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Optimization Study of Desert Traversing Routes Based on Floyd and Greedy Algorithms

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Abstract: This paper is based on a desert traversal game to reach the endpoint within the specified time and keep as much money as possible, so it is necessary to give a reasonable choice of routes and optimize the routes. This paper defines the adjacency matrix of the graph and borrows the Floyd algorithm to get the two shortest routes: "to mine" and "not to mine"; secondly, based on the basic assumption that "players will give priority to routes containing villages", the shortest routes are optimized and the shortest routes are optimized to be "to mine" and "not to mine". Secondly, based on the basic assumption that "players will prefer the route containing villages", the shortest route is optimized to the shortest route passing through villages; Thirdly, based on the objective of "retaining as much money as possible", mining in mines is divided into "continuous mining" and "non-continuous mining". "Finally, the greedy method is used to obtain the funds of the three cases of the two routes are 9410-yuan, 10430 yuan, and 9800 yuan, and the remaining funds are compared to obtain the optimal route for the player to pass the game. Afterward, the weather probability of each day is estimated and the weather sequence is randomly generated; secondly, combining the map information and the weather condition of the day, the dynamic strategy should be adopted by the player given; again, Monte Carlo simulation is used to simulate the whole decision-making process, and the performance of the model is optimized by adjusting the parameters of the model.

Keywords: Floyd Algorithm; Greedy Method; Monte Carlo Simulation; Desert Traversal.

1. Introduction

In the process of traveling or long-distance traversing, it is often encountered to reach the finish line within the specified time and keep as much money as possible, and to achieve the above goals, the choice of routes from the start to the finish line is extremely important. The changing weather, and limited amount of water and food make it inevitable to encounter some risks during the journey, so how to give a reasonable route choice and optimize the route within the controllable risk is the key point to consider.

This paper is based on the study of a small desert crossing game, the game consists for the player with a map, using the initial funds to buy a certain amount of water and food as daily supplies, according to the rules of the game and different ecological settings, the player from the starting point, walking in the desert, and ultimately in the stipulated time to reach the end and retain as much money as possible, that is, to pass the level of success. The basic rules of the game are as follows:

(1) The basic unit of the game is the day. The game starts on Day 0 and the player is at the starting point. The player has to reach the endpoint on or before the deadline, otherwise, the game fails. Water and food are the basic supplies for the player to cross the desert and are measured in boxes. The total amount of water and food a player can have per day must not exceed 1,200 kg due to the weight limit, and the player must not run out of food and water before reaching the endpoint.

(2) Weather conditions in the desert are "sunny", "hot" and "sandstorm" and are the same in all areas of the desert. Each day, players may travel from one area of the map to another adjacent area or stay where they are. Walking is allowed on hot and sunny days but must stay put on sandstorm days.

(3) A player who stays in place for 1 day consumes the base amount, and a player who walks for 1 day consumes 2 times the base amount. On Day 0, players may purchase water and food at the starting point with their initial funds, or return to or stay at the starting point, but cannot purchase resources more than once. When the player reaches the end point, he can return the remaining resources, but the price is only half of the base price.

(4) Players can get money by mining at the mine, and the income gained from mining for one day is the base income. However, the amount of resources consumed by mining is 3 times the base amount, and you cannot mine on the day you arrive at the mine, but you can mine on the day of a sandstorm. When passing through a village or staying in a village, players can purchase water and food at 2 times the base price with their remaining funds or base earnings from mining at the mine.

Therefore, based on the above game rules, this paper optimizes the traversal routes in the desert traversal game, combining Floyd's algorithm, greedy method, and Monte Carlo simulation to help players get the optimal strategy to pass the level [1-3].

