Research on analysis of desert crossing problem based on Dijkstra model

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Abstract. This article analyzes the optimal solution of the game desert nuggets in different situations. Taking into account the weather, the amount of resources (water and food), the travel conditions and the number of people in the same group, more funds are reserved for reaching the end. According to the requirements of different backgrounds, various models and solutions are proposed. Based on the Dijkstra model and using methods such as greedy algorithm and game theory, run under Linux terminal to find the optimal strategy.

1. Introduction
The game Desert Nuggets is a team game designed to cultivate players' goal setting and goal management capabilities. The game-related content has been simplified, and additional elements such as the tomb of the king and the mysterious old man have been deleted. Extend the time to 30 days, increase the initial funds and other settings, and decompose the optimal solution of the game into three problems:

(1) Know the weather conditions for 30 days, find the optimal strategy;
(2) only know the weather conditions of the day, choose under normal circumstances Optimal strategy; (3) n players start at the same time, play games with each other, and analyze the strategy that enables the players to obtain the optimal solution.

2. Basic description

2.1. Model assumptions
(1) Assuming that the weather conditions of the same weather type are the same and in an ideal state;
(2) Assuming that no matter how much weight is loaded every day, it has nothing to do with resource consumption and does not increase or decrease resource consumption;
(3) Assuming that the distances between all adjacent areas in the map are equal, and it takes exactly one day to arrive;
(4) Assuming that all resource consumption is only related to weather and sports behavior, and has nothing to do with other subjective factors;
(5) Assuming that the resource prices of the starting point and the village will not be affected by external environmental factors, such as the epidemic situation and economic crisis, there will be no price changes for multiple purchases and large-scale purchases;
(6) It is assumed that the game character will not be fatigued and stopped when the weight is any value between 0-1200kg.

### 2.2. Symbol Description

| Number | Parameter | Meaning |
|--------|-----------|---------|
| 1      | $w_i$     | Water consumption/box on day $i$ |
| 2      | $f_i$     | Food consumption/box on day $i$ |
| 3      | $c_i$     | Weight of load-bearing resources on day $i$ /kg |
| 4      | $D_i$     | Day $i$ |
| 5      | $p_i$     | The price of the $i$-th purchase of materials |
| 6      | $C(i)$    | Player ID $i$ |
| 7      | $W_i$     | $W_1$ is sunny weather, $W_2$ is high temperature weather, $W_3$ is sandstorm weather |

### 3. Model establishment and solution for problem 1

Refer to the map of the first level, through the basic analysis of resource allocation and ultimate goal, use Dijkstra's method to divide the map into dots, and use disorderly arrows to indicate the relevance and continuity of each serial number area. In this way, a food and water replenishment and consumption model is established. In the line chart trend model, the impact of weather, funds, and load changes are analyzed emphatically, and the three factors are quantitatively expressed.

Through calculation, several schemes to and from the starting point, the village, the mine, and the ending point are initially obtained. The optimal plan is shown in Figure 1, which is to make full use of resources, avoid the impact of $W_3$’s work stoppage, and obtain more capital income in the mine.

#### 3.1. Establishment and Solution of Mathematical Model of Level 1

The maximum number of game days is 30, of which 6 days can not be walked on sandstorm days, that is, the number of walking days does not exceed 24; you must pass 15 villages and 12 mines at the same time; choose the shortest path from the starting point 1 to village 15 and you are not allowed to go back. Therefore, the programming termination conditions are set as: no more than the specified time, upper limit of load, and no negative number of consumables carried. If it appears, the simulation will be terminated immediately. Choose the shortest path: 1—25—24—23—22—9—15—14—12—14—15—14—12—14—15—9—21—27.

![Figure 1](image1.png)

**Figure 1.** The relationship between level 1 funds and the number of days.

![Figure 2](image2.png)

**Figure 2.** The relationship between resources (food and water) and the number of days in level 1.

From 1-15, the first consideration is how many days it takes. Since $W_3$ cannot walk, $D_8$ reaches the village. The second consideration is the minimum amount of resources required from 1-15: According to the weather conditions, 1-15 requires at least $w_{98} + f_{98}$. The upper limit of the weight is 1200kg. After calculating the lowest $w_{98} + f_{98}$, there is still 710kg of load space; the water at the starting point is 5 RMB a box, and the food at 10 RMB a box; and the price at the village is twice the starting point. Therefore, the more food you buy at the starting point, the more cost-effective it is.
Therefore, perform the first calculation and use all the remaining weight to purchase $f_{335}$. The second thing to consider is whether $f_{335}$ is sufficient for the later journey. The current preliminary plan for the shortest path is 1-15 for eight days ($w_{98}, f_{98}$). Remaining load to buy $f_{335}$, continue walking on the ninth and tenth day, $D_{16}$ walks to mine 12, and cannot mine on that day. Therefore, both November and December are mining. (9, 10, 11, 12 four days spent $w_{86}, f_{72}$), as shown in Figure 3.

