some termination rule is met.

Spider network search strategy

0. Initialize the starting population (the set of fixed network points) by a uniformly deployed set $S=\{\boldsymbol{y}^0, \ldots, \boldsymbol{y}^{|S|-1}\}$ and order the solutions increasingly according to their objective function values into the sequence $\boldsymbol{y}^{u(0)}, \ldots, \boldsymbol{y}^{u(|S|-1)}$. Determine the best-found solution $\boldsymbol{y}^c = \boldsymbol{y}^{u(0)}$.

1. Process the population $\boldsymbol{y}^{u(0)}, \ldots, \boldsymbol{y}^{u(|S|-1)}$ and network center $\boldsymbol{y}^c$ in the following way: Update the network center by $\boldsymbol{y}^c = \text{argmin}\{f(BestSol(\boldsymbol{y}^c, \boldsymbol{y}^{u(i)})): i=1, \ldots, |S|-1\}$ and insert $\boldsymbol{y}^c$ into the new population. Then, perform subsequently for $i=1, \ldots, |S|-1$ $\boldsymbol{y}^* = BestSol(\boldsymbol{y}^{u(i)}, \boldsymbol{y}^{u(i-1)})$ and insert $\boldsymbol{y}^*$ into the new population, if there is no identical solution. Finally perform $\boldsymbol{y}^* = BestSol(\boldsymbol{y}^{u(0)}, \boldsymbol{y}^{u(|S|-1)})$ and add $\boldsymbol{y}^*$ to the new population, if there is no identical solution.

2. If the termination rule is met, then terminate and return the best-found solution as the output of the algorithm. Otherwise reorder new population, determine the new network center $\boldsymbol{y}^c$ and go to step 1.

Results

Region	*m*	*p*	|*S*|	*h*	*Val*	*CT* [s]
BA	87	14	23	24	26649	0.12
BB	515	36	172	66	44751	119.38
KE	460	32	60	60	45587	24.82
NR	350	27	83	50	48940	16.76
PO	664	32	232	60	56703	123.52
TN	276	21	137	38	35274	10.21
TT	249	18	212	32	41338	10.29
ZA	315	29	112	52	42110	20.66

Pop:	7		6		5		4	
Reg.	*gap*	*CT*	*gap*	*CT*	*gap*	*CT*	*gap*	*CT*
BA	0.0	0.13	0.0	0.14	0.0	0.11	0.0	0.11
BB	0.0	112.75	0.0	111.47	0.0	113.87	0.0	101.85
KE	0.0	23.76	0.0	23.36	0.0	22.26	0.0	20.63
NR	0.0	16.55	0.0	19.13	0.0	15.43	0.0	14.46
PO	0.0	126.31	0.0	125.04	0.0	126.05	0.0	122.55
TN	0.0	10.34	0.0	9.69	0.0	11.85	0.0	9.01
TT	0.0	11.49	0.0	10.18	0.0	9.97	0.0	8.89
ZA	0.0	20.77	0.0	21.98	0.0	25.28	0.0	18.40

Results

mts:	105		90		75		60	
Reg.	*gap*	*CT*	*gap*	*CT*	*gap*	*CT*	*gap*	*CT*
BA	0.0	0.13	0.0	0.13	0.0	0.13	0.0	0.12
BB	0.0	109.54	0.0	102.08	0.0	91.91	0.0	69.38
KE	0.0	24.11	0.0	24.43	0.0	24.36	0.0	24.84
NR	0.0	16.50	0.0	16.37	0.0	16.89	0.0	17.52
PO	0.0	120.30	0.0	91.58	3.6	87.73	0.0	90.16
TN	0.0	10.51	0.0	10.53	0.0	9.92	0.0	10.41
TT	0.0	9.81	0.0	11.32	0.0	9.78	0.0	11.84
ZA	0.0	20.33	0.0	20.10	0.0	20.41	0.0	20.37

mts:	45		30		15	
Reg.	*gap*	*CT*	*gap*	*CT*	*gap*	*CT*
BA	0.0	0.13	0.0	0.14	0.0	0.12
BB	0.0	63.69	0.0	36.09	0.0	34.78
KE	0.0	25.52	0.0	25.27	0.0	17.60
NR	0.0	16.83	0.0	17.69	0.0	15.19
PO	0.0	51.02	0.0	48.03	0.0	49.01
TN	0.0	10.05	0.0	10.01	0.0	11.22
TT	0.0	10.42	0.0	10.17	0.0	13.91
ZA	0.0	20.76	0.0	20.38	0.0	17.73

Conclusion

Effective performance of the emergency medical service plays a very important role in human life. Thus, searching for the optimal service center deployment requires different advanced approaches and operations research knowledge. This paper was focused on a heuristic approach to emergency medical service system designing, in which the spider network search strategy for p-location problems was applied. Performed numerical experiments have proved that this algorithm represents a suitable tool for middle-sized and large instances. By the study of the results quality measured by the value of gap from the optimal solution, we have found, that the suggested strategy finds the optimal solution in most cases. In addition, sensitivity of suggested approach on the values of two parameters was studied. Based on the results we can conclude, that we have introduced a very useful tool for emergency medical service system design problem.