The research of camping along the big long river based on optimized model

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Abstract

This paper establishes a model to schedule trips down the Big Long River. The goal is to develop the best schedule and determine the carrying capacity of the river. This paper set out essential limits in the process of calculating the utilization ratio of the campsite to simplify the model preliminarily. It proposes scheduling groups down river in order to maximize the campsite utilization. In order to ensure each group enjoy a wilderness experience, this paper simplifies the model by the hypothesis that the travel groups behind could never catch up with the groups which are in front of them. This paper calculates the camp utilization ratio in a six-month season, and regards it as the objective function. Eventually, this paper determines the schedule to launch an optimal mix of trips, of varying duration and propulsion that will utilize the campsites in the best way possible.

Keywords: optimization algorithm, optimized model, mathematical modelling

1 Introduction

1.1 PROBLEM STATEMENT

Visitors to the Big Long River can enjoy scenic views and exciting white water rapids. The rise in popularity of river rafting calls for a solution to allow more trips to travel down the river [1]. River trips all start at First Launch and exit the river at Final Exit, 225 miles downstream [2]. Passengers take either oar-powered rubber rafts or motorized boats to spend 6 to 18 nights camping on the river, start to finish. No two groups can occupy the same site at the same time. Minimal contact with other groups of boats on the river should also be considered to ensure each group enjoy a wilderness experience in the optimal solution [3].

1.2 MODEL OVERVIEW

We propose scheduling groups down the Big Long River in order to maximize the campsite utilization.

- We calculate the camp utilization ratio during six months, and regard it as the objective function. Obviously, when the camp utilization increases, there will be more travel groups can travel the river.
- To simplify the model preliminarily, we set out essential limits in the process of calculating the utilization ratio of the campsite.

1.3 CONSTRAINTS

The problem specifies the following constraints:

- Six months mentioned in the problem equals to 180 days.
- About each group travels the same miles every day, but different groups can travel different miles in a day. Each group can only stay one night at the same campsite. Both oar-powered rubber rafts and motorized boats sails on a uniform velocity (oar-powered rubber rafts on 4 mph and motorized boats on 8 mph).
- We can prescribe the proportion of oar-powered rubber rafts to motorized boats.
- The travel groups behind could never catch up with the groups which are in front of them.
- Groups can travel only between 8 a.m. and 6 p.m., a maximum of 10 hours of travel per day.

1.4 CASE STUDY

Shechter and Lucus (1978) developed the wilderness use simulation model (WUSM) to simulate hikers' use of trail segments, cross-country travel routes and camping sites in order to estimate the numbers of encounters and potential conflicts among groups [4]. The WUSM model lacked many details of the actual river trip situation, but having fixed trip itineraries with only launch date and trip length as variables [5].

A computer program called the Grand Canyon River Trip Simulator has been developed for use by managers at the Grand Canyon National Park. GCRTSim consists of a database and a simulator, as well as extensive analysis tools [6]. The database will eventually contain approximately 500 trip diaries collected in 1998 and 1999 that report stops for activities and camping along the 226 mile Colorado River corridor within the purview of the National Park Service [7-8]. The simulator provides users

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with the opportunity to set up prospective launch schedules for rafting trips and to simulate rafting seasons using these launch calendars. Both the trip diary database and the results of the simulations can be analysed using extensive graphing tools [9]. The analysis can provide insight into use levels that could impact both the recreational experiences and the treasured resources along the Colorado River corridor [10].

2 Definitions and notation

The Grand Canyon is an ideal case study for our model, since it shares many characteristics with the Big Long River. The Canyon's primary river rafting stretch is 226 miles, it has 235 campsites, and it is open approximately six months of the year. It allows tourists to travel by motorized boat or by oar-powered river raft for a maximum of 12 or 18 days.

Figure 1 shows that the distance of two neighbouring campsites is around 1mile so we can assume that the total number of campsites is fewer than 224.