$D_{13}, D_{14}$ continue to walk, from 12 mines to 15 villages to supply resources. ($w_{26}, f_{26}$ for two days on 13 and 14) After arriving in the village, to replenish sufficient resources, you need to go to the mine for long-term mining, but you must prepare to go from the village to the mine, mine in the mine, and return from the mine to the village. The total amount of resources required for the three parts. After two days' journey from $D_{15}$ and $D_{16}$ to the mine, $D_{16}$ can't mine on that day, and $D_{17}$ starts to mine. Stay from $D_{17}$ to $D_{25}$. Set $D_{17}$ and $D_{25}$ two sandstorm days without mining (15-25 these nine days cost $w_{190}, f_{191}$). $D_{26}, D_{27}$ two days, from the mine 12 back to the village 15 to supply resources (two days consumption $w_{26}, f_{28}$). The last three days from the village to the end ($w_{42}, f_{38}$). From this, it can be accurately obtained $72+26+191+28+38=355$, that is, there is no need to buy food in the later stage, and the food is just consumed by the end. Through this idea, the model in Figure 4 is established.

3.2. Establishment and Solution of Mathematical Model of Level 2

All the weather in the second pass is known, and the shortest path of this pass is determined by Dijkstra's method to study the optimal solution[3]. The journey from the starting point to the mine is 9 days ($w_{233}, f_{265}$), passing through 2, 3, 4, 12, 21, 29 in turn to reach 30 mines, of which $W_3$ stays for two days. Mining for 4 days almost ran out of water resources. Therefore, $D_{14}$ reaches 39 villages for replenishment. At this time, all the water resources are used up (remaining $f_{56}$). Replenish the resources needed in the villages to reach the upper limit of load ($w_{186}, f_{174}$) as much as possible. $D_{16}$ reaches the 55th mine and mines for 6 days. (Remaining $w_{16}, f_{12}$). $D_{23}$ arrived at No. 62 village for the final supply ($w_{126}, f_{128}$). $D_{24}$ returned to No. 55 mine, mining for 4 days, $D_{30}$ reached the end of 64, exhausted all resources at the same time, retaining the maximum remaining funds. In this level, the probability of $W_1$ is about 30%, the probability of $W_2$ is about 50%, and the probability of $W_3$ is about 20%.
4. Model establishment and solution for problem 2

4.1. Establishment and Solution of Mathematical Model of Level 3

Knowing that there is no $W_3$ within ten days of the third level, using the knowledge of probability theory, combined with the fifth level of the same map, the probability of the occurrence of the fifth level of the weather is inferred, and the probability of $W_1$ or $W_2$ is 50%. Through the analysis of the map, we can enumerate the two shortest routes: mining and not mining. Specific resource consumption is shown in Table 1. Among them, $W_2$ mining income is -205 RMB, and staying consumes resources 135 RMB, so $W_2$ does not mine.

| Status          | Stay       | Walk       | Mining       |
|-----------------|------------|------------|--------------|
| Sunny           | Water: 3boxes 15RMB | Water: 6boxes 30RMB | Water: 9boxes 45RMB |
|                 | Food: 4boxes 40RMB | Food: 8boxes 80RMB | Food: 12boxes 120RMB |
|                 | Total 55RMB  | Total 110RMB | Total 165RMB |
| Hot             | Water: 9boxes 45RMB | Water:18boxes 90RMB | Water:27boxes 135RMB |
|                 | Food: 9boxes 90RMB | Food:18boxes 180RMB | Food: 27boxes 270RMB |
|                 | Total 135RMB  | Total 270RMB | Total 405RMB |

$W_1$ mining revenue 35RMB  $W_2$ mining revenue -205RMB

Table 1. Resource consumption table of the third stage

The first mining route: 1→4→3→9 mine→11→13 end. Among them, it takes 5 days for the journey and 5 days for the mining time. Through the prediction of the weather, the following four situations can be drawn:

1. There are $2W_2$, $3W_1$ in the journey, which consumes 870 RMB; the mining process has $2W_2$, $3W_1$, which consumes 765 RMB, and the gain is 600 RMB; that is, the final consumption is 1635 RMB, the gain is 600 RMB, and the remaining 8965 RMB.

