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Determining Site Location to Find Shortest Path Based on Multi-objective Decision Model

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ABSTRACT

This paper studies the problem of site selection and tour route, establishes multi-objective decision model and optimizes the line model, uses the Floyd algorithm and uses MATLAB and lingo to program to provide the optimal scheme of site selection and tour route respectively. A single-target optimization model was established, a minimum value function was established for the total distance after weighting, the shortest path length of any two communities was calculated using the Floyd algorithm, and the site of the water and electricity payment was obtained to facilitate residents to pay the utility bill. By establishing the constraint optimization line model, the shortest path of any two residential areas is obtained by The Floyd algorithm, establish the shortest path spanning tree whose root is residential area no.6, and the regions are divided, then optimal tour is obtained.

Keywords: Floyd algorithm; Shortest path; Decision model; Minimum spanning tree

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1. Introduction

The problem of site selection is one of the classic problems in operational research. The research on site selection is very extensive, from cities, industrial belts, economic and technological development zones, branches of transnational economic groups to airports, water conservancy facilities, human settlements, sales outlets and warehouses, distribution centers and other location decision-making are the scope of site selection research, involving economic, political, social, management, psychological and engineering geology and other disciplines. Site sekection is one of the most important long-term decisions, the location of the good or bad directly affect the service mode, service quality, service efficiency, service cost, and so on, thus affecting the profit and market competitiveness, and even determine the fate of enterprises. Good site selection will bring convenience to people's lives, reduce costs, expand profits and market share, improve service efficiency and competitiveness, poor site selection will often bring great inconvenience and loss, and even disaster. Therefore, the study of site selection has great economic, social and military significance.

Use the following example for analysis.1. There are 52 residential areas in a county and city, and the population (units: thousands) of each county are shown in the following table:

Table 1: Population of each area of residence

Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Population	10	12	18	6	10	15	4	8	7	11	13	11	16
Number	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Population	11	8	9	22	14	8	7	10	15	28	18	13	12
Number	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
Population	23	29	13	15	16	27	6	3	4	8	9	13	12
Number	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**
Population	13	15	8	15	8	5	11	16	15	13	6	9	7

The location question is raised: the county government is now proposed to build six hydropower inquiries, payment points, ask edging water and electricity inquiries, payment points how to build, where to build in order to facilitate residents to pay inquiries for water and electricity.

The issue of patrol routes was raised: Is now ready to set up a number of police stations in this county, for each police station allocation area, so that accidents occur in any place, the police can arrive within 3 minutes of the incident, ask how to plan out the police point is reasonable, please give specific location and number of police points. (Police cars are travelling at 60km/h)

The question of tour route is raised: the residential area 6 is the place where the person in charge lives, and now the person in charge starts from the residential area 6, is divided into three teams to patrol all the areas, ask how to plan in order to maximize efficiency.

2. Model assumptions

(1) The distance between the residents of each settlement is the shortest distance between the residential areas.

(2) In the same police station there is a police force that can be sent out to all residential areas of the district at the same time, there is no scheduling problem.

(3) The police station departs immediately after receiving the warning message, ensuring that all 3 minutes are spent on the road and that there is no response time.

(4) There will be no other circumstances on the way out of the police to affect the arrival time of the police.

3. Symbol description

Symbol	Name
I	A collection of utility stations or out-of-the-spot points
J	A collection of residential areas
k_j	The population of aresidential area j
l_{ij}	The shortest distance from residential area i to residential area j
u_j	Number of times the residential area j was over-covered
x_i	(0-1) variable, take 1 when building site in area i, take 0 when not built
y_{ij}	(0-1) i variable, site covering residential area j when take 1, not cover 0

4. The problem analysis

4.1 Analysis of site selection issues

This question, after giving the number of utilities to be arranged, requires this article to give the arrangement of the shortest walking distance for the total residents. Therefore, when considering the issue, this paper needs to consider the impact of the number of residents in each residential area on the overall water and electricity point arrangement, that is, the population needs to be weighted.

Since the same neighbourhood may be covered twice, it is important to give due consideration to similar situations so that this coincident rate is minimized and the resource utilization is higher.