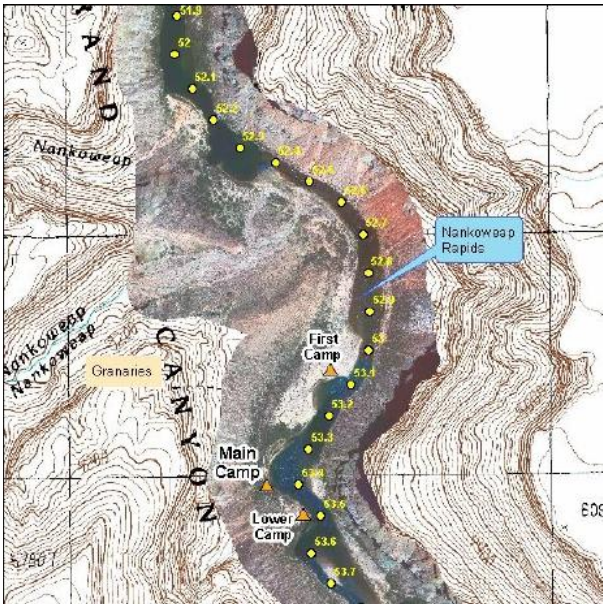

FIGURE 1 The campsite of the Grand Canyon

The manager wants to know ways in which to develop the best schedule and determine the carrying capacity of the river. For the sake of determining how to schedule an optimal mix of trips, of varying duration (measured in nights on the river) and propulsion (motor or oar) that will utilize the campsites in the best way possible, we simplify the model by some essential constraints.

We obtain from the problem statement that the travel duration of each group is limited in 6 to 18 nights and each group can only move downstream and stay one night at the same campsite. So we have $18 \le Y \le 224$, $6 \le N_i \le 18$. The velocities of each group are V_i = 4 mph or V_i = 8 mph.

TABLE 1 Definitions and Notation

Variable	Explanation
X	the total number of groups launched by managers in 6 months
Y	the total number of campsites
N_i	the days group i traveling on the river
V_i	the velocity of group i
T_i	the date of group i start
$L_{i,j}$	the sequence number of campsite where group i stays at the date j
t_i	the time group i traveling each day on the river
S_i	the course group i traveling each day on the river
m_i	the number of campsites group i pass by but not stay each day
n_k	the number of campsite k be occupied
∂_k	the utilization of campsite k
$M_{i,j+1}$	the distance between group i and the group in front

3 Methods

3.1 THE GRAND CANYON

X groups travel down the Big Long River each year during a six month period (the rest of the year it is too cold for river trips). So $1 \le T_i \le 180$, where T_i is the date when the group i starts.

We construct a matrix, with the elements of the matrix describing the sequence number of campsite where group i stays at the date j, so $1 \le j \le X$, $1 \le j \le N_i$. We know:

$$t_i = \frac{225}{(N_i + 1)V_i}, \tag{1}$$

$$S_i = V_i t_i = \frac{225}{N_i + 1}, \tag{2}$$

$$S_i = \frac{225 - L_{i,1}\dfrac{225}{Y+1}}{N_i}, \tag{3}$$

$$S_i = L_{i,j} - L_{i,j-1}. \tag{4}$$

The distance of two neighbouring groups is:

$$M_{i,i+1} = \left\{ (T_{i+1} - T_1) t_{i+1} V_{i+1} - (T_i - T_1) t_i V_i \right\} \frac{Y+1}{225}. \tag{5}$$

Since we assume that the travel groups behind could never catch up with the groups which are in front of them, we get:

$$m_i = S_i \frac{Y+1}{225} - 1, \tag{6}$$

$$n_{i+1} \le M_{i,i+1} + n_i. \tag{7}$$

The utilization of campsite k is:

$$\partial_k = \frac{n_k}{180}, 1 \le k \le Y, \tag{8}$$

$$\sum_{k=1}^{Y} n_k = \sum_{i=1}^{X} \frac{N_i}{180Y}. \tag{9}$$

We define the final objective function:

$$f = \max \sum_{i=1}^{X} \frac{N_i}{Y}. \tag{10}$$

4 Conclusions

4.1 STRENGTH

- In our optimization algorithm model, we make some reasonable assumptions to decrease the number of unknown variables. Then we transform the complex problems into solvable mathematical model of non-linear programming.
- We assume that each team travels the same miles every day, and we do not allow different groups to meet at the travel course. Therefore, we weaken the condition that all groups on the river meet less as soon as possible and only consider the maximal carrying capacity of the river.
- We take advantage of the method of optimization algorithms and find the objective function, and then we adopt Lingo to solve the problem.

4.2 WEAKNESS

- In our optimization algorithm model, we assume that each team travels the same miles every day and we do not allow different teams to meet at the travel course on the river. While our models attempt to get a reasonable and convincing result, there also exist limitations.
- While using the Lingo to solve this problem which contains a large number of variables, it has some limitations in dealing with large scale optimization.
- All the process does not consider the impact of weather factors, but the weather does affect the actual schedule.

4.3 IMPROVEMENTS

In our optimization algorithm model we presume that each team travels the same miles every day and cannot meet any other teams. In fact, this situation does not exist in real life. If we abandon this assumption and re-establish restraint conditions and objective function, we will get the solution more in line with the actual situation.

