Based on BP neural network model and queuing theory to build taxi driver decision model

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Abstract. In this paper, the decision-making model based on BP neural network and queuing theory is used to solve the decision-making problem of taxi driver whether to go to the airport to carry passengers. Using BP neural network model, this paper analyzes the influence of season, time, urban GDP, urban population, urban consumption level and other factors on the locomotive occupancy rate; analyzes the influence of airport location, weather, alternative means of transportation and other factors on the taxi selection rate, and obtains the demand of taxi based on the probability of different passenger pairs; compares the "storage pool" taxi The number of cars, according to the taxi driver's minute salary level and working time, is predicted by queuing theory in the period of joining the "car storage pool waiting" and seeing off passengers, and the decision is made by comparing the expected income in the same period of time.

1. Introduction
The two choices faced by taxi drivers who send passengers to the airport are affected by many factors. The number of flights arriving in a certain period of time and the number of vehicles already in the "car storage pool" are known information. The number of flights arriving in a certain period of time is different from the number of passengers carried in a flight to get the number of passengers in the "full seat" situation.

For the first time, the neural network model is used to analyze the number of passengers in different seasons and in different days in the same time period, different city GDP and different city population, the predicted output is the flight occupancy rate, i.e. passenger volume. The second time, the neural network model is used to analyze the input of airport location and weather influencing factors in different cities, the predicted output is the passenger occupancy rate, i.e. the probability of taxi mode being selected. The Poisson distribution is used to establish the passenger pair riding probability the demand for taxis; the number of known "car storage pools" determines whether the taxi driver has the right to join the "car storage pool" to wait for reception. Through the taxi driver's salary level and working time in minutes, the income of queuing time and reception time is obtained by queuing theory, and the income of no-load departure in the same time is calculated, and the decision-making mathematical model of taxi driver is obtained by comparing the income.
2. Model hypothesis and symbol description

2.1. Model hypothesis
1. It is assumed that passengers always tend to choose the shorter queue when choosing the queue arrangement.
2. It is assumed that the driver and passengers follow the administrator's schedule.
3. It is assumed that the arrival time of each passenger from the exit of the flight building to the queue is the same.
4. It is assumed that each driver has more accurate control over the vehicle.
5. It is assumed that the data obtained are true and reliable.

2.2. Symbolic explanation

| Symbol | Explain |
|--------|---------|
| $A_i$  | All models of the airport |
| $a_i$  | Number of aircraft owned by different aircraft types |
| $b_i$  | Number of passengers allowed for different types of flights |
| $P_a$  | Flight full capacity |
| $K_1$  | Flight occupancy |
| $K_2$  | Passenger rate |
| $P_b$  | Passenger traffic volume |
| $P_c$  | Number of passengers |
| $X_i$  | Influence factor |
| $N_t$  | Taxi demand |
| $N$    | Number of taxis in "car storage pool" |
| $\pi$  | Driver's unit minute income |
| $D$    | Fare paid by passengers |

3. Establishment and solution of the model

3.1. The demand model of taxi quantity based on BP neural network

Based on the known flight number information, first determine the upper limit of the number of arrivals in the time period, and record all models owned by the airport as set $A$,

$$A = \{A_1, A_2, A_3, \ldots, A_n\};$$  \hspace{1cm} (1)

The number of aircraft owned by different aircraft types is recorded as $a_i$,

$$a_i = [a_1, a_2, a_3, \ldots, a_n];$$  \hspace{1cm} (2)

The number of passengers allowed for different types of flights is recorded as $b_i$,

$$b_i = [b_1, b_2, b_3, \ldots, b_n];$$  \hspace{1cm} (3)
The number of people who arrive at the flight with full load in this time period is recorded as \( P_a \),

\[
P_a = ab^T = \sum_{i=1}^{n} a_i b_i;
\]

Then, determine the flight occupancy rate \( K_1 \), analyze the influencing factors including season, time, urban GDP, urban population, urban consumption level, respectively, record the five kinds of factors as \( X_1, X_2, X_3, X_4, X_5 \), as the input unit of the neural network model.

The main human factors for air transportation include natural factors, regional economic development factors and regional population factors.

Among them, natural factors are mainly affected by seasonality. The climate in spring and autumn in China is cool, which is not only the best season for people to travel, but also the season for all kinds of business activities and important meetings. In summer, many places in China have a hot climate, and important business activities and important meetings are held in cool areas, and a large number of students in summer vacation form spring, summer, autumn and autumn the shipping market was particularly strong during the festival. In winter, the climate in most areas is cold, and there are few business and important meetings. During the Lantern Festival of the Spring Festival, most people choose to stay at home rather than travel, which produces a short climax during the Spring Festival. However, the passenger traffic volume from November to March is generally small. The time factor is air transportation in different periods of the day. Most people will choose to arrive in the daytime rather than at night. The arrival time of air transportation is mostly in the afternoon and evening, and the number of arriving time in the morning is less.

Among them, regional economic development and GDP are closely related to the level of urban consumption. The GDP shows that air transport promotes the flow speed and scale of production factors and products, and air transport has the effect of industrial concentration and aggregation. Under the positive feedback cumulative cycle mechanism, the impact of air transport on regional GDP is from population, employment, resident income the development of other industries will be affected in many aspects. The level of urban consumption is represented by the retail of social goods. With the improvement of residents' income, the upgrading of consumption structure, and the close cross regional economic ties, the number of people who choose air travel is generally more in cities with higher consumption level, and air transport is relatively developed in cities with higher consumption level.

The impact of regional population on air transport is mainly reflected in the fact that the more urban population, the larger the base number of choice of transportation mode. As one of many modes, air transport will also be used more in areas with more urban population.