2. There are $2W_2$, $3W_1$ in the journey, which consumes 870 RMB; the mining process has $3W_2$, $2W_1$, which consumes 735 RMB, and the gain is 400 RMB; that is, the final consumption is 1605 RMB, the gain is 400 RMB, and the remaining 8795 RMB.

3. There are $3W_2$, $2W_1$ in the journey, which consumes 1030 RMB; the mining process has $2W_2$, $3W_1$, which consumes 765 RMB, and the gain is 600 RMB; that is, the final consumption is 1795 RMB, the gain is 600 RMB, and the remaining 8805 RMB.

4. There are $3W_2$, $2W_1$ in the journey, which consumes 1030 RMB; the mining process has $3W_2$, $2W_1$, which consumes 735 RMB, and the gain is 400 RMB; that is, the final consumption is 1765 RMB, the gain is 400 RMB, and the remaining funds are 8635 RMB.

The second non-mining route: 1→5→6→13 end. A total of 3 days of walking distance, through the prediction of the weather, the following four situations can be drawn:

1. $3W_1$, consuming 330 RMB, remaining 9670 RMB;
2. $W_2+2W_1$, consuming 490 RMB, remaining 9510 RMB.
3. $2W_2+1W_1$, consumes 650 RMB, and the remaining 9350 RMB;
4. $3W_2$, consumes 810 RMB, and the remaining 9190 RMB.

By comparison, mining is not as cost-effective as direct access. Therefore, the best strategy for this level is to start with $w_{54}$ and $f_{54}$, take the second non-mining route and reach the end point, so that the remaining funds can be kept the most.
4.2. Establishment and Solution of Mathematical Model of Level 4
According to statistical calculations, the probability statistics analysis of the 30-day weather in the first pass shows that the probability of $W_1$ is about 30%, the probability of $W_2$ is about 50%, and the probability of $W_3$ is about 20%.

Table 2. Resource consumption table of level 4

| Status | Weather   | Stay          | Walk          | Mining         |
|--------|-----------|---------------|---------------|----------------|
| Sunny  | Water: 5boxes 25RMB | Water: 10boxes 50RMB | Water: 15boxes 75RMB |
|        | Food: 7boxes 70RMB   | Food: 14boxes 140RMB  | Food: 21boxes 210RMB |
|        | Total 95RMB          | Total 190RMB         | Total 285RMB |
| Hot    | Water: 8boxes 40RMB | Water: 16boxes 80RMB | Water: 24boxes 120RMB |
|        | Food: 6boxes 60RMB   | Food: 12boxes 120RMB | Food: 18boxes 180RMB |
|        | Total 100RMB         | Total 200RMB         | Total 300RMB |
| Sandstorm | Water: 10boxes 50RMB | Water: 20boxes 100RMB | Water: 30boxes 150RMB |
|        | Food: 10boxes 100RMB | Food: 20boxes 200RMB | Food: 30boxes 300RMB |
|        | Total 150RMB         | Total 300RMB         | Total 450RMB |

$W_1$ mining revenue 715RMB  $W_2$ mining revenue 700RMB  $W_3$ mining revenue 550RMB

The route from the starting point to the mine is: 1→2→3→8→13→18 mine; the route from the mine to the village is: 18 mine→13→14 village→13→18 mine; the route from the mine to the end point is: 18 mine→19→20→25 end point; the route from the village to the end point is: 14 village→19→20→25 end point. Draw the following two schemes:

1. Suppose there are two rounds of replenishment from the mine to the village, and finally to the end at the mine. It takes 5 days from the starting point to the mine, and according to the weather conditions of the first pass, $W_3$ stays once in 5 days. Therefore, the journey from the starting point to the mine is 6 days, the replenishment takes 8 days, and it takes 3 days from the mine to the end point. Pass the previous question According to the analysis of $W_3$, the mining profit is the largest at $W_3$, so $W_3$ is used for mining. In summary, the journey takes 17 days, of which 1 $W_3$, 6 $W_1$, 10 $W_2$; mining takes 13 days, of which 4 $W_3$, 3 $W_1$, 6 $W_2$. Because some of its resources are purchased in the village, which is twice the basic price, when calculating the resource consumption price, the statistics are calculated based on 150% of the basic consumption. The total consumption resource price is 6,765 RMB, the total income is 13,000 RMB, and the remaining funds are 16,235. RMB.