TABLE 2 Optimal Schedules

optimal X	43				
No.	Nights	Starting day No.	The sequence No. of campsite which the team first stay	Boat type	Travel hour per day
1	14	1	4	m	3
2	13	1	1	m	3
3	11	2	3	o	4
4	11	3	3	o	4
5	11	4	3	o	4
6	14	5	3	m	3
7	14	6	3	m	3
8	10	6	2	o	4
9	14	7	4	m	3
10	11	8	4	o	4
11	10	8	2	o	4
12	10	9	2	o	4
13	11	10	3	o	4
14	11	10	4	o	4
15	11	10	3	o	4
16	11	10	4	o	4
17	10	11	2	o	4
18	11	12	4	o	4
19	11	12	3	o	4
20	10	13	1	o	4
21	13	14	2	m	3
22	11	14	4	o	4
23	13	15	1	m	3
24	10	16	1	o	4
25	10	16	2	o	4
26	13	17	2	m	3
27	9	17	4	o	2
28	13	18	2	m	3
29	10	19	2	o	4
30	11	20	3	o	4
31	11	21	3	o	4
32	13	21	1	m	3
33	10	22	2	o	4
34	10	23	2	o	4
35	13	23	1	m	3
36	14	23	4	m	3
37	11	24	4	o	4
38	10	25	2	o	4
39	10	26	1	o	4
40	11	27	4	o	4
41	11	28	3	o	4
42	10	29	2	o	4
43	11	30	3	o	4

5 Discussion and future work

In the process of solving the questions raised in the above issue, we have some important discoveries. We have established an optimization algorithm model (Appendix) successfully solved the maximum carrying capacity of the Big Long River within a half year and the schedule of travel arrangements for travellers who come here. Now, we write this memo to tell Managers our important findings.

The results of our optimization algorithm model are particularly detail. As long as we input the parameters necessary, results can be got. The results include the launched number of the two types of boats every day, their start time, their duration time (from 6 to18days) on the river and even the serial number of campsite each group lives every night. By controlling the way of launch we guarantee that the boats launched late can never catch up with the boats in front. In this way, our model ensures that every trip can enjoy a wilderness experience, with minimal contact with other groups of boats on the river as well as the maximal carrying capacity of the river.

By improving the algorithm, an important discovery has been found. We found how the number of campsites on the river corridor affects the number of boats Managers can send downstream. If the campsite number is less, namely, the parameter Y we input is less, the maximal carrying capacity of the river decreases accordingly. Conversely, if the number of campsites increases, the maximal carrying capacity of the river becomes larger accordingly.

When this model is applied to the Colorado River, if we find the number of boats Managers can send downstream small, our algorithm can tell us how many more groups could be added to the river each day. Conversely, if we are experiencing river congestion, we can determine how many groups should be reduced on the river, as well how many groups waiting to begin their travel should be reduced? If we have the data of future waitlists, our algorithm can output schedules in advance, allowing Managers to schedule the precise campsite location of any group.

Our algorithm has been thoroughly applied to the Colorado River. Compared with the previous data; the deviation of it is small. We believe that our model is a powerful tool for determining the river's maximal carrying capacity, optimizing daily schedules, and ensuring that people will be able to complete their trip as planned as well as enjoying a true wilderness experience.

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Appendix

```
!fu1;
sets:
data1/1..3/:m,t,i;
endsets
max=@sum(data1:m);
n=@sum(data1:m);
m(1)/m(2)=0.3065/0.3675;
m(1)/m(3)=0.3065/0.326;
@sum(data1:t)=180;
@for(data1:m<=i*t);
data:
i=1 2 3;
enddata
@for(data1:@gin(m));
@for(data1:@gin(t));
end

!fu2;
sets:
data1/2,3/:m,t,i;
endsets
max=@sum(data1:m);
n=@sum(data1:m);
m(1)/m(2)=0.6/0.4;
@sum(data1:t)<=180;
@for(data1:m<=i*t);
data:
i=2 3;
enddata
@for(data1:@gin(t));
end

!fu3;
sets:
m/1..8/:n,x,y,t;
endsets
data:
zhanshu=?;
enddata
@for(m(i):x(i)=225/zhanshu*n(i)/4);
@for(m(i):t=zhanshu/n(i));
@for(m(i):y(i)=225/zhanshu*n(i)/8);
data:
n=1 2 3 4 5 6 7 8;
enddata
end
```

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