From neural network model

![Figure 1. Sample training BP neural network model](image-url)
\[ C^{(j)}_1 = g\left(\theta_0^{(j-1)} x_0 + \theta_1^{(j-1)} x_1 + \theta_2^{(j-1)} x_2 + \theta_3^{(j-1)} x_3 + \theta_4^{(j-1)} x_4 + \theta_5^{(j-1)} x_5\right) \] (5)

\[ K_1 = h_\phi(x) = g\left(\theta_0^{(j)} C_0^{(2)} + \theta_1^{(j)} C_1^{(2)} + \theta_2^{(j)} C_2^{(2)} + \theta_3^{(j)} C_3^{(2)} + \theta_4^{(j)} C_4^{(2)}\right) \] (6)

Determine passenger volume \( P_b \),

\[ P_b = K_1 P_a ; \] (7)

Then determine the taxi occupancy rate, analyze the influencing factors including airport location, weather and alternative means of transportation, and record them as \( X_6, X_7, X_8 \).

Passengers choose taxi as the main influence of the location of mobile phone field, weather and alternative transportation factors. The distance between the airport location and the city center will be the main factor for passengers to decide whether to choose a taxi. When the airport is close to the city center, the taxi has the advantage of fast, safe and affordable price, which is chosen by passengers. When the airport is far away, passengers will choose self-driving or airport bus and other modes of transportation, and the long-term distance will result in higher cost output; weather factors will also result in order to influence the factors for passengers to choose taxis, in sunny weather, the taxi ride environment is comfortable, while the airport subway or other public transport modes are crowded, the taxi choice probability will be higher, in rainy weather, the taxi route and speed are limited, which will not be the first choice for passengers; at the same time, the airport has other alternative means of transportation, the airport bus will lead to the densely populated destinations in the urban area, and the price is cheap, but it does not have the timeliness and service performance is inferior to that of the taxi. The passenger flow of the airport subway is too large and crowded, and most of the passengers will not go directly to the destination, while the number of people who choose to drive by themselves is relatively small, and most of them do not have the conditions of "landing with a car".

From neural network model

\[ C^{(j)}_1 = g\left(\theta_0^{(j-1)} x_0 + \theta_1^{(j-1)} x_1 + \theta_2^{(j-1)} x_2 + \theta_3^{(j-1)} x_3 + \theta_4^{(j-1)} x_4 + \theta_5^{(j-1)} x_5\right) \] (8)

\[ K_2 = h_\phi(x) = g\left(\theta_0^{(j)} C_0^{(2)} + \theta_1^{(j)} C_1^{(2)} + \theta_2^{(j)} C_2^{(2)} + \theta_3^{(j)} C_3^{(2)} + \theta_4^{(j)} C_4^{(2)}\right) \] (9)

Determine the number of passengers \( P_c \),

\[ P_c = P_a K_2 ; \] (10)
Then, determine the probability distribution of the number of different groups, and record it as \( P(X = k) \), \( k = 1, 2, 3, 4 \),

\[
P(X = k) = \frac{\lambda^k e^{-\lambda}}{k!}, k = 1, 2, 3, 4;
\]

(11)

The demand for taxis is recorded as \( N_r \),

\[
N_r = \sum_{k=1}^{4} P_e P(k)
\]

(12)

### 3.2. Determining the estimated waiting time based on the queuing theory of "role exchange"

The time point for the driver to make a decision is recorded as \( t_s = 0 \), the arrival characteristics of the flight, and the airport management personnel are responsible for "batch quantitative" release of taxis into the "load zone", and arrange a certain number of passengers to get on the train. The arrival time of passengers from getting off the aircraft to being "batch released" is regarded as a negative exponential distribution of parameters \( \mu \), and the time interval of the successive arrival time of the driver is regarded as a parameter Negative exponential function of \( \lambda \).

Record the number of boarding points as \( S \), according to the model \((M/M/S)\) of queuing theory, the average length of stay per taxi is recorded as \( W_s \),

\[
W_s = \frac{L_s}{\lambda}
\]

(13)

\[
L_s = L_q + \rho = \rho^{2s} \left[ \sum_{n=0}^{s-1} \frac{\rho^n}{n!} + \frac{\rho^n}{s!(1 - \rho_s)} \right]^{-1} + \frac{\lambda}{\mu}, \quad \rho_s = \frac{\lambda}{s\mu}, \quad \rho = \frac{\lambda}{\mu}
\]

(14)

The number of taxis in the "storage pool" known to the driver is recorded as \( N \), Predict the waiting time for the driver as \( t_w \),

\[
t_w = N \cdot W_s;
\]

(15)

### 3.3. Driver decision model based on the inequality of driver's salary and income at the same time

Record the driver's daily salary as \( m \), minutes of daily working time are recorded as \( t \), pay per minute is recorded as \( \pi \).

Exist \( \pi = m/t \), record the delivery time as \( t_g \), the fees paid by passengers in time are recorded as \( D \), \( D = k_1 t_g + k_2 \), \( k_1, k_2 \) is a coefficient in a linear relationship.

The decision-making of taxi drivers is obtained by comparing the cost paid by passengers with the predictable cost earned in the time of queuing and seeing off \( (t_g + t_w) \cdot \pi \),

Column inequality

\[
(t_g + t_w) \cdot \pi \leq D
\]

(16)
\[ t_w \leq \frac{D}{\pi} - t_e, \tag{17} \]

4. conclusion

If the inequality is true, the driver's decision should be to wait in line for passengers in the arrival area;

If the inequality is not true, it means theoretically that the cost of queuing and seeing off time is greater than the cost paid by passengers, and the driver's decision should be to go back to the city directly.

References

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