Analysis of Decision and Arrangement Problems for Desert Crossing Based on Dynamic Programming Model

Wang Chunli*, **Linlin Fan, Mei Zhang, Keyue Chen**
School of Tourism Data,Guilin Tourism University, Guilin, Guangxi, China,541006
**Corresponding Author.*

Abstract: A playing method is aimed at the walkthrough of cross the dessert. First of all, the game is based on knowing all the weather conditions in advance, establishing the upper limit of load, initial capital, basic income, basic consumption, time and other conditional indicators, and then build dynamic programming model which is related to shortest path method. Moreover, given the weather conditions of the day to make dynamic choice, it can use Markov prediction model to forecast the weather and work out optimal revenue strategy. Finally, use game theory to analyze and renew your strategy sets, and adjust your strategy according to analysis result, putting forward reasonable and effective conclusion.

Keywords: Cross the Dessert; Dynamic Programming; Shortest Path; Markov Prediction; Game Theory

1. Introduction

With the development of the society, game have become an indispensable part of entertainment in people’s life. Now there is a game of dessert, players have only one map, use the initial amount to buy certain materials, and walk in the desert from the beginning to the end. There are village supply depot,mine and different climates on the map. The way of the game is as follows: try to give the best revenue plan for the player under the known weather of each day, or the player only knows the weather of that day and decides the action plan for that day, or under the condition of having n players, the resource consumption is doubled as the basic energy; If n gamers dig a mine, one consumes three times as much resources, and if they buy resources in the same village at the same time, the unit price increases four times. The rest of the basics are the same as in the single-player game. This makes the research analysis.

2. The Establishing and Solving of Player Decision- Making Model

In the process of solving the game, players will face different natural conditions or objective conditions in the game state, so it is necessary to make corresponding decisions on the stage and state of players, and use dynamic programming multiple decisions to study the optimal solution of the game, so as to enable players to better survive in the game and surpass other players.

Firstly, to solve routing problems we consider using Dijkstra algorithm to solve the shortest path problem, and then consider the two routes with and without revenue. Then, combined with all the conditions to constrain our results, especially for the unknown weather, we can adopt the Markov prediction model to predict the weather of tomorrow, and use the strategy theory to compete with the players playing the game together to plan the optimal route plan.

2.1 Research Idea

During the process ,game players have always played around the survival and profit, calculate the shortest distance to save players supplies,consider whether there is income or not,make a balance between weather conditions and the benefit of arriving at the mine,analyze the stage,state,decision,evaluation phase and indicator function under the dynamic programming[1-2], therefore, get the optimal route.

2.2 The Shortest Path of Dijkstra

Objective function:

$$Y_{\max} = 10000 - y_1 - y_2 + y_3 + y_4 \quad \text{..................(1)}$$

$$S.J\begin{cases} 3W_1 + 2F_1 \le 1200 \\ 5W_1 + 10F_1 + 10W_2 + 20F_2 \le 10000 + y_3 \\ \sum_{j=0}^{k} w \le W \\ \sum_{j=0}^{k} f \le F \end{cases} \quad \text{........(2)}$$

Explanation of nouns: W refers to the total tanks of water, F refers to the total tanks of food, W_1 and F_1 are the initial purchases, W_2 and F_2 are the second purchases, y_1 and y_2 respectively represent the cost of first and second purchases, y_3 represent the money earned from mine, and y_4 represent the money gained from the final sale of the food.

The factors that affect players making decisions: level clear,weather,supplies,maximum of profit , and finally, to get the maximum of objective function.

The fundamental thinking of Dijkstra's Algorithm[3-5]:

At first, setting an aggregat $S=\{V_0\}$,and another aggregate is $V-S$={another vertex}, the distance value corresponding to the vertex in the $V-S$ is (V_0,V_i) , the $D(V_0,V_i)$ is the weight value on the arc, and if not, the $D(V_0,V_i)$ is the ∞ (set a large integer).

Selecting a vertex which exists the incident edge connected with the vertex $V_{\min}$ in the S from $V-S$, and add it to the S.

Revising that to go from V to any vertex in aggregate $V-S$.

repeating the above steps (2),(3)about $n-1$ times until S contains all of the vertexes, that is $V_{\min}=V_i$.

In the first level, the requirements of the game are to assume that there is only one player, and the weather conditions of each day are known in advance throughout the game period, so please try to give the optimal strategy of the player under general circumstances. The level map is shown in the figure below:

After calculating, it takes at least 8 days to reach the mine from the starting point. Considering the weather conditions, it takes 10 days or 11 days to reach the mine. The routine is shown in Fig.2 :

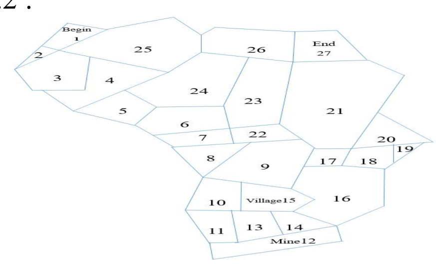

Figure 1. First Level Map

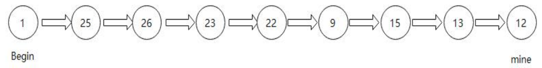

Figure 2. Shortest Path to Mine

Function:

$$y_1 max = 5W + 10F \quad \text{..................(3)}$$

$$s.j\begin{cases} W \le 228 \\ F \le 220 \\ 3W + 2F \le 1200 \end{cases} \quad \text{......................(4)}$$

