Research on Game Strategy of Crossing Desert

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Abstract. This paper analyzes the players in the game of "crossing the desert", and puts forward the optimal customs clearance strategy to help the game players reach the destination within the specified time under the condition that the remaining funds are retained as much as possible. Firstly, the redundant paths are eliminated and the complete subgraph of the game map is drawn to improve the speed of computer optimization. Then, the multiple rules in the game are transformed into the constraints in the planning model, such as load constraint, remaining fund constraint, resource margin constraint and so on. By solving the model based on adjacency matrix and mixed integer programming, the rationality of the optimization strategy is verified by an example. The waiting model is used to decompose the number of players and consider different space and time to maximize the revenue of a mine as much as possible, while reducing the basic consumption of latecomers in a certain area and the consumption of resources purchased in the same village.

1. Introduction
There is a "across the desert" game, the goal of the game is to arrive at the end of the specified time, and retain as much money as possible. Players can use a map to purchase a certain amount of water and food (including food and other daily necessities) as supplies with initial funds, and walk in the desert from the starting point. On the way, players will encounter three different weather conditions, such as "sunny", "high temperature" and "sandstorm". Players can supplement funds or resources in mines and villages.

2. Known daily weather conditions
The map of the first level of the game consists of 1 starting point, 1 ending point, 1 village, 1 Mine and many common areas. Players can purchase initial resources at the starting point, buy supplies in villages, and mine in mines to obtain basic income. The player needs to reach the destination on or before the prescribed 30 day deadline with the support of resources that do not exceed the maximum load. After reaching the destination, the player's game ends. If the water or food has been exhausted in order to reach or not reach the destination within the specified time, it is regarded as a failure of the game.

In order to solve the problem, this paper uses the 0-1 integer programming model to obtain the maximum value of the optimal remaining resources, and then puts forward the optimal strategy for players in general. Namely:
At the same time, to meet the eight basic rules of the game, the following constraints are created:

\[
C_n = c - (pl + qf) + \sum_{i=1}^{n} We - \sum_{j=1}^{n} y_j \cdot 2p - \sum_{i=1}^{n} z_i \cdot 2q
\]  

(1)

At the same time, in order to meet the eight basic rules of the game, the following constraints are created:

\[
g \left( l - \sum_{i=1}^{n} A_i (1 + s_i + 2W_i) + \sum_{i=1}^{n} y_i \right) + h \left( f - \sum_{i=1}^{n} B_i (1 + s_i + 2W_i) + \sum_{i=1}^{n} z_i \right) \leq b
\]

\[
c - (pl + qf) + We - 2[\sum_{i=1}^{n} p y_i + q \sum_{i=1}^{n} z_i] \geq 2(p y_{i+1} + q z_{i+1})
\]

\[
2p \cdot y_i + 2q \cdot z_i \leq C_{n-1}
\]

\[
\sum_{i=1}^{n} A_i \cdot s_i + 2\sum_{i=1}^{n} A_i W_i - \sum_{i=1}^{n} y_i - l \leq -A_i
\]

\[
\sum_{i=1}^{n} B_i \cdot s_i + 2\sum_{i=1}^{n} B_i W_i - \sum_{i=1}^{n} z_i - f \leq -B_i
\]

(2)

\[\begin{align*}
W_i &\leq \sum_{j=1}^{k} x_{ij} \\
x_{i+1} &\leq x_{ij} + s_i \\
s_i &\leq 1 - w_{i+1} \\
W &\leq 1 \\
\sum_{i=1}^{k} x_{ij} &\leq 1
\end{align*}\]

At the same time, there are corresponding constraints on the resource margin:

\[
\begin{align*}
\sum_{i=1}^{n} A_i \cdot s_i + 2\sum_{i=1}^{n} A_i W_i - \sum_{i=1}^{n} y_i - l &\leq -A_i \\
\sum_{i=1}^{n} B_i \cdot s_i + 2\sum_{i=1}^{n} B_i W_i - \sum_{i=1}^{n} z_i - f &\leq -B_i
\end{align*}
\]  

(3)

That is, in the process of travel, we must ensure that there is surplus water and food. When reaching the end of the day, the surplus of water and food can be zero:

\[
\begin{align*}
\sum_{i=1}^{n} A_i \cdot s_i + 2\sum_{i=1}^{n} A_i W_i - \sum_{i=1}^{n} y_i - l &\leq -A_i \\
\sum_{i=1}^{n} B_i \cdot s_i + 2\sum_{i=1}^{n} B_i W_i - \sum_{i=1}^{n} z_i - f &\leq -B_i
\end{align*}
\]

(4)

The load constraint is one of the most important constraints in the process of marching. Players carry more than their own weight limit.
At the same time, due to the sandstorm weather must stay, the constraint conditions are generated:

\[
\begin{align*}
&x_{i+1,j} \leq x_{ij} + s_i \\
&x_{ij} - s_i \leq x_{i+1,j} \leq (1-s_i) + (1-x_{ij}) & i = 1, 2, \ldots, a-1
\end{align*}
\]  

(6)

Case 1: "no mining"

In this case, in order to minimize the resource consumption, players must choose the nearest route to shorten the clearance days as much as possible. In order to reflect the rigor of the data, this paper provides the purchase of water resources, food resources and capital surplus for 3, 5 and 10 days of customs clearance. The specific information is shown in the table below (because the fourth day is sandstorm weather and must stay, so the customs clearance days cannot be 4 days).