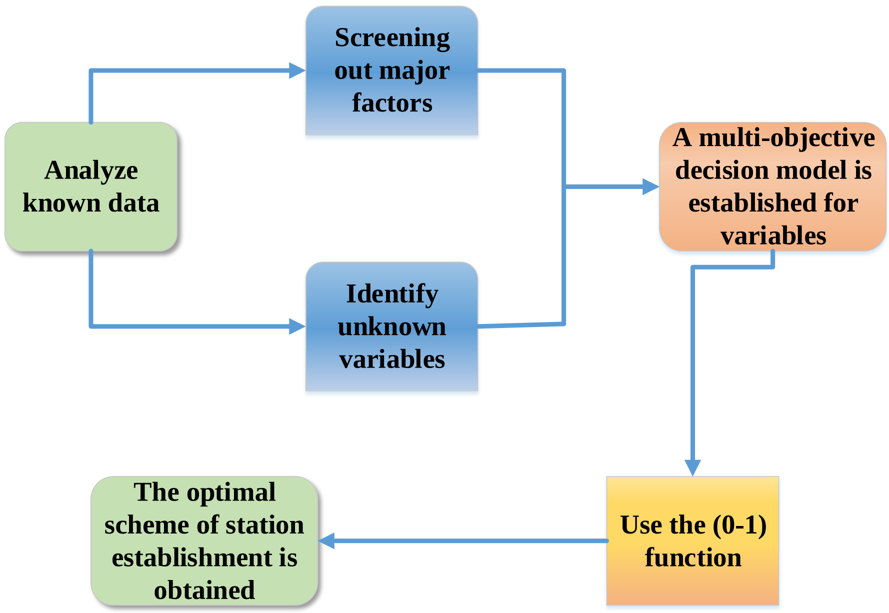

Fig.1: Flowchart of Site Selection Issues

4.2 Analysis of tour issues

This question does not give the number of police points that need to be laid out, but gives a range of police points can be covered, that is, 30 000 meters, for which this article can analyze the direct distance relationship between the various residential areas, initially determine which police points may be near several residential areas. In order to improve the utilization of resources The limitation conditions of this article should limit a residential area to be covered by only one out of the police station, and then according to other conditions first to find out the minimum number of police points, and then according to this number to push back to get the minimum number of deployment location of the warning point, that is, the program required by this question.

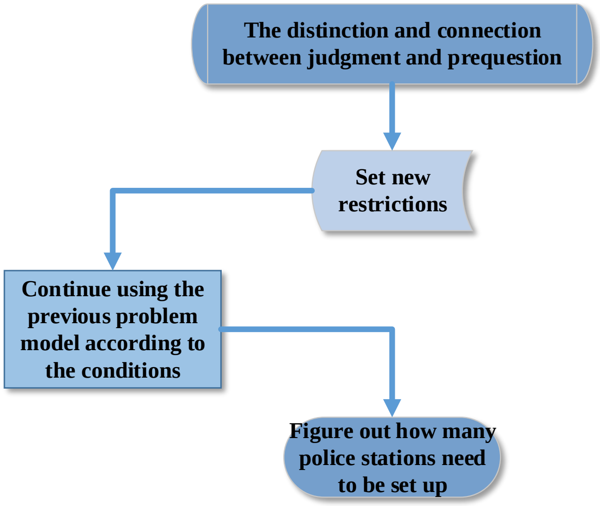

Fig.2: Flowchart for TourIng Route Issues

4.3 Analysis of tour route issues

This question is to solve is a problem of maximizing efficiency, the point to consider is mainly to make each group of leaders walking path of the largest number of total patrol, the total patrol path of the three groups of leaders will be relatively small. This question can be translated into a salesman's question, and use the idea of Euler's tour to consider this question for this article, you can use the optimal line model

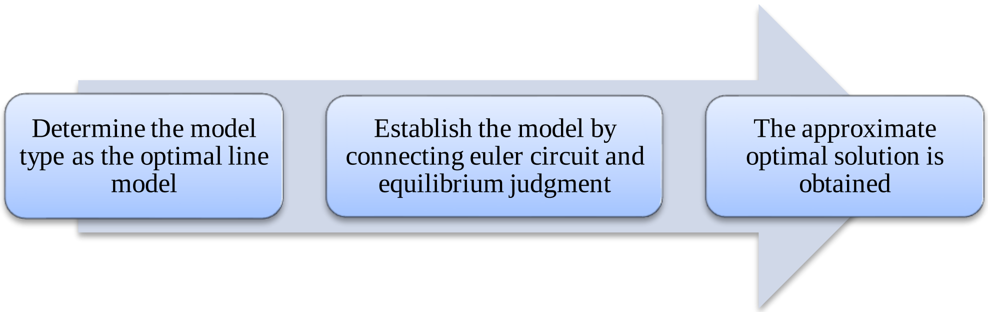

Fig.3: Flowchart for TourIng Route Issues

5. Data analysis

Find the shortest path:

The location problem and the issue of patrol routes need to calculate the distance matrix D between the two communities, record the corresponding shortest path, so that partition as a reference condition. The shortest path algorithm is mainly implemented by the improved floyd-warshall algorithm, and finally obtains D the distance matrix and corresponding shortest path between any two cities. The specific principles of the algorithm are as follows:

(1) Construct an adjacent matrix L using inter-community road information.

If there is no directly connected road between the city i and j, than the element of (i, j) is positive infinity.

$$L = \begin{Bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{Bmatrix}$$

Inter-community road information can be seen n is 52,according to theinter-community road information table can be derived from L the adjacent matrix as .

(2) Obtain the distance matrix D between the two communities. The (i, j) elements of D, R, are respectively represented as D_{ij}, R_{ij} $(i=1,2,...52; j=1,2,....52)$, for all the cities I, j and k, $D_{ij}=D_{ik}+D_{kj}$, $R_{ij}=k$ (Means that the distance from city i to city j is through city k. if means that the two cities can reach directly). Through MATLAB and lingo software programming calculation matrix D and R. The flowchart is as follows:

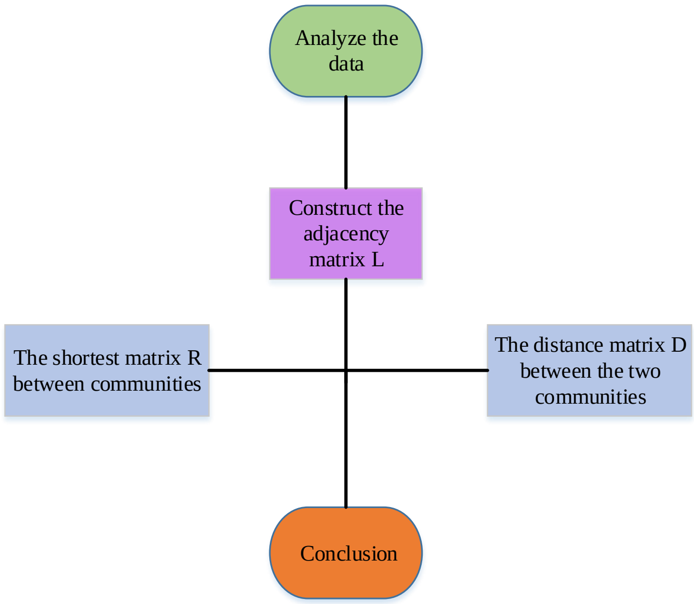

Fig.4: Flowchart of the algorithm

5.1 Data analysis of site selection issues

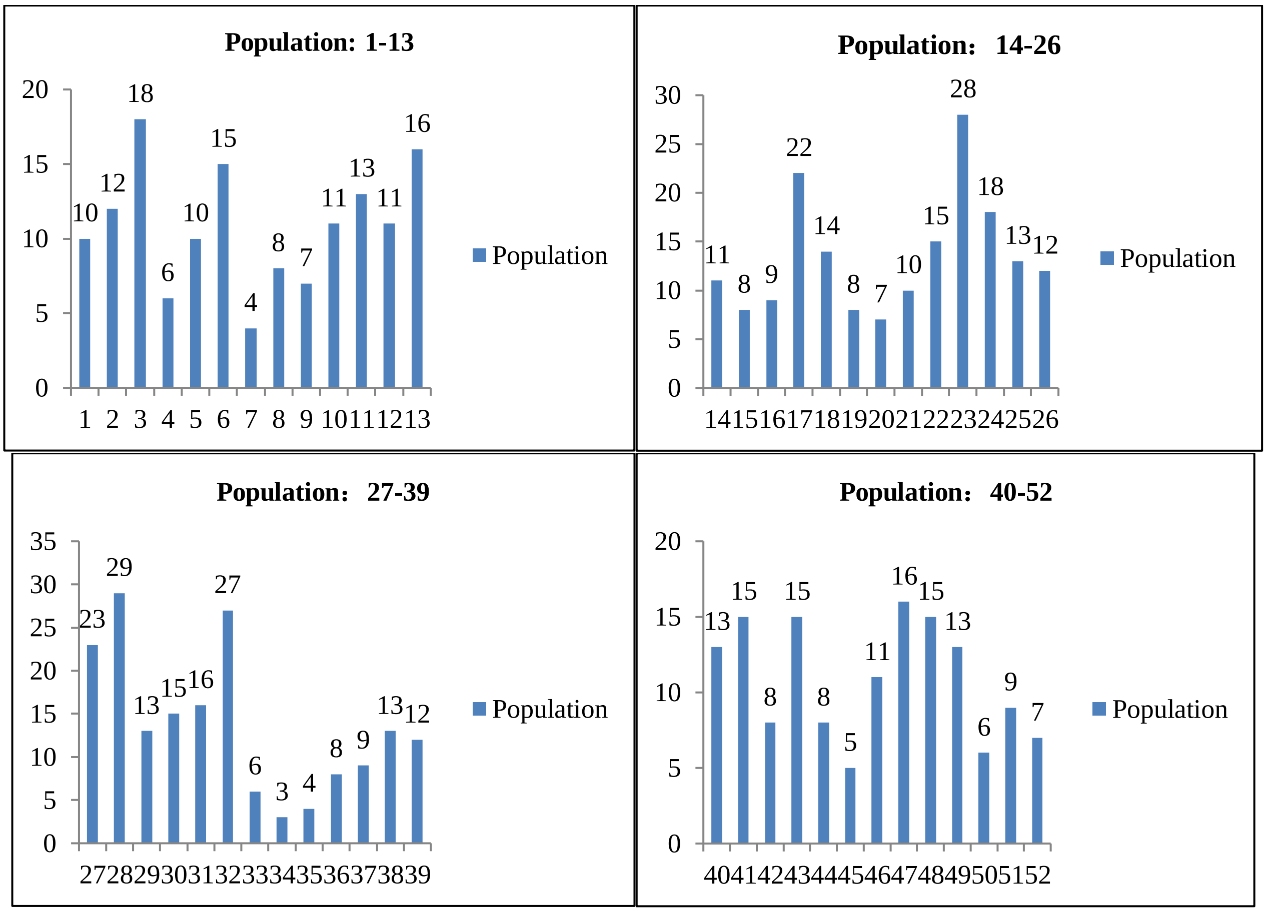

Fig.5:A comparative chart of the population of each region

According to the population map can be seen 3,6,17,23,28 , 32 and other communities have a relatively large population, when considering the construction of hydropower inquiries, pay- ment points station should make these areas to hydropower inquiries, payment points. The dis- tance of the station is relatively short, so the selected hydropower inquiry, the address of the payment point station will be more reasonable.

5.2 Data analysis of tour ingresss issues

Police cars were required to arrive at the scene of the incident in three minutes. Based on the driving speedof the police car 60km/h, it is concluded thatthe maximum distance between the police station station and the point in the corresponding area should be less than d = 3 x60/60km x 30(100 m). That is, the maximum driving distance for a police car is 30 hundred metres.

5.3 Data analysis of tour ingresss issues

(1) Definition: a graph g is a binary group (V(G), E(G)), in which the elements are called the vertices of graph G.

(2) Gives a method ofseeking the minimum tree generation (breaking the ring method):

Set G a connectivity graph of n nodes, the smallest spanning tree produced by the algori- thm below.

