Research on "crossing the desert" based on BFS and game theory

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Abstract: The background is a game of "crossing the desert", which requires players to solve the player's optimal strategy under the given game rules. The goal of the game is to arrive at the end of the game within a specified time, with as much money as possible .In order to reduce resource consumption, players should give priority to the shortest path from the starting point through mines and villages to the destination, and then discuss the optimal scheme in detail. When calculating the shortest path, the map is abstracted into a no right map and transformed into a matrix form, and then the breadth first search algorithm (BFS) is used to solve the problem. On this basis, the problem is considered: for a single player with known weather in a specified time, the game is played. Firstly, according to whether there are villages or mines, this paper discusses the optimal strategy of players under different map types. The first pass and the second pass belong to the type of villages with mines, and mining can bring net income. In this regard, firstly, BFS is used to find the shortest path through the mine, and combined with the specific weather to calculate the resource consumption on the path that players must pass through. In order to increase the income, allocate as much time as possible to the mining, and then determine the mining scheme and the best village supply scheme. Then, considering the overall situation, the total resource consumption and village supply situation in the whole process are calculated, and the optimal resource allocation strategy is obtained by using linear programming. To sum up, it is the optimal strategy. According to the above strategies, the optimal strategy of the first level is to go to the mine along the shortest path 1-25-26-23-22-9-15-13-12, then to the village for replenishment after 7 days of mining, then continue to dig for 3 days, and finally reach the terminal point along 12-14-16-17-21-27, with the remaining capital of 10440 yuan; the second pass is to mine for 5 days along 1-2-10-11-20-21-29-30, return to the mine for 9 days after mining, and finally arrive at the terminal point along 39-47-56-64The remaining capital is 12505 yuan. In this paper, programming, logical reasoning and numerical calculation are used to obtain the optimal strategy through BFS, linear programming and game theory. Because some problems are easier to understand with logic proof than with code, this paper uses the method of combining program and reasoning to find the "shortest path" to solve the problem.

1. Game background

A game of "crossing the desert". In this game, players need to use a map and limited initial resources to search for mines and villages in the desert, and get as much money as possible when they reach the destination.

The rules of the game are as follows:

1) Players must arrive at the destination within a given time;

2) Players can mine in mines and buy materials in villages, but the price will be more expensive than the starting point;

3) The amount of resources consumed by different activities is different;

4) Players can only move to one adjacent area at a time.

2. Problem analysis

"Crossing the desert" game can be divided into two aspects: the shortest path planning problem and the decision-making problem. For this game, we can use the breadth first search algorithm (BFS, hereinafter referred to as BFS) to plan the shortest path players can take in the game, and then determine the specific action plan through decision-making.

For the first level, according to the game assumption, the player takes the same day from any area to the adjacent area. Therefore, the map can be abstracted as an unauthorized graph, and the adjacency matrix required by BFS can be obtained according to this unauthorized graph. Using BFS, the shortest route from starting point 1 to village 15, mine 12 and village 15 to destination 27 is obtained. After obtaining these shortest routes, the following problems are determined by calculation:

1) From the starting point 1, go along the shortest route to the terminal 27, which has more surplus funds, or is it more profitable to take a detour to mine 12?

2) If you are sure to go to mine 12 for mining, are the water and food purchased at the starting point sufficient, and do you need to go shopping in the village?

3) If you want to go to the village, when is the best time to go?

After determining the above problems, we can get the player's optimal strategy.

3. Strategy analysis

The goal of the game is to arrive at the destination within the specified time and to have as much money as possible when reaching the destination. Under this goal, the analysis of the inflow and outflow of funds can be obtained

In the case of all known weather conditions, the maximum amount of funds remaining at the destination must meet the following conditions:

1) Ensure that the resource surplus is zero when the destination is reached. The price of the remaining water and food at the end of the game is only half of the original price. However, we can make players purchase just enough resources at the beginning of the game by deployment, so as to reduce the capital loss of this part and ensure the maximization of income;

2) When the profit brought by a mining day is greater than the consumption of mining, we should allocate as many days as possible to mine, so as to ensure the maximization of interests.

4. Level solution

The first map type is "there are villages, there are mines", combined with the strategy given above to solve.

Looking at the map, the village is close to the mine. First find the shortest path of "starting point mining village ending point" or "starting point village mining ending point". Through BFS, the shortest path is as follows: 1 -- > 25 -- > 26 -- > 23 -- > 21 -- > 9 -- > 15 (Village) -- > 14 -- > 12 (mine) - > 14 -- > 15 (Village) - > 9 -- > 21 -- > 27 (end point).

