Based on greedy thought and discrete optimization design of airport bus area

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Abstract: Most airports have taxi-carrying areas where passengers and taxis line up for departure. Proper design of the bus area can effectively improve the efficiency of passengers on the premise of ensuring safety. In this paper, an optimization model of passenger boarding efficiency is established by means of greedy thoughts. The study object is divided into several identical subdivisions, and each object is matched with a "pickup point", a certain number of taxi berths and passenger queuing points. Through discrete optimization, the design scheme of the corresponding "loading point position" and the number of taxi berths when the loading efficiency reaches the highest is solved.

1. Introduction

Domestic airports limit taxis to queue up to pick up passengers in a designated area, which is called the "arrival area" from the airport to the urban area or surrounding areas. The area connected with the "arrival area" is the "loading area", and there are manual or machine control between the two areas. Passengers are allowed to queue up in the "load zone" to board. In order to ensure the safety of vehicles and passengers, when all taxis in the "loading area" leave with passengers, the control will release the taxis queuing in the "arrival area" into the "loading area" to wait for passengers to board. The "loading area" is composed of "taxi queuing area", "passenger queuing area" and "boarding point". Among them, "taxi queuing area" refers to the designated parking area for taxis waiting for passengers after controlled release, and each taxi can only park in the designated parking space; "passenger queuing area" refers to the area where passengers waiting to leave the airport waiting for boarding, and each passenger needs to queue up in this area; and "boarding point" is the connection between the above two queuing areas. In order to ensure the safety of vehicles and vehicles, passengers in the "passenger queuing area" can only queue up to enter the "taxi queuing area" after passing through the "boarding point". There can be multiple "boarding points", and passengers can queue up in the "passenger queuing area" corresponding to each "boarding point".

2. Efficiency of boarding system

Suppose that the distance between the passengers in the "passenger queuing area" is DP, the distance PS between the passengers at the head of the queue and the "boarding point" is 0, the center distance of the two parallel lanes is RW, half of the length of the vehicle is SL, and the safety distance is SD. In the "boarding point", there are m taxis on the left and N taxis on the right. Under the initial state, there are 2 (M + N + 1) taxis waiting for "taxi". The "boarding point" can provide taxis for at least 2 (M + N + 1) passengers. For the I (I = 1,2,3,...) on the right side of the "boarding point" from right to left .The taxi far away from the "boarding point" is the 2nd I-1 passenger in the queue. The total walking distance from the waiting position to the corresponding taxi is

$$ds = dp(2i - 2) + rw + (n + 1 - i)(sd + 2sl) \qquad (1)$$

3. Solving the maximum value of boarding system efficiency

The ultimate purpose of establishing the above boarding system is to seek a reasonable design scheme of the research object, that is, the design scheme of "passenger capacity", "vehicle capacity" and "boarding point location" within the unit research object, so as to maximize the riding efficiency of the overall "load zone". Taking the efficiency of the train as the objective function, the design scheme (M and N) and efficiency are studied"The optimization model of this paper is established.

3.1 Determination of objective function

$$\max \quad \eta = \frac{2(m+n+1)*num}{sumT} \qquad (2)$$

3.2 Determination of constraint conditions

In the process of solving the objective function, except that x, DP, RW, SD, SL and PV are constants, the independent variables are m and N, and the secondary variables are I and j, which satisfy the following requirements

$$
\begin{cases}
tr = \dfrac{\max\{dp*(2i-2)+rw+(n+1-i)*(sd+2sl),\ dp*(2i-1)+(n+1-i)*(sd+2sl)\}}{pv} \\
\qquad (i = 1,2,3,\cdots,n) \\
tm = \dfrac{\max\{2dp*n+rw+sd+2sl, dp*(2n+1)\}}{pv} \\
tl = \dfrac{\max\{dp*(2n+2m)+rw+m*(sd+2sl),\ dp*(2n+2m+1)+m*(sd+2sl),\ dp*(2m+2n+1)+j*(sd+2sl)+sl\}}{pv} \\
\qquad (j = 1,2,3,\cdots,m) \\
T = \max\{tr, tm, tl\} \\
num = \dfrac{x+sd}{2sl*(m+n+1)+sd*(m+n)+sd} \\
\Delta t = \begin{cases} 0, T \le tl \\ T-tl, T > tl \end{cases} \\
sumT = T + \Delta t * (num - 1) \\
0 \le m+n < \dfrac{x}{2sl} \\
m \ge 0, n \ge 0, num > 0
\end{cases}
\qquad (3)
$$

These relations are the constraints of this paper.