The basic idea of the algorithm: After placing the edges of Figure G in decreasing order of power, examine each edge in turn, and, while remaining connected, delete the maximum weight edge each time until the remaining n-1 edges.

(3) Definition of equilibrium (i the smaller the description of the better the equilibrium of the grouping).

(4) This article treats 52 communities as 52 vertices, with the distance being weighted, creating an adjoining matrix, and the shortest distance to w. The tree with w as its root is drawn as follows:

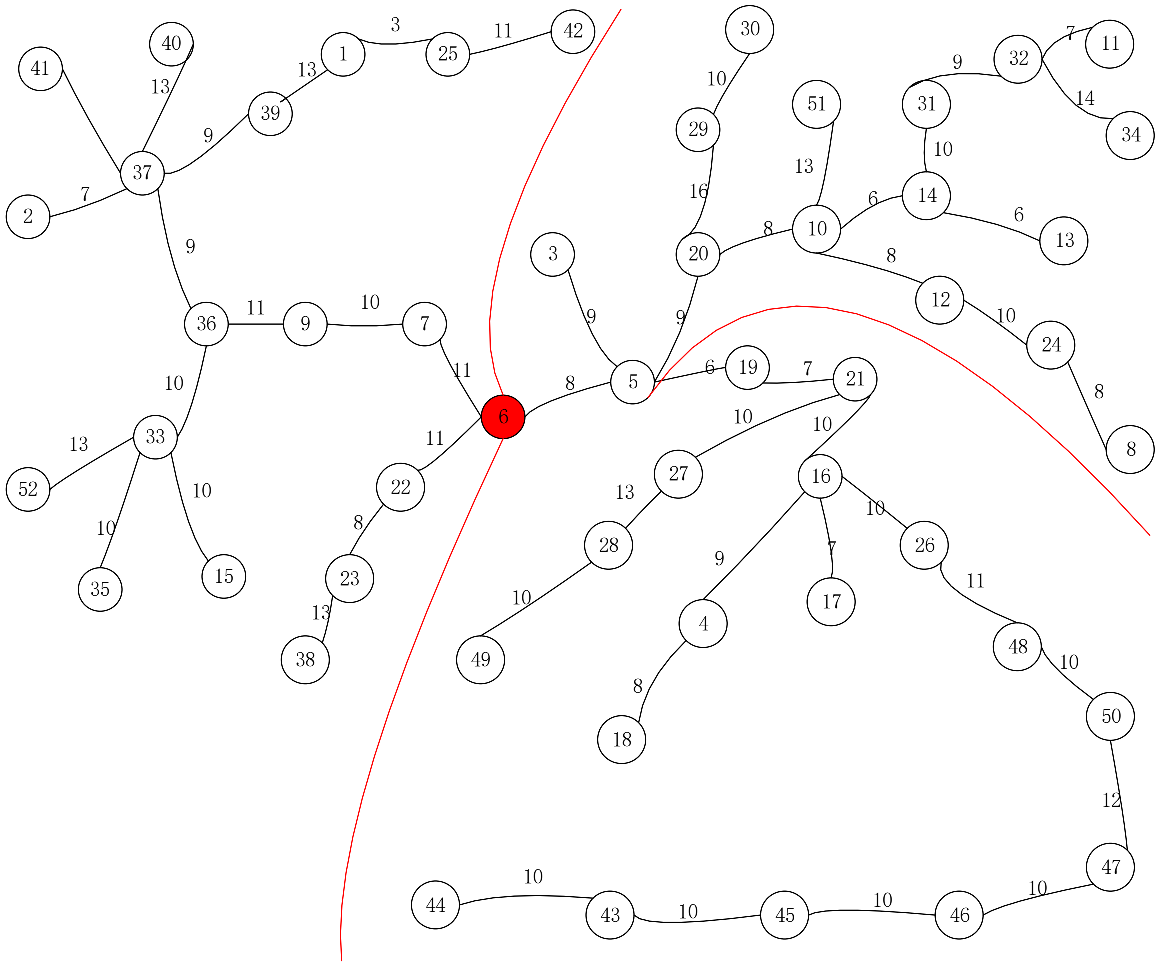

Fig.6：Roots of a tree diagram

6. The establishment and solution of site selection problems

6.1 Location issues The creation of the model

6.1.1 Determining the target function

The question requires a as convenient as possible hydropower inquiry, payment point sits set up program, and the number has been determined to build 6, so the requirement is 52 residential areas to their nearest site distance and the minimum. So the target function is the total distance of all residents to the nearest utility site. S

$$S = \sum_{i=1}^{52}\sum_{j=1}^{52} k_j l_{ij} y_{ij}$$

6.1.2 Determining constraints

(1) Since all utility stations add up to six, there are $\sum_{i=1}^{52} x_i = 6$

(2) i Only if a utility station is established in j the residential area, the residential area can be covered, that is,

$$y_{ij} - x_i \le 0$$

(3) j The total number of times the residential area is covered by i the residential area utility site minus the number of times the excess coverage shall be greater than or equal to 1, that is,

$$\sum_{i=1}^{52} y_{ij} - u_j \ge 1$$

6.1.3 Determine the definition of the 0-1 function

$$y_{ij} = \begin{cases} 1 & \text{Utility station i covers residential area j} \\ 0 & \text{Utility station i dose not covers residential area j} \end{cases}$$

$$x_i = \begin{cases} 1 & \text{Establish a utility station in residential area i} \\ 0 & \text{Do not set up utility stations in residential area i} \end{cases}$$