Finally get this : $Y_{\max} = 10000 - y_1 - y_2 + y_3$

In the second level, the game requirements are the same as the first level, the level map is shown in Fig.3:

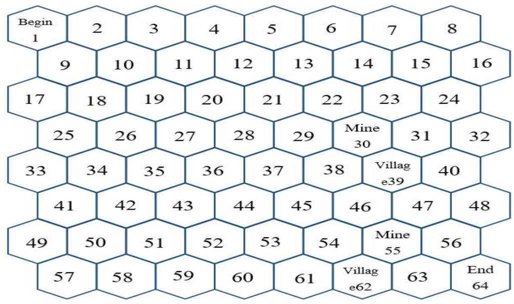

Figure 3. Second Level Map.

The best Revenue route:

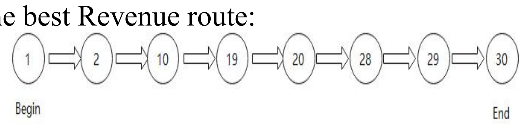

Figure 4. Shortest Path to Mine

$$Y_{\max} = 10000 - y_1 - y_2 + y_3 \quad \text{............(5)}$$

Function:

$$\begin{cases} W_1 + W_2 = 124 + 3\sum_{j=10}^{10+N} w_j + 2\sum_{j=10+N}^{14+N} w_j \\ F_1 + F_2 = 110 + 3\sum_{j=10}^{10+N} f_j + 2\sum_{j=10+N}^{14+N} f_j \\ 3W_1 + 2F_1 \le 1200 \\ y_1 + y_2 \le 10000 + y_3 \end{cases} \quad \text{.................(6)}$$

Explanation of nouns: w_j represents the total number of water tanks consumed on the j day , f_j represents the total number of food tanks consumed on the j day.

3. Markov Forecasting Model

3.1 Research Route

The weather here is unknown, and we only get the weather condition of the day. If we want to forecast the weather in tomorrow with the known weather conditions of the day, what we should consider first is the Markov Forecasting

Model, and forecast through the previous data collection.

3.2 Establishment and Solvation about Model

For the third level, the game requires that there is only one player, and the player only knows the weather conditions of the day, so he can decide the action plan of the day according to this, and try to give the best strategy for the player under general conditions. The level map is as follows:

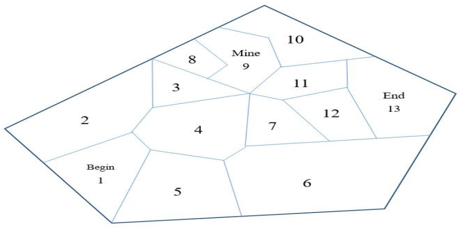

Figure 5. Third Level Map

According to the shortest distance, as shown in the illustration:

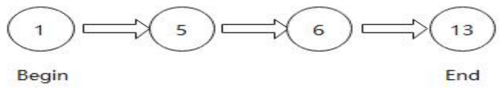

Figure 6. Start to Finish

The consumption resources in three-days walk:

$$\begin{cases} \sum_{j=1}^{3} w_j \\ \sum_{j=1}^{3} f_j \end{cases}$$

Remaining cost: $y = 10000 - y_1$

It can be concluded that working in the mine for 6 days, from the perspective of income, from the starting point to the mine and then to the end, the player cannot earn back the cost in a limited period of time. Therefore, no matter what the weather is, we should choose directly from the beginning to the end, which is the most cost-effective scheme.

For level 4, the game requirements are consistent with level 3. The level map is as follows:

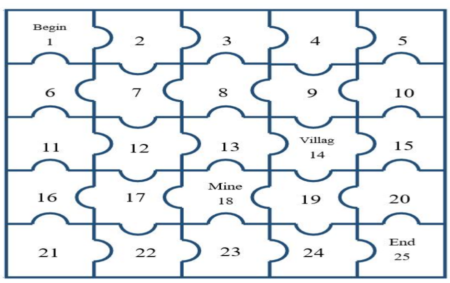

Figure 7. Fourth Level Map

In order to forecast the weather probability of tomorrow, Markov prediction method[6-8] can be used to predict the probability of weather in tomorrow, $\pi_j(k)$ indicates that the event is known condition when be in the initial state $(K=0)$,and after K state transitions, the probability of the event in the state E_j at the K moment (period) is:

$$\sum_{j=1}^{N} \pi_j(k) = 1 \quad \text{.......................(7)}$$

To start with the initial state, the process of reaching state E_j after K state transitions can be regarded as the process of first reaching state after K state transition, and then reaching state E_j after E_i experiences one state transition. According to the no aftereffect and Bayes[9] conditional probability formula of Markov Process, it is:

$$\pi_j(k) = \sum_{i=1}^{n} \pi_i(k-1) P_{ij} \, (j = 1, 2, \cdots n) \quad \text{.........(8)}$$