2. Shortest route model based on Floyd and greedy algorithm

2.1. Floyd's algorithm for solving the shortest route

Floyd algorithm can give the shortest path between any two nodes in the network, based on the map to construct the adjacency matrix, the construction principle is that if the player can be reached from a region of the map to another region adjacent to it, then the corresponding value of this element in the adjacency matrix is 1; if it is inaccessible, the value is 0. In this way, the adjacency matrix is defined as shown below [4, 5].

$$\begin{bmatrix} 0 & 1 & 0 & \cdots & \cdots & \cdots & 1 & 0 & 0 \\ 1 & 0 & 1 & \cdots & \cdots & \cdots & 0 & 0 & 0 \\ 0 & 1 & 0 & \cdots & \cdots & \cdots & 1 & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & & & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & & \ddots & & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & & & \ddots & \vdots & \vdots & \vdots \\ 1 & 0 & 1 & \cdots & \cdots & \cdots & 0 & 1 & 0 \\ 0 & 0 & 0 & \cdots & \cdots & \cdots & 1 & 0 & 1 \\ 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 & 1 & 0 \end{bmatrix}_{27\times 27} \quad (1)$$

Therefore, with the help of Floyd's shortest-circuit algorithm, the following two shortest routes with and without passing through the mine are obtained:

(1) shortest route 1 (without the mine): starting point $1->25->26->$endpoint27;

(2) shortest route 2 (after the mine): starting point $1->25->24->23->21->9->10->11->$mine $12->11->10->9->21->$end point 27.

Based on the basic assumption that "players will prioritize routes that contain villages", the shortest route (2) (passing through mines) is modified as follows: Start $1->25->24->23->21->9->$Village $15->13->$Mine $12->13->$Village $15->9->21->$Finish 27, and shortest route is shown schematically in Figure 1.

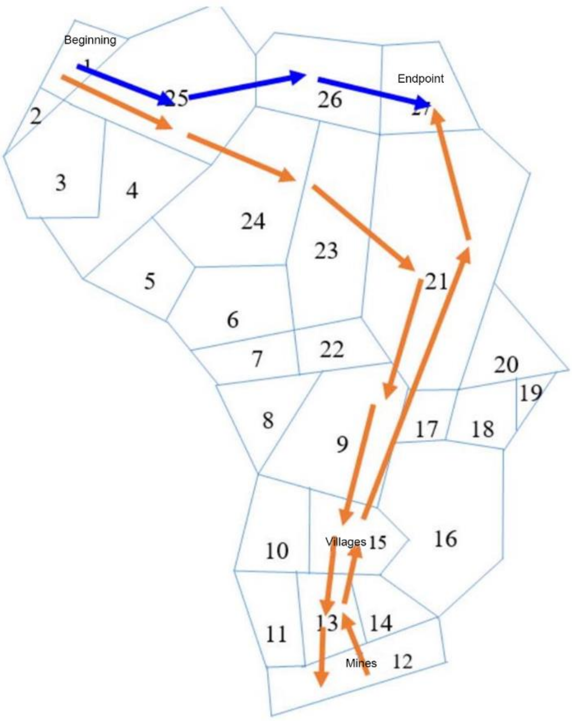

Figure 1. Schematic diagram of the shortest route

2.2. Calculation of remaining funds based on the greedy method

(1) For shortest route 1 (without mine): Start $1->25->26->$ End 27.

a. Weather Factor: Since the player did not encounter any sandstorms, he/she will arrive at the finish line on the third day (before the deadline).

b. Whether the weight limit is reached or not: W_{ij} is the water consumption, walking consumption, mining consumption based on the weather condition, in boxes; E_{ij} is the food consumption, walking consumption, mining consumption based on the weather condition, in boxes.

$$W_{ij} = \begin{pmatrix} 5 & 8 & 10 \\ 10 & 16 & 20 \\ 15 & 24 & 30 \end{pmatrix} \quad (2)$$

$$E_{ij} = \begin{pmatrix} 7 & 6 & 10 \\ 14 & 12 & 20 \\ 21 & 18 & 30 \end{pmatrix} \quad (3)$$

Where: i denotes the player movement state, i is 1 for base consumption, i is 2 for walking consumption, i is 3 for mining consumption; j denotes the weather condition, j is 1 for sunny, j is 2 for high temperature, j is 3 for sandstorm.

The weather of the first three days is high temperature, high temperature and sunny respectively. According to Equation (4), the total consumption of the player in the first three days is calculated, i.e., the weight of the first day.

$$F_g = 2\times(3W_{22}+2E_{22})+(3W_{21}+2E_{21}) \quad (4)$$

Where: F_g is the first day's load, the total consumption (kg) of the player is calculated to be 202 kg, which does not exceed the load limit.

c. Remaining funds: According to formula (5).

$$S_1^1 = 10000 - 2(5W_{22}+10E_{22}) - (5W_{21}+10E_{21}) \quad (5)$$

Where: S_1^1 is the amount of money left in shortest route 1, and the player's remaining money is calculated to be 9,410 yuan.