In summary, a single-target optimization model with site selection problems is obtained:

$$\min s = \sum_{i=1}^{52}\sum_{j=1}^{52} k_i l_{ij} y_{ij}$$

$$s.t. \begin{cases} \sum_{i=1}^{52} x_i = 6 \\ y_{ij} - x_i <= 0 \\ \sum_{i=1}^{52} y_{ij} - u_j >= 1 \\ y_{ij} = \begin{cases} 1 & \text{Utility station i covers residential area j} \\ 0 & \text{Utility station i dose not covers residential area j} \end{cases} \\ x_i = \begin{cases} 1 & \text{Establish a utility station in residential area i} \\ 0 & \text{Do not set up utility stations in residential area i} \end{cases} \end{cases}$$

6.2 Location ProblemS Solution model

Programming through THE MATLAB software, the six utility stations should be built in 6,14, 25,26,28,37 zones.

Table 2 : Distances from1-13 regions to six utility stations

Area	1	2	3	4	5	6	7	8	9	10	11	12	13
6	35	33	17	28	8	0	11	19	21	18	30	10	22
14	56	57	32	43	23	24	35	21	45	6	18	14	6
25	3	26	27	23	36	38	42	57	45	53	68	48	60
26	42	65	30	19	26	34	45	53	55	36	60	44	48
28	56	64	32	42	23	31	42	48	52	22	46	30	34
37	22	7	44	48	48	40	30	48	20	58	52	50	62
Area	40	41	42	43	44	45	46	47	48	49	50	51	52
6	53	52	48	51	51	53	53	49	44	37	47	31	46
14	77	73	69	66	72	61	61	57	52	34	55	14	63
25	35	20	11	14	13	24	34	44	50	65	52	66	48
26	74	59	50	37	47	27	25	15	11	38	13	49	80
28	84	73	69	65	72	55	53	43	26	10	36	35	77
37	13	14	35	39	38	49	59	69	75	77	77	71	23

6.3 Results Analysis of Site Selection Issues

Table 3: Regions to The Nearest Region stake in the payment point

Area	Closest area	Total area	Population (thousands)
6	3,5,6,7,8,12,19,22,23,24	10	135
14	10,11,13,14,20,29,30,31,32,34,51	11	141
25	1,18,25，38,42,43,44,45,	8	86
26	4,16,17,21,26,46,47,48,50	9	107
28	27,28,49	3	65
37	2,9,15,33,35,36,37,39,40,41,52	11	101

As can be seen from the table above, the other five community-covered residential areas, with the exception of the 28-zone payment points, have been relatively low, proving that the feasibility of the scheme is relatively high. There would be a slight gap in terms of the actual coverage of the population, but overall the gap is not too large and is within acceptable limits.

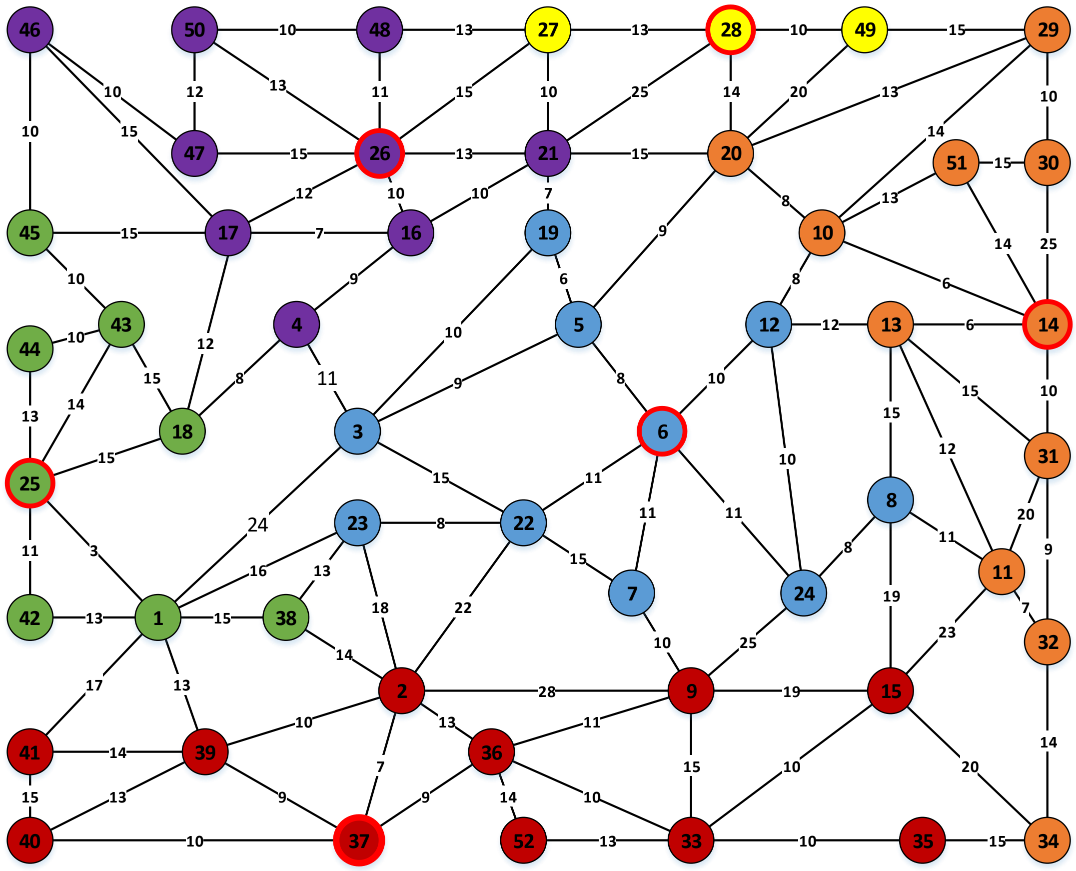

Fig.7：Area nearest distribution map

From the figure above, it is clear that for the establishment of a utility station in 6 areas, it is basically according to the length of the line and number of lines connected in some residential areas to divide the entire area map into several pieces, such an arrangement can make the average distance to the minimum, to meet most of the requirements given by the problem.

