Research on Airport Taxi Optimization Scheduling based on Artificial Intelligence

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Abstract: With the rapid development of China's transportation industry, aircraft has become one of the important means of transportation for people to travel. Due to the particularity of aircraft, the construction of airport is located in the periphery of the city, so the taxi has become an important public transportation tool to connect the airport and the city. Taxi drivers will be faced with two choices: go to the arrival area and wait in line to take them back to the city, or leave the airport empty and return to the city. Therefore, how to reasonably optimize and schedule the number of cars and passengers to maximize the interests of taxi drivers has become an important issue.

1. Introduction

In recent years, China's transportation industry has developed rapidly, and aircraft and high-speed rail have gradually become the preferred means of transportation for people to travel. The traditional airport pickup model calls for taxis to line up at designated "storage pools. "However, with the development of the taxi industry, the number of taxis waiting in the pool will increase, and the waiting time will also be longer, which leads to the higher time cost of taxi drivers.

At the same time, it is also affected by many other factors in real life, such as weather and traffic conditions, which will increase the cost of drivers. So many drivers chose to return to the city empty to continue soliciting passengers instead of waiting. Therefore, when faced with two situations, the driver chooses to wait or return to the city with no load, which requires qualitative and quantitative analysis.

2. Factor One: The Number of Taxis Waiting to Carry Passengers

We use TDABC modeling method [1] to find the relationship between cost and waiting time. The process is as follows:

Table 1. The process

Symbolic representation	Instructions
C_K	The cost of the driver's time waiting for passengers at the k th airport
pc_k	The actual income of the driver at the k th airport
r_j	The motivation rate of the j th taxi at the airport exit
$1/ut_{jk}$	The total time of waiting for the j th taxi at the k th airport exit
q_{ij}	The motivation rate of the i th passenger consuming the j th taxi
co_i	The cost of the i th passenger to the driver

From the known data, $r_j = \sum_{k=1}^{l} ut_{jk} \cdot \frac{c_k}{pc_k}$ $PC = \sum_{k=1}^{l} pc_k$

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Note: CO is the matrix of co_i, Q is the matrix of q_{ij}, UT is the matrix of ut_{jk}, C/P is the matrix of $\frac{c_k}{p_{ck}}$.

So, the net profit earned by the driver who chooses to stay and wait in the accumulator pool is: $I_0 = PC - CO$.

3. Factor Two: The Number of Passengers Waiting at the Airport Exit

We have made statistics on the passenger flow and growth rate of a certain airport in 2016 and 2017, and the peak of airport handling capacity can be seen from Figure 1. Horizontal coordinate is month, vertical coordinate is passenger flow, unit is 10 thousand person-time. The upper curve is the passenger flow data of 2017, while the lower curve is the passenger flow data of 2016. Figure 2 shows the month-person-growth model of the airport in 2016.

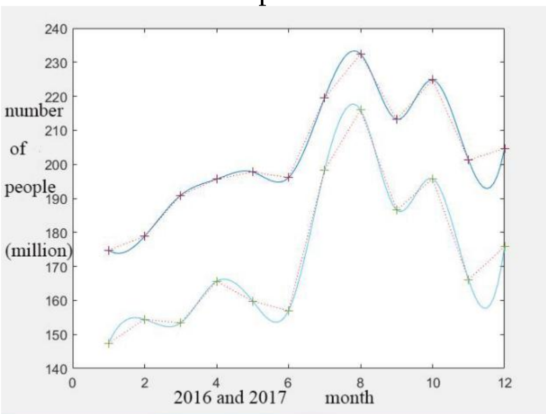

Figure 1. The Peak of airport handling capacity

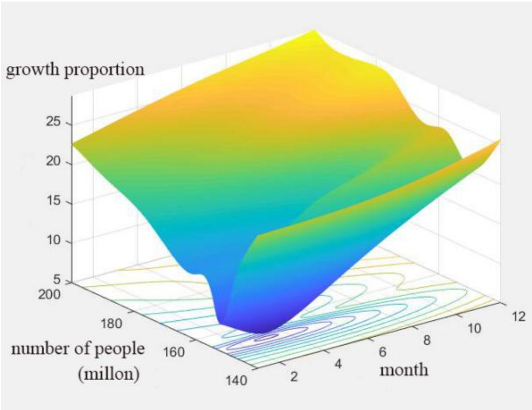

Figure 2. The Month-person-growth model of the airport in 2016

Based on the actual data, we use the integrated decision tree model to predict the passenger flow.