(2) For shortest route 2 (passing through the mine): Start $1->25->24->23->21->9->$ Village $15->13->$ Mine $12->13->$ Village $15->9->21->$ End 27.

The appearance of village 15 provides more possibilities for players to make multiple decisions for mining, and this paper discusses the following two cases of continuous mining and discontinuous mining based on the shortest route 2.

For continuous mining, the route is as follows: Start $1->25->24->23->21->9->$ Village $15->13->$Mine $12->13->$Village $15->9->21->$Finish 27.

If the weight limit is satisfied, players will buy as much food as possible and as little water as possible at the starting point, because the unit price of food in the village is twice as much as the unit price of water. However, it is not advisable to buy too much food, because the weight of each box of food is less than the weight of each box of water, i.e., the amount of water consumed (kg) is greater than the amount of food consumed (kg), and due to the weight limit, buying too much food will result in not being able to buy enough water to support the player to go back to the village again on the eighth day.

$$W_1 = 3W_{22}+3W_{21}+2W_{13} \quad (6)$$

$$E_1 = 3E_{22}+3E_{21}+2E_{13} \quad (7)$$

$$W_2^1 = \sum_{i=1}^{6} W_i \quad (8)$$

$$E_2^1 = \sum_{i=1}^{6} E_i \quad (9)$$

Where: W_i is the amount of water the player needs to buy in each stage; E_i is the amount of food the player needs to buy in each stage (here we only take the first stage as an example); W_2^1 is the total amount of water the player needs to buy in Case 1 of Shortest Route 2; E_2^1 is the total amount of food the player needs to buy in Case 1 of Shortest Route 2, the total of the six stages add up to the player's total purchase of 349 cases of food and 379 cases of water, subtracting the amount of water and food the player bought at the starting point, we can get the total amount of water and food purchased at the village twice is 19 cases of food and 199 cases of water respectively.

The total amount of food and water purchased by the player during the trip is 349 cases, and 379 cases of water. Subtracting the amount of water and food purchased by the player at the starting point, the total amount of water and food purchased at the villages in the two trips is 19 cases of food and 199 cases of water respectively.

At the starting point, the unit price of water is 5 yuan, and the unit price of food is 10 yuan; in the village, the unit price of water is 10 yuan, and the unit price of food is 20 yuan. The total cost of purchasing food and water, together with the 7,000 yuan of income gained from seven days of mining, is summarized by the formula (10).

$$S_2^1 = 10000 + 7000 - (5 \times 180 + 10 \times 199) - (10 \times 330 + 20 \times 19) \quad (10)$$

Where S_2^1 is the remaining funds for Shortest Route 2 Case 1, the remaining funds for Shortest Route 2 Case 1 are calculated to be 10,430 yuan.

Players do not mine consecutively, i.e., they can go to village 15 during the mining period to buy water and food and then go back to mine 12 to continue mining. The route is as follows: Start 1−> 25−> 24−> 23−> 21−> 9−>Village 15−> 13−>Mine 12−> 13−>Village 15−> 13−>Mine 12−> 13−>Village 15−> 9−> 21−>Finish 27.

The player has four chances to get resource supplies, namely to buy water and food with the initial funds at the starting point, and the remaining three times to buy water and food with the remaining funds or funds gained from digging at the villages when they reach them. Same as scenario one.

The total amount of food purchased by the player at the starting point is 330 cases, and the total amount of water is 180 cases; subtracting the purchases made at the starting point from the total purchases made by the player, by using equations (11) and (12).

$$CW_2^2 = W_2^2 - 180 \quad (11)$$

$$CE_2^2 = E_2^2 - 330 \quad (12)$$

Where: CW_2^2 is the total amount of water purchased in the village; CE_2^2 is the total amount of food purchased in the village; W_2^2 is the total amount of water purchased in Case 2 of the shortest route 2; E_2^2 is the total amount of food purchased in Case 2 of the shortest route 2; the calculated total amount of food purchased in the village is 140 cases, and the total amount of water purchased is 320 cases.

c. Remaining Funds: Considering the player's initial funds and the base income gained from mining for 10 days, and removing the cost of purchasing food and water, the following formula is used in Equation (13).

$$S_2^2 = 10000 + 10000 - (180 \times 5 + 320 \times 10) - (330 \times 10 + 140 \times 20) \quad (13)$$

Where S_2^2 is the remaining funds for Shortest Route 2 Case 2, the remaining funds for Shortest Route 2 Case 2 are calculated to be 9,800 yuan.