7. The establishment and solution of the tour route problem

7.1 Tour ingress issues

Since the question is to determine the location and number of the alarm points, and the position is related to the number of values, so this question needs to get the smallest number of alarm points, that is, to establish the number of alarm points and other variables of the relationship

7.1.1 The establishment of the tour ingress model one

Determining the target function

Through the driving speed of the police car given by the stem, this article can be said that in the absence of other factors, to meet the requirements of the question of the furthest police distance of 3000 meters. According to this condition This article this paper can set up a function to find the smallest number of warning points set up, that is:

$$\min y = \sum_{i=1}^{52} x_i$$

Determining constraints

(1) In order not to waste resources, it is necessary to determine that each residential area is covered by only one warning point, i.e.:

$$\sum_{i=1}^{52} y_{ij} = 1$$

(2) The shortest distance from the warning point i to the residential area j should be less than or equal to 3000 meters, i.e. :

$$l_{ij}y_{ij} \le 30$$

(3) Only if a police station is set up in a residential area i, it is possible to make the police station cover j the residential area, that is:

$$y_{ij} - x_i \le 0$$

In summary, the model for obtaining the minimum number of warning points is:

$$\min y = \sum_{i=1}^{52} x_i$$

$$s.t.\begin{cases} \sum_{i=1}^{52} y_{ij} = 1 \\ l_{ij}y_{ij} <= 30 \\ y_{ij} - x_i \le 0 \end{cases}$$

7.1.2 The establishment of TourIng Route Issues Model 2

Because the minimum number of police points is obtained through model one, so when the location of the alarm point is required, this paper only requires the corresponding area of model one, that is, the number of restrictions need to be added.

(1) Determining the target function

In the case of the number of police points, this article needs to build the target function with the smallest total distance from all residential areas to the nearest police station, i.e.:

$$\min S = \sum_{i=1}^{52}\sum_{j=1}^{52} l_{ij}y_{ij}$$

(2) Determining constraints

The data used in model one when building model two of the tour ingress problem follows the constraints of model one, so the new target function has one more constraint than model one.

In summary, the model of the optimal warning point scheme is

$$\min S = \sum_{i=1}^{52}\sum_{j=1}^{52} l_{ij}y_{ij}$$

$$s.t.\begin{cases} \sum_{i=1}^{52} y_{ij} = 1 \\ l_{ij}y_{ij} <= 30 \\ y_{ij} - x_i \le 0 \end{cases}$$

7.2 Tour Ingling Problems Solution model

Solution result for Model One: The minimum number of warning points is 4.

Solution results of Model One: Get the optimal warning point scheme as shown in the following table:

Table 4: Optimal Warning Point Solutions

Location of the police station	Jurisdiction	Number of jurisdictions (thousands)
10	6,7,10,11,12,13,14,19,20,22,24,28,29,30,31,32,49,51	251
17	3,4,5,16,17,18,21,26,27,43,45,46,47,48,50	192

33	8,15,33,34,35,52	106
39	1,2,9,23,25,36,37,38,39,40,41,42,44	174

7.3 Results Analysis of Tour Ingnesse Issues

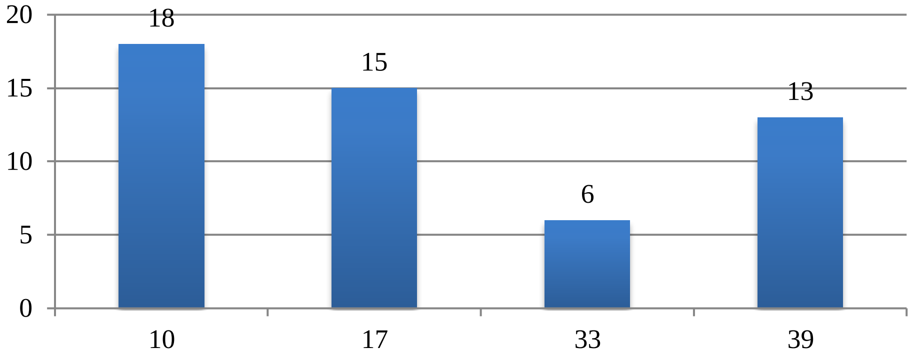

Fig.8: Number of police-managed areas

As can be seen from the figure above, the number of residential areas responsible for the four different out of the police stations is relatively different, through the analysis of distance information in the stem this paper can be seen that the main reason for this situation is in the 33rd community and several other out of the community is far away, that is, the area belongs to a small community of remote areas, need a separate police station to include it.