If record the row vector $\pi(k) = [\pi_1(k), \pi_2(k), \cdots, \pi_n(k)]$, and then according to formula (8), the recurrence formula for calculating the state probability can be obtained step by step:

$$\begin{cases} \pi(1) = \pi(0)P \\ \pi(2) = \pi(1)P = \pi(0)P^2 \\ \vdots \\ \pi(k) = \pi(k-1)P = \pi(0)P^k \end{cases} \quad \text{...................(9)}$$

In the formula(9), $\pi(0) = [\pi_1(0), \pi_2(0), \cdots, \pi_n(0)]$ is the initial state probability vector.

State transition is of probability, and there are only four possibilities about weather conditions: sunny to sunny, sunny to high temperature, sunny to sandstorm, high temperature to high temperature, high temperature to sandstorm, sandstorm to fine, sandstorm to high temperature and sandstorm to sandstorm. We can simulate the weather, from sunny to sunny twice, from sunny to high temperature for 5 times, from sunny to sandstorm for 2 times, from high temperature to sunny for 5 times, from high temperature to high temperature for 6 times, from high temperature to sandstorm for 3 times, from sandstorm to sunny for 2 times, from sandstorm to high temperature for 3 times, and from sandstorm to sandstorm once. Therefore, we can record sunny as E_1 high temperature as E_2 ,sandstorm as E_3 .So the matrix is following:

$$P=\begin{bmatrix}0.22 & 0.56 & 0.22\\ 0.36 & 0.43 & 0.21\\ 0.33 & 0.50 & 0.17\end{bmatrix}$$

4. Game Theory Model Establishment

4.1 Research Ideas

In a "N" human game, people need to combine old and new rules to handle the multiplayer solution. Different routes took by different players, as well as all kinds of weather, stay time, mining and other issues, which need to be comprehensively discussed. It can be analyzed according to the single player game method first, and then combined with the available two-person scheme to discuss.

4.2 The Establishment and Solution of Model

In the fifth level of the game that requiring in the case of "N" players, assuming that all the weather conditions of each day are known in advance during the whole game period, the action plan of each player should be determined on the "0" day and cannot be changed hereafter. Trying to give general strategies that the player should take in normal circumstances. The level map is as follows:

4.2.1 Route: Begin to End

The shortest route from the beginning to the end is only three days. Taking all factors into consideration, and choose the best route for customs clearance as soon as possible.

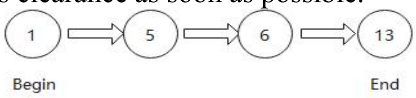

Figure 8. Start to Finish

The scheme presentation and analysis under different strategies need to be customized by the players, then play to choose the route they want to pass.

4.2.2 Establishment of Game Model in the Sixth Level

There are at least two players on the same map in the game requirement. Knowing the weather conditions of each day, the remaining players' action plan and the amount of remaining resources after the action was finished on that day in advance. Then, players determine their action plan for the next day. By establishing a game theory model [10-11]. Setting I to represent player in the game ,there is $I=\{1,2,3\}$, S_i represents player strategy set,including resources,economy,weather conditions,etc.There is a strategy set in S_i

$$s=(s_1,s_2,s_3) \quad \text{..................(10)}$$

I is 1, represents sunny days; I is 2, represents high temperature; I is 3, represents windstorm. In addition, another route should be recorded. The set of S in the whole situation can be explained by the Cartesian product [12-13] of the strategy sets of all players.

$$S=S_1\times S_2\times S_3 \quad \text{.....................(11)}$$

For any situation, $s\in S$ player i ,can win a $H_i(s)$,thus obtaining a vector win function.

$$H(s)=(H_1(s),H_2(s),H_3(s)) \quad \text{............(12)}$$

4.3 Solution of Model

Making a perfect strategy analysis [14 - 15] and the design scheme. In the set of a computer, it doesn't seem to be found immediately by participants, which needs to be defined possibly from different factors. There are four basic plans in this direction. The first one is from the starting point to the end directly. The second one is from the starting point to the village to buy new goods first, then set out to mine, and finally to the finish line. Or from the beginning to the mine, then to the village, and finally to the end. Or from the beginning to the mine, and then back to the beginning, and then start again to the end. The player's mental tactic is sitting and observing the chance of plan, and may also exists a condition that the player anticipating bad weather and not acting. When purchasing materials in villages and working in mines, players' strategies will be changed accordingly. These strategies are made to survive longer or earn more money from mines. Finally, players only need to work out the vector win function to solve this problem.

5. Conclusion

In this paper, according to the dynamic programming model, shortest path method, Markov prediction, game theory for calculation and analysis, using a large number of data processing, so that the results are relatively reliable. In the analysis of game theory model, the important strategy sets are mainly considered, and some insignificant ones can be considered to be eliminated. Game theory can handle any behavior with competitive or antagonistic quality well. So when we play a difficult game across the desert, we can use these methods to crack and get the best solution.

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