2.3. Optimal strategy determination

The remaining fund of Route 1 is 9,410 yuan, and the maximum remaining fund of the two scenarios of Route 2 is 10,430 yuan. According to the ultimate goal of desert, crossing players is to reach the endpoint within the specified time and keep as much money as possible, this paper chooses the first scenario of the shortest route 2 as the optimal strategy for players to pass the first level.

In summary, the optimal strategy for players to pass the first level is shown in Table 1 when the weather conditions of each day of the whole period are all known in advance.

Table 1. Players' optimal strategies

Routes	Start 1−> 25−> 24−> 23−> 21−> 9−>Village 15−> 13−>Mine 12−> 13−>Village 15−> 9−> 21−>End point 27		
Resource purchases	Start 1	Water: 180 cases	Food: 330 cases
	Village 15	Water: 199 cases	Food: 19 cases
Mining days	7 days		
Specific schedule	Time	Routes	Arrival point
	1-8	1−> 25−> 24−> 23−> 21−> 9−> Village 15	Village 15
	9-10	13−> Mine 12	Mine 12
	11-17	Mine 12	Stay in the mine 12 Mining
	18	Mine 12	Work stoppage stays at the mine 12
	19-20	13−> Village 15	Village 15
	21-23	9−> 21−>End point 27	End point 27

3. Models for route optimization taking into account weather variability

3.1. Impact of weather factors on earnings expectations

In this paper, we categorize each decision into two aspects: the change of resources (water, food, money) and the change of the player's position. After each decision, we need to update the player's state (location, water, food, money). Resource changes, mainly involves the supply strategy in the village and the mining strategy in the mine. The replenishment strategy determines how much water and food the player buys in the village, and the mining strategy determines whether or not the player mines in the mines to increase money, and affects the player's location change. Location changes are mainly related to the player's movement strategy. The movement strategy determines whether the player moves forward or stays, and the direction of movement.

The decision of whether to move or not is mainly based on the factors of "weather" and "location". Using the weather data given in the previous question, we calculate the expected value of the effect of weather on the profit. Due to the low probability of sandstorms and the necessity to stay in sandstorms, this paper does not include sandstorms in the decision-making factors. The expected value of the consumption of water and food resources (in boxes) for staying and moving during hot and sunny days is calculated as follows.

The strategy of moving on sunny days and staying on hot days minimizes resource consumption.

If the player decides to move, then he needs to choose the next location. For a location, there may be more than one alternative next location. For the model to be able to move toward the end point, the player needs to have a greater tendency to move towards the endpoint. At the same time, for the model to jump out of the local optimal solution, the player is also allowed to move away from the endpoint with a certain probability. In this paper, we use the shortest path of a candidate point from the endpoint to represent this probability and perform the normalization and square-curve operation on it. By adjusting the order of the operation, we can adjust the probability of the player choosing the worse solution (the candidate point is far away from the endpoint), and ensure that the model converges as much as possible under the circumstance of no more than 30 rounds of iterations.

$$\text{probability} = \frac{1}{x^2} \quad (14)$$

To maximize the profit, when players are located in mines, they should mine as much as possible while keeping enough resources. In this paper, we use the weather data given in the previous problem to calculate the expected value of the effect of weather on traveling time and resource consumption.

Since the chances of sunny days and high temperatures are half and half, we follow the principle of moving on sunny days and resting on high temperatures. In this paper, 2×d×(c sunny +c high temperature) is used as the red line of the material reserve, when the remaining resources are less than this value, it means that the player should start to move along the shortest radial path to the end, otherwise there is a high probability of not being able to pass the level.

Since the stay has been determined, the decision of whether to mine or not depends only on the "weather". We utilize the given weather data to obtain the expected value of the weather's impact on the mining revenue.