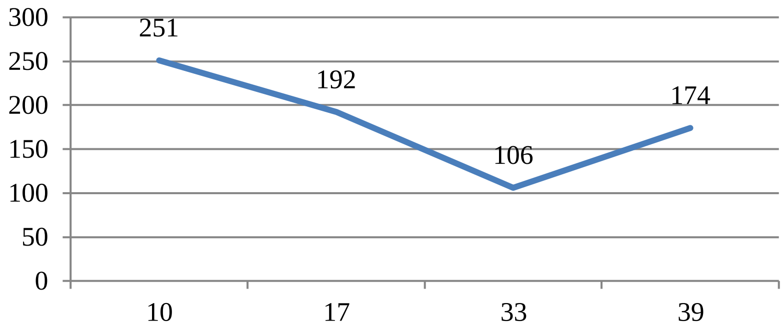

Fig.9: Number of police station management areas

As can be seen from the figure above, the communities above the road map in the main part are more closely connected, and the map below has fewer roads and fewer total communities, so the population is less important than the first two outings, but the importance of these two spots is also high.

Table 5: Minimum distance from the respective warning points in each region

Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Distance	13	10	26	16	17	18	25	26	15	0	24	8	12
Area	14	15	16	17	18	19	20	21	22	23	24	25	26

Distance	6	10	7	0	12	23	8	17	29	28	18	16	12
Area	27	28	29	30	31	32	33	34	35	36	37	38	39
Distance	27	22	13	23	16	25	0	25	10	10	9	24	0
Area	40	41	42	43	44	45	46	47	48	49	50	51	52
Distance	22	23	26	25	29	15	15	25	23	28	25	13	13

As can be seen from the table above, the arrangement for the police station is very reasonable, the furthest police distance reached 29 000 meters, basically reached the upper limit of the police distance. The average police distance of 17.15 meters is also very reasonable, even taking into account a little unexpected factors can meet the needs of the vast majority of residents, that is, the feasibility of the program is very high, can be put into daily use, is a very high degree of optimization of the program.

8. The establishment and solution of the tour route problem

8.1 Tour Issues Model Building

The problem to solve is a tour route near the optimal solution of the design, according to the meaning of the question, this article will be the tour road map abstracted into a attached right no-way connectivity map, $G(V,E)$ first to three groups to patrol, to achieve this purpose This article needs to be $G(V,E)$ divided into three subplots, $G_a\left(a=1,2,3\right)$ in each subplot to find the best $L_a\left(a=1,2,3\right)$ loop, so this article You can get the target function as

$$\min L = \sum_{a=1}^{3} \min L_a$$

Regarding this result This article needs to establish a equilibrium analysis, i.e. the equilibrium degree of the actual distance, for

$$\min \alpha_a = \frac{\max L_a - \min L_a}{\max L_a}$$

There are and have only one constraint, i.e.

$$\sum_{a=1}^{3} V_a = 52$$

8.2 Tour Problem Sydby Model

The optimal route arrangement is calculated by lingo, as shown in the following table:

Table 6: Three-team route

Team	Route	Away
One	6-5-19-21-27-28-27-48-50-47-26-16-17-46-45-43-44-43-18-4-3-5-6	230
Two	6-22-23-2-38-1-42-25-1-39-41-40-37-36-52-33-9-7-6	217
Three	6-24-8-15-34-35-34-32-31-11-13-14-51-30-29-49-20-10-12-6	249

The equilibrium of the actual distance is also calculated to be 12.8%.