**Table 1. list of customs clearance of three kinds of non mining**

| Customs clearance days | water resource Purchase / kg | Food resources Purchase / kg | Capital surplus Situation / yuan | Residual water / kg | Food surplus / kg |
|------------------------|----------------------------|----------------------------|---------------------------------|-------------------|------------------|
| 3                      | 126                        | 76                         | 9410                            | 0                 | 0                |
| 5                      | 162                        | 112                        | 9170                            | 0                 | 0                |
| 10                     | 294                        | 196                        | 8630                            | 0                 | 0                |

Case 2: "mining"

In this case, in order to achieve the maximum capital surplus, it is necessary to earn as much money as possible in the mine, and at the same time, the consumption in the journey should be considered. For this purpose, this paper provides five kinds of customs clearance paths, as shown in the following table:

**Table 2. list of customs clearance of five kinds of mining**

| Customs clearance days | water resource Purchase / kg | Food resources Purchase / kg | Capital surplus Situation / yuan | Residual water / kg | Food surplus / kg |
|------------------------|----------------------------|----------------------------|---------------------------------|-------------------|------------------|
| 26                     | 573                        | 626                        | 10225                           | 0                 | 0                |
| 27                     | 537                        | 662                        | 10375                           | 0                 | 0                |
| 28                     | 516                        | 684                        | 10490                           | 0                 | 0                |
| 29                     | 516                        | 684                        | 10290                           | 0                 | 0                |
| 30                     | 516                        | 684                        | 10090                           | 0                 | 0                |
Table 3. location in villages in 28 days

| Purchasing resources | Purchase times | for the first time | The second time | third time |
|----------------------|----------------|-------------------|-----------------|-----------|
| Water resources / kg  | 561            | 78                | 60              |
| Food resources / kg   | 0              | 50                | 40              |
| Cost / yuan           | 1870           | 760               | 700             |

Table 4. players in mines within 28 days

| situation | Days | Money earned | Spending money |
|-----------|------|--------------|----------------|
| stop      | 4    | 0            | 550            |
| mining    | 8    | 8000         | 2175           |

Through the comparative analysis of the above two situations, the following conclusions are drawn: in the first pass, when the customs clearance days are 28 days, namely, the optimal solution is to purchase 516 kg of water resources and 684 kg of food resources, and 10490 yuan of surplus bonus can be obtained. The required clearance days are 28 days. During this period, there are 7 days to stay and 8 days to mine. Players spend 4280 yuan at the starting point to purchase materials, including 172 boxes of water and 342 boxes of food, with a total weight of 1200 kg, which does not exceed the maximum load. After the game starts, the player experiences the consumption of staying, walking and mining under different weather conditions, and gets the mining income at the same time, and finally reaches the terminal point on the 28th day. At this time, the remaining fund is the largest among many schemes, reaching 10490 yuan.

3. Weather conditions are known for that day

The transition probability matrix is a branch concept in Markov chain, which divides a research process into m states. The sample starts from any state and passes through any transfer, any one of the necessary states.

Transfer probability matrix:

\[ R = [p_{11}, p_{12}, \ldots, p_{1n}] \]  

(7)

When the total number of possible transitions of sample state m is I, the transition probability from this state to a future state is

\[ P_i(m, m+n) = P\{X_m + n = a_j \mid X_m = a_i \} \]  

(8)

In this paper, three kinds of weather probabilities in question 2 are predicted according to the transition probability model. According to the existing weather probability, the weather probability in the process of customs clearance in the future is predicted.

Prior weather probability

\[ R = \begin{bmatrix} p_{11}p_{12}p_{13} \\ p_{21}p_{22}p_{23} \\ p_{31}p_{32}p_{33} \end{bmatrix} \]  

(9)
The prior probability of three kinds of weather is used as transfer probability matrix to forecast the future weather. The probability of sunny, high temperature and sandstorm are

\[
R = \begin{bmatrix}
0.5 & 0.4 & 0.1 \\
0.47 & 0.43 & 0.1 \\
0.3 & 0.6 & 0.1 \\
\end{bmatrix}
\]  \hspace{1cm} (10)

The probability of three kinds of weather forecast is as follows:

4. Conclusion
In this paper, the linear programming model is used to analyze the optimal strategy of the game of "crossing the desert". The eight game rules in the game are transformed into equality constraints or non equality constraints in the linear programming model, such as weight-bearing constraints, residual capital constraints, resource constraints and other constraints. A number of 0-1 variables are used to represent the game states such as the staying and marching, whether mining or not. The maximum surplus fund is taken as the objective function to solve the problem.

Taking the number of days in the game as the simulation test value, the computer simulation method is used to simulate the game state, output the remaining funds, remaining water, surplus food and the path of the player, so as to determine the optimal strategy of the player through each level. The results are scientific and accurate.

The game optimal strategy can be used as the reference problem solution of multi-objective graph theory planning problem without distance as the condition; in the planning problem with many constraints and difficulty, the transformation idea of planning condition in this paper can be used for reference; this paper is a planning problem solving method based on computer simulation, and its scientific city and accuracy can be used in urban planning and road traffic planning. It will be divided into forward-looking disciplines and industrial fields which are more forward-looking and difficult to operate in practice, so as to scientifically predict the future in the form of simulation test.

5. References
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