The strategy of mining on sunny days and resting on hot days is used to maximize returns.

Since the decision to buy supplies in the village does not consume actual days, in most cases, the decision to buy supplies should be made at the end of the decision.

Since the decision to buy supplies in the village does not consume actual days, in most cases it is necessary to decide at the end of the decision whether the current location is a village or not, and if it is, then decide to buy supplies (not buying supplies is equivalent to buying 0 supplies, which simplifies the problem). The goal of the game is twofold: the primary goal is to pass the game, and the secondary goal is to maximize money. Combined with the red line of supplies from the previous solution, we can use the strategy of replenishing supplies to the red line of supplies to ensure that we can reach the end of the game in the desired situation calculated earlier and to minimize the waste of money.

3.2. Monte Carlo-based method for randomly generating weather effects on models

The Monte Carlo method was used to randomly generate weather, and 1000 experiments were conducted to observe the effects of different decision parameters on the model. Adjusting the order of the square curtain operation on the reciprocal of the shortest path of the candidate point from the endpoint when choosing the forward direction, from 1 to 10, with 0.1 as the step size, the pass rates of the model were calculated, and the results are shown in Figure 2 [6, 7].

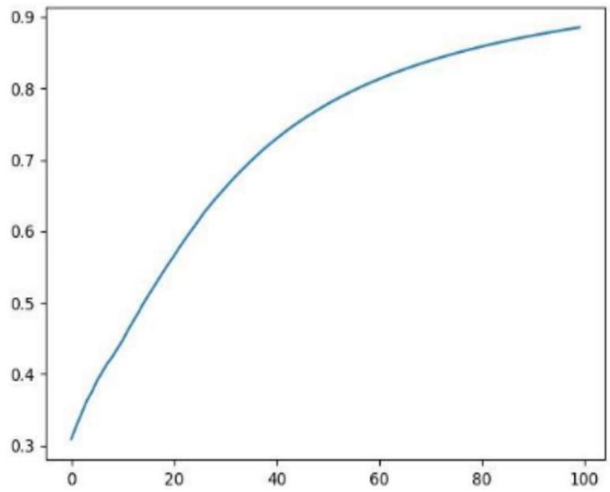

Figure 2. Results of the game pass rate test (horizontal coordinate is the number of iteration rounds, vertical coordinate is the pass rate)

From the figure, it is easy to see that, under the same initial conditions, when the order is larger, i.e., players tend to choose candidate points closer to the endpoint, the clearance rate of the model is higher, which is in line with the initial intuition and expectation.

4. Conclusions

In this paper, we define the adjacency matrix of the graph and borrow Floyd's algorithm to get the two shortest routes of "digging to the mine" and "not digging to the mine", which are Start 1−> 25−> 26−>End 27 and Start 1−> 25−> 24−> 23−> 21−> 9−> 10−> 11−> Mine 12−> 11−> 10−> 9−> 21−> End 27 respectively. > 21−> 9−> 10−> 11−> Mine 12−> 11−> 10−> 9−> 21−>Terminal 27; Secondly, based on the basic assumption that "Players will prefer routes containing villages", the shortest route is optimized to the one passing through the villages; Thirdly, based on the assumption that "Retaining as much money as possible", the shortest route is optimized to the one passing through villages; Thirdly, based on the assumption that "Retaining as much money as possible", the shortest route is the one passing through villages. The goal of "retaining as much money as possible", to mine mining is divided into "continuous mining" and "non-continuous mining" two cases; Finally, the use of greedy method to find the two routes of the three kinds of Finally, using the greedy method to find two routes of three kinds of funds were 9410 yuan, 10430 yuan, 9800 yuan, compared with the remaining funds, so the player through the first level of the optimal route for the starting point of 1−> 25−> 24−> 23−> 21−> 9−>Village 15−> 13−>Mine 12−> 13−>Village 15−> 9−> 21−>Terminal 27.

Subsequently, the weather probability of each day is estimated and the weather sequence is randomly generated; secondly, combined with the map information and the weather condition of the day, the dynamic strategy that the player should adopt is given; thirdly, Monte Carlo simulation is used to simulate the whole decision-making process, and the performance of the model is optimized by adjusting the parameters of the model.

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