3.3 Solve

In this paper, it can be considered as a double discrete optimization, in which the first variables m and N can only be taken in a certain interval. For each set of determined (m, n), the values of secondary variables I and J can be taken in a certain interval, so that the function corresponding to the secondary variable can obtain the optimal solution, and then the function corresponding to the first-order variable can be determined through the equation relationship, that is, the optimal solution with the objective function.

4. Inspection and analysis

4.1 Test

According to common sense and national standards, the following constant values are taken as

Table 1 Corresponding table of constant values

Symbol	significance	Value
PV	Passenger walking speed	1.1m/s
SL	Half the length of the vehicle	5.0m
SD	Safe distance between berths	10.0m
X	The road leader of "taxi queuing area"	1000.0m
DP	Distance between passengers in "passenger queuing area"	1.0m
RW	Center distance of two parallel lanes	4.0m

Thus, the value range of M + N is [0,100].

When n takes a definite value in the interval, such as 50, the value range of I is determined as [1,50], and the corresponding TR is
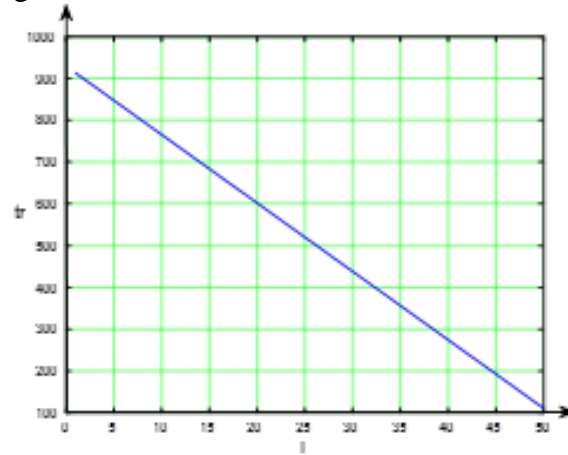

Fig. 1 The change trend of TR with I

Therefore, when n is taken as 50, the maximum value of TR is 912.7.

In this case, if M is a certain value in [0,50), for example, when 40, the value range of J is determined as [1,40], and the corresponding TL is
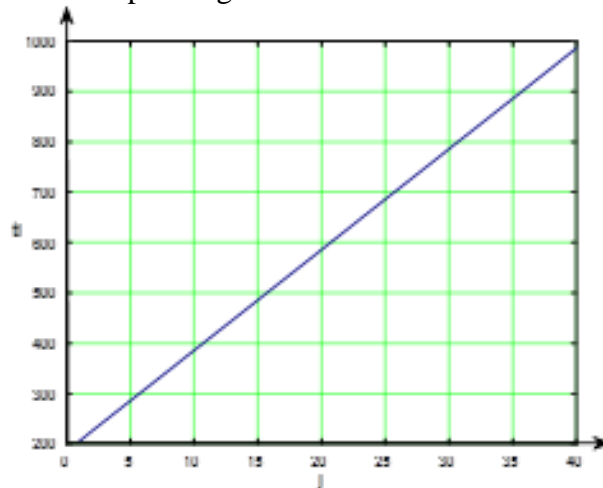

Fig. 2 Variation Trend of TL with J

Therefore, when n = 50 and M = 40, the maximum value of TL is 986.

Therefore, t = max {912.7986112.7} = 986T=0。

Since num = 0, Ie=0.Therefore, n = 50, M = 40 is not a feasible design scheme.