8.3 Results Analysis of Tour Ingnesse Issues

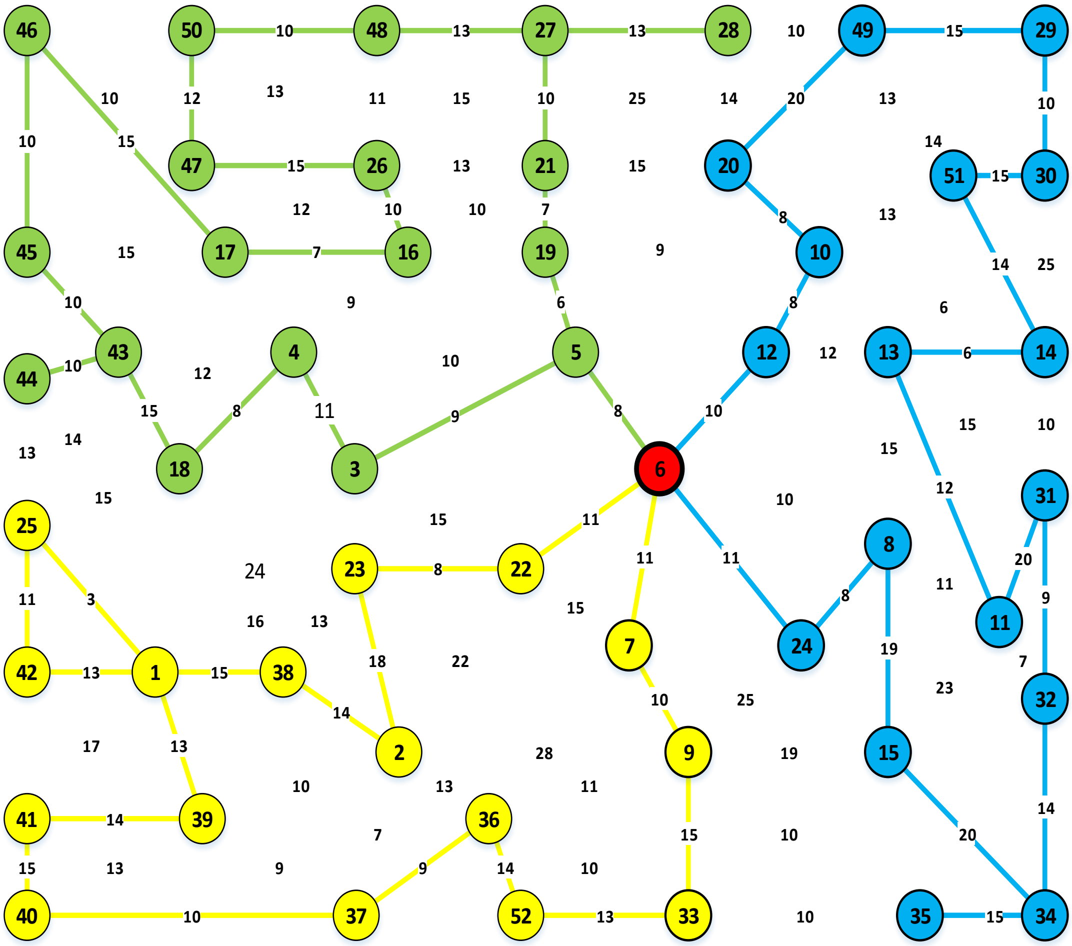

Fig.10：Team map

From the figure above, it can be seen that each group of leaders of the tour route is relatively average, and fewer repeating the line, reflecting the feasibility of the whole scheme is relatively high, can achieve the model when the model is established on the three sets of distance assumptions, the initial solution to the problem.

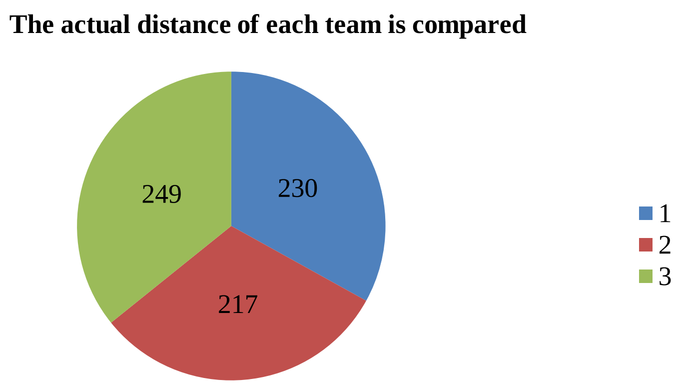

Fig.11: Comparisonof the actual total distance of each team

From the figure above, it can be seen that the total distance of the three groups is relatively close, very close to the expected results, reflecting the scheme is relatively average, the feasibility is very high and very close to the objective facts.

For equilibrium:12.8% equilibrium is more acceptable, indicating that the scheme has a relatively high universality and is more suitable for implementation. Such a scenario can also score the human resources of the person responsible as much as possible, so that each set of tasks conforms to objective facts. And the more average results represent a more accurate approximate optimal solution.

9. Model evaluation

9.1 Model benefits

(1)The model involves the distance and population, is the optimal solution obtained after weighting, and has a strong representativeness.

(2)The model is highly applicable and can solve similar multi-regional stationing problems, such as the establishment of shelters or hospitals.

(3)Model THREE is representative, and its thinking can be applied to similar patrol problems or messenger problems and similar situations.

(4)The results of model research have great practical significance, which can be extended to real life to solve problems with due regard to common errors.

9.2 The disadvantages of the model

(1)The calculation in model three is approximate, which does not guarantee the absolute optimal solution.

(2)Models I and II are too idealized to take into account stays or communications, and there is no time for delays outside of the reservation.

10. Improvement and promotion of models

10.1 Improvementsto the model

Model one with the art of zoning model, greatly improve the program of the whole and time show miscellaneousness, can also be simplified model, with the nearest neighbor method to approximate the optimal solution of the region, and then with the poor method to solve, compared with the simple method of poverty to simplify the scale of the problem, and make the model answer convincing.

10.2 Promotionof the model

(1) Multiple simulations can be combined with computers to make the results more accurate.

(2) The tour process should consider the length of time spent in the community.

(3) The division of the area can be increased, and the comparison of multiple scenarios is more convincing.

Model i and 2 can be used for the planning of general stationing problems, model three model can not only be used for disaster inspection, but also to solve the travel route settings.

11. Conclusion

This paper solves the problem of site selection and tour route, establishes multi-objective decision model and optimizes the line model, adopts the Floyd algorithm, and uses MATLAB and lingo programming to find the optimal scheme of site selection and tour route respectively. Through the establishment of a single-target optimization model, the establishment of a minimum value function on the weighted total distance, using the Floyd algorithm and using MATLAB programming to calculate the shortest path length of any two communities, and using lingo programming to facilitate residents to pay water and electricity bills of the site in 6, 14, 25, 26, 28 and 37 six residential areas. On the issue of tour routes, ignoring the impact of population on the basis of the pre-question model, first obtain the minimum number of police stations to meet the conditions, and then obtain the specific establishment of residential areas based on the minimum number of establishments. Establish the constraint optimization line model, use the Floyd algorithm to find the shortest path of any two residential areas, establish the shortest path to the root of the tree in the 6th residential area to generate the tree, and divide the regions. Three optimal tour routes were obtained, and the equilibrium of the scheme was α = 12.8%,and theequilibrium was better. The model set up in this paper can make reasonable use of resources, comprehen- sive analysis to arrive at the optimal route scheme, can solve similar multi-regional station- ing problems, such as shelter or hospital establi- shment. The optimal tour route scheme can make more effective use of police resources and have a positive impact on the maintenance of regional law and order.

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