The above-mentioned basic route can be abstracted as the form

Supply mode	Supply conditions	Specific supply requirements
Front end supply	There is a "village mine" link in the basic route, which can be replenished at the front end of the route to directly increase the mining days.	Make up to 1200 kg in the village.
Terminal supply	There is a "village terminal" link in the basic route, which can indirectly increase the mining days by replenishing at the end of the route.	When arriving at the village, the existing resources should be as small as possible. Replenish the resources at the village so that the resource amount is 0 when the player just reaches the destination.
Circulating supply	The village is close to the mine and can reach the end point before the deadline after one cycle.	When leaving the mine, ensure that the remaining resources can reach the village. It is a replenishment cycle to record the end of supply, leaving the village and returning to the village again. The amount of village supply is the total resource consumption in a supply cycle, which includes the consumption of returning to the mine plus the consumption of mining and re arriving at the village.

For the front-end route, as the route is determined and the weather conditions are known, it is calculated that the village will reach the village on the 8th day, and then the supply will be conducted and the mine will arrive at the mine on the 10th day. It takes at least 5 days for the end of the storm.

After that, it enters the circulation route.

First of all, mining starts. According to the above strategic requirements, when leaving the mine, the remaining amount of resources needs to meet the road consumption to the village, so the first mining takes 7 days; on the 18th day, it stops in case of sand storm, and then leaves the mine on the 20th day to arrive at the village. The supply meets the recycling supply mode and returns to the mine on the 22nd day. At this time, there are 8 days left, and it is necessary to reserve 5 days for return journey. Therefore, it is only possible to leave after mining for 3 days.

After the route is obtained, the total resources consumed by the whole route are calculated, and then the optimal purchase scheme is solved by integer programming

It is located in the starting point to buy X1 boxes of water and X2 boxes of food. It is the first time to buy X3 boxes of water and X4 boxes of food in the village, and the second time to buy X5 boxes of water and X6 boxes of food in villages. $x_1,x_2,x_3,x_4,x_5,x_6$are integers, and the target is to find

$$f = 5 * x_1 + 10 * x_2 + 10 * x_3 + 20 * x_4 + 10 * x_5 + 20 * x_6 \tag{1}$$

The minimum value of, f is the amount of money spent.

Since the money gained from mining is certain, the maximum value of surplus funds can be obtained by finding the minimum value of F. According to the actual situation, x_1,x_2,x_3,x_4,x_5,x_6 have the following relationships:

1) In order to ensure that there are no resources left at the destination

$$x_1 + x_3 + x_5 = 500 \tag{2}$$

$$x_2 + x_4 + x_6 = 470 \tag{3}$$

2) For the first time, the number of water and food boxes was positive

$$x_1 \geq 88 \tag{4}$$

$$x_2 \geq 84 \tag{5}$$

3) The second replenishment of resources in the village made the number of water and food boxes positive

$$x_1 + x_3 \geq 327 \tag{6}$$

$$x_2 + x_4 \geq 297 \tag{7}$$

4) The whole process has been purchased for three times, and the weight bearing after each purchase should not be greater than 1200kg

$$3 * x_1 + 2 * x_2 \leq 1200 \tag{8}$$

$$3 * (x_1 + x_3) + 2 * (x_2 + x_4) \leq 1834 \tag{9}$$

$$3 * (x_1 + x_3 + x_5) + 2 * (x_2 + x_4 + x_6) \leq 2847 \tag{10}$$

Therefore, the following integer programming model can be established

Objective function: min $5 * x_1 + 10 * x_2 + 10 * x_3 + 20 * x_4 + 10 * x_5 + 20 * x_6$

$$St: \begin{cases} x_1 + x_3 + x_5 = 500 \\ x_2 + x_4 + x_6 = 470 \\ x_1 \geq 88 \\ x_2 \geq 84 \\ x_1 + x_3 \geq 327 \\ x_2 + x_4 \geq 297 \\ 3 * x_1 + 2 * x_2 \leq 1200 \\ 3 * (x_1 + x_3) + 2 * (x_2 + x_4) \leq 1834 \\ 3 * (x_1 + x_3 + x_5) + 2 * (x_2 + x_4 + x_6) \leq 2847 \\ x_1, x_2, x_3, x_4, x_5, x_6 \geq 0 \end{cases} \tag{11}$$

By solving the above formula, we get x_1=116,x_2=426,x_3=211,x_4=0,x_5=173,x_6=44,f=9560.

5. Strategy evaluate

Advantages analysis

1) This paper only uses BFS to find the shortest path, and the remaining decision and analysis are proved by logical reasoning. Compared with the program, this logic proof is easier to understand and makes the solution of the level more efficient.

2) From the common point of view of resources and funds, the game is calculated according to the consumption of resources. After the end of the game, the global optimal allocation of resources is considered by using integer programming.

Defect analysis

1) Based on logical reasoning, the method to obtain the optimal strategy is highly dependent on the actual situation, and the solution method has a small scope of application.

6. Summary

In this paper, logic reasoning, calculation, programming and other methods are used to obtain the optimal strategy of each level through BFS and linear programming. The advantage of diversification is that we can choose the most suitable method according to different problems, reduce the difficulty of thinking and computational complexity, instead of trying to solve them all at once with deep learning, which provides some reference for other similar optimal route problems and multi player game problems.

References

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