2. Suppose that a supply is carried out from the mine to the village, and finally to the end point in the village. It takes 5 days from the starting point to the mine, of which 1$W_3$ causes a stay, so the journey from the starting point to the mine is 6 days, the replenishment takes 4 days, and the village to the destination takes 3 days. The journey takes 13 days and the mining time is 17 days. Among them, the distance is 1$W_3$, 4$W_1$, 8$W_2$, and the mining has 4$W_3$, 5$W_1$, 8$W_2$. The total resource
consumption price is 8,765 RMB, the total income is 17,000 RMB, and the remaining funds are 18,235 RMB.

Comparing the above two schemes, we can see that going from the starting point to the mine, then going to the village for replenishment, returning to the mine, and then going to the village for replenishment, the most benefit is gained from going to the end.

5. Model establishment and solution of problem 3
Two players are playing the game at the same time. It is necessary to judge whether to mine, whether mining can obtain higher profits, and save more reserved funds. Therefore, four routes are planned in this level and specific plans are proposed respectively.

5.1. Establishment and Solution of Mathematical Model of Level 5
Four feasible routes and corresponding specific plans, namely:

1. Mining route: 1→4→3→9 mine→11→13 end point. $D_1$ departs, $D_3$ arrives at the mine, digs for 5 days, $D_9$ leaves the mine, $D_{10}$ arrives at the end.
2. Route without mining: 1→5→6→13 end. $D_1$ starts, $D_3$ reaches the end.
3. No mining route: 1→4→5→12→13 end. $D_1$ starts, $D_3$ reaches the end.
4. No mining route: 1→4→7→12→13 end point. $D_1$ starts, $D_4$ arrives at the end.

| Status | Weather | Stay | Walk | Mining |
|--------|---------|------|------|--------|
| Sunny  |         |      |      |        |
|        | Water: 3 boxes 15RMB | Water: 6 boxes 30RMB | Water: 9 boxes 45RMB |
|        | Food: 2 boxes 40RMB | Food: 8 boxes 80RMB | Food: 12 boxes 120RMB |
|        | Total 55RMB | Total 110RMB | Total 165RMB |
| Hot    |         |      |      |        |
|        | Water: 1 boxes 45RMB | Water: 18 boxes 90RMB | Water: 27 boxes 135RMB |
|        | Food: 9 boxes 90RMB | Food: 18 boxes 180RMB | Food: 27 boxes 270RMB |
|        | Total 15RMB | Total 270RMB | Total 405RMB |

Based on the resource consumption in Table 3 and the above four routes, four strategies are synthesized:

The first strategy: Both players choose option one. each player consumes the same resources. The cost of each resource totals 3365 RMB. Since the two are mining at the same mine at the same time, their respective income is 500 RMB, and the final remaining funds are 7135 RMB. The remaining funds of the two people are 14,270 RMB.

The second strategy: Both players choose option two. each player consumes the same resources, and their respective resource consumption prices total 760 RMB, and the final remaining funds are 9,240 RMB. The two have a joint remaining fund of 18480 RMB.

The third strategy: $C(1)$ chooses option two, $C(2)$ chooses option three. $C(1)$ consumes a total resource price of 600 RMB, and the final remaining fund is 9,400 RMB. $C(2)$ The total resource consumption price is 600 RMB, and the final remaining fund is 9,400 RMB. The remaining funds of the two people are 18,800 RMB.

The fourth strategy: $C(1)$ chooses option two, $C(2)$ chooses option four. $C(1)$ consumes a total of 490 RMB in resource prices, and the final remaining fund is 9,510 RMB. $C(2)$ The total resource consumption price is 600 RMB, and the final remaining fund is 9,400 RMB. The remaining capital of the two people is 18910 RMB.

By comparison, the fourth strategy can maximize the amount of remaining funds for both parties, and the third strategy can achieve a win-win situation for both parties to obtain the same maximum amount of remaining funds. From the perspective of the game, strategy four has obtained the maximum remaining funds and is the best strategy. But from the perspective of social people
strategy three can ensure that two players cooperate willingly and achieve a win-win situation. At this
time, the third strategy is the best strategy.

6. Summary
Based on specific game rules and routes, this paper establishes a food and water replenishment and
consumption model and a map model made by Dijkstra's method[5]. In the line chart trend model, the
impact of weather, funds, and load changes are analyzed emphatically, and the three factors are
quantitatively expressed. From the overall situation, the prediction result of this model is better, and
the overall route is close to the shortest route, which is closer to the optimization result.

When calculating short-term consumption funds, graph theory and data analysis are used. The basic
basis is that many areas in the map are connected to the same area, and greedy ideas are added to the
consideration of the seven-branch function and the method of violence. This method fully pays
attention to the influence of the walking path on the final funds, and the solution process is simple and
clear.

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