Based on the prediction model of XGBoost [2], the specific data processing structure is designed, and the data collected is preprocessed and features extracted. The extracted features are shown in the following Table 2:

Table 2. The extracted features from data

Characteristic	Characteristic value
month	1-12
quarter	1-4
winter and summer vacation	0: neither H: winter vacation S: summer vacation
growth rate	0: relatively stable +: rise -: reduce

A three-dimensional model of month-person-growth rate is obtained. As shown in Fig 3:

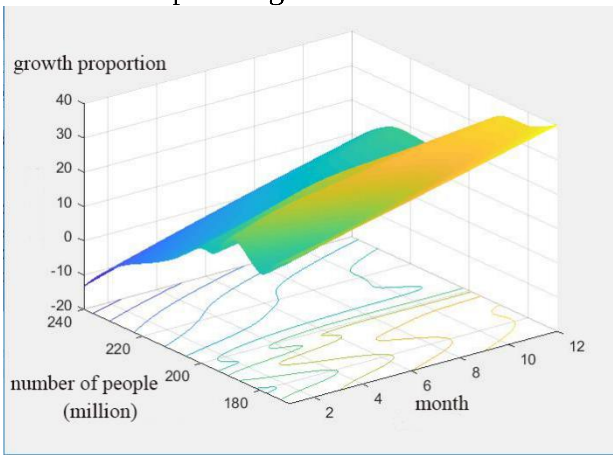

Figure 3. A three-dimensional model of month-person-growth rate

4. Factor Three: The Distance from the City Center to the Airport

Suppose that the taxi driver's income is I in a day, which is summarized as a formula as follows:

$$I = n \times [(C_0 \times S) - C - M \times (S + S_0)]$$

Table 3. Interpretation of the values in the formula

Symbolic representation	Instructions
I	The taxi driver's net profit every day
C_0	The income from the city center to the airport
S_0	empty taxi's mileage of a day
S	taxi's mileage of a day with passengers
C	The fee needs to be payed to the driver's company
M	The cost of a taxi per kilometer
n	The time of taxi drivers carry passengers on average every day

The times of carrying passengers is also affected by congestion.

In this treatise, we use the bus index: Pti to measure the congestion index of urban traffic: $Pti = \frac{Ot}{wt} = \frac{(ct - wt)}{wt}$

Based on the above factors, the taxi driver's daily profit is as follows:

$$I_0 = \frac{4}{Pti} \times n \times [(C_0 \times S) - C - M \times (S + S_0)]$$

5. Factors Synthesis Analysis

Suppose the actual passenger flow of an airport in a city is T ,the distance of an empty taxi from the city to the airport is S_0, the average speed of the taxi back to the city is v_1.

Therefore, we draw the following conclusions:

Plan A: When choosing to wait in the airport car storage pool, the net profit is:

$$I_1 = \sum_{j=1}^{m} \sum_{k=1}^{l} q_{ij} \cdot ut_{jk} \cdot T \cdot \frac{c_k}{pc_k}$$

Plan B: When choosing to drive back to the city without passengers, the profit is:

$$I_2 = \frac{4}{Pti} \times \frac{ut_{jk} T\bar{v}}{S_0} \times \left[(C_0 \times S) - C - M \times (S + S_0) \right]$$

Therefore, the driver's option is: $I = \max\{I_1, I_2\}$

6. Rationality Analysis

Combined with the collected passenger flow and taxi flow of Zhengzhou airport, a curve is obtained. and we collected a large number of actual data of driver's income and waiting time. A scatter diagram is drawn by fitting method. The fitting degree of curve and scatter graph was compared to verify the rationality of the model.

The graphs and scatter plots of Plan A are shown in Fig 4, and Plan B in Fig 5:

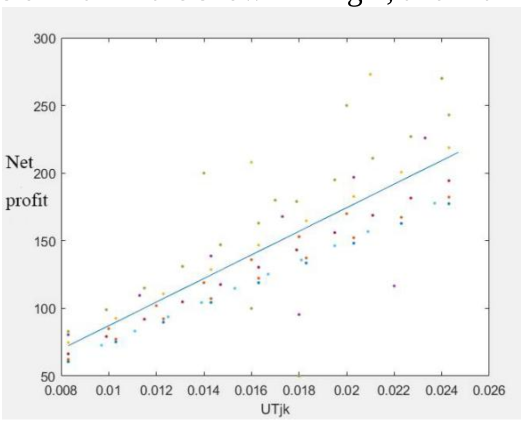

Figure 4. The graphs and scatter plots of Plan A

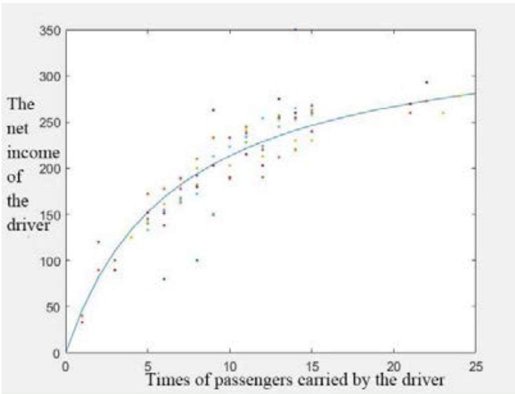

Figure 5. The graphs and scatter plots of Plan B

As can be seen from the figure, the fitting degree of scatter and straight line is higher, and the model is reasonable.

References

[1] Z. J. Sun: Modeling and Error Analysis of Time-driven Activity-based Costing (Master, Hebei University of Technology, China,2011).

[2] R. J. Jia, X. L. Ran, J. L. Wu, C. B. Dai, Z. M. Qi, J. Chen: Airport Passenger Flow Prediction Based on XGBoost Algorithm. Journal of Civil Aviation.Vol.2(2018), No.6 , p.34-37.