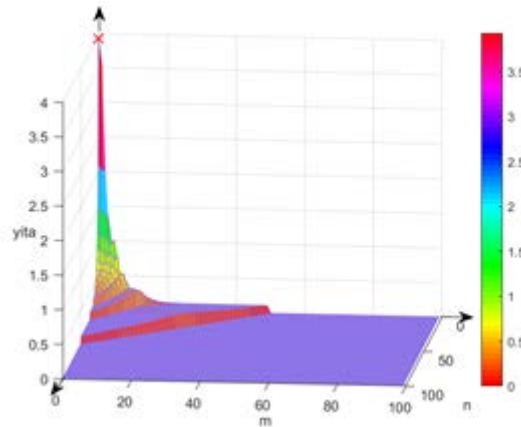For all m and n that can be retrieved, repeat the above logic to obtain

Fig3 η The change trend chart with N, M

As can be seen from the above figure, there is an optimal solution in the definition domain, which makes the riding efficiency reach the highest. The specific conclusions are as follows:

Table 2 corresponding table of variable calculation results

Symbol	significance	result
M	The number of taxis on the left side of a taxi line corresponding to the "boarding point" in the research object	1column
N	The number of taxis on the right side of a taxi line corresponding to the "boarding point" in the research object	0column
Num	Research object / maximum number of "boarding points"	25individual
car_Num	Maximum number of taxis in "load zone"	100Vehicle
man_Num	Maximum number of passengers in "load zone"	100people
η	Ride efficiency	3.9

That is to say, under the premise of constant values according to table 1, there is an optimal design scheme, that is, the dual lane is divided into 25 small areas, each area is composed of a "boarding point" and two columns (a total of 4 taxis), and the "boarding point" is aligned with the taxi on the right, and the riding efficiency reaches the maximum: 3.9 taxis can be boarded in unit time.

4.2 Analysis

Except for the independent variables m, N, I and j, there are official standard data of passenger walking speed PV, safe distance between berths SD and half of vehicle length SL in constant parameters. The road length x of taxi queuing area and the center distance RW of two parallel lanes can be directly provided by the actual Airport, and these parameters have great certainty "The distance between passengers (DP) in "passenger queuing area" comes from subjective experience. Although the social comfort distance of 1 m is taken as the value of DP, in practice, the passengers in the airport queue will be more compact. Therefore, it is reasonable to doubt whether this model is applicable to all DP values.[3]

Without changing other parameters, taking DP = 0.4,0.6,0.8,1.0,1.2, we can get

Table 3 corresponding table of M, n changing with DP

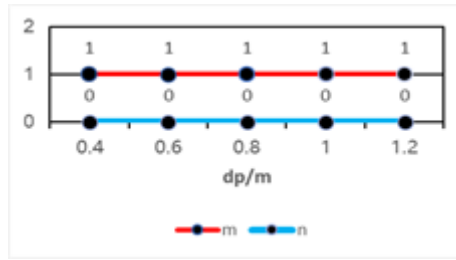| DP / M	0.4	0.6	0.8	1.0	1.2
M	1	1	1	1	1
N	0	0	0	0	0
η	4.20	4.10	4.01	3.92	3.84

Fig4 η Change trend with DP

It can be seen from the figure that m and n do not change with the change of passenger queue spacing DP, which means that in general, m and N are not sensitive to DP, and the model is effective.

5. Conclusion

The passenger boarding efficiency optimization model established in this paper comprehensively considers the safety and efficiency in the design process of parallel two lane "load zone" in the actual airport, and solves the optimal design scheme applicable to various actual airport "load zones", which has good flexibility and reusability. Moreover, the whole model effectively avoids the influence of subjective data on the results, which ensures the feasibility of the model conclusion. The algorithm of the whole article is more complex and can be simplified; in addition, the location of the "boarding point" is limited to the place aligned with the taxi, and the situation that the "boarding point" is set between two taxis is not considered.

References

[1] Kang Guihua. Introduction to computation [M]. China Railway Press: Beijing, 2016.08:123

[2] Central People's government network of the people Republic of China (China government network). Regulations for the implementation of the road traffic safety law of the people Republic of China [Z]http://www.gov.cn/banshi/2005-08/23/content_25579.htm,2017-03-23.

[3] Meerschaert, M.M. mathematical modeling method and analysis (4th Edition) [M]. China Machine Press: Beijing, 2014.12:1