Prediction Model of Passenger Disturbance Behavior in Flight Delay in Terminal

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Abstract. Flight delays disposal is always a tricky problem in civil aviation. The prediction model of passenger disturbance is of great significance to improve civil aviation service level and spot management capability in flight delays. Taking Shenzhen airport as an example, the 2016-2017 flight delay data is analyzed. Based on the BP neural network algorithm, a prediction model is set up by using influence factors which include depth of delay, scheduled flight departure date, current moment, passenger density of gates and ground service company. According to this mode, weight of influence factors is calculated by training neural network. The Prediction Model of passenger disturbance in flight delay is established. The results show that the model prediction accuracy is over 90%, when the number of learning times is 50000. The prediction model is effective, by which the civil aviation staff can make more accurate decisions in large-scale flight delays in civil aviation.

1. Introduction
Flight delay disposal has always been an important factor affecting the service level of civil aviation. For civil aviation staff, it is a long-term and arduous task for civil aviation to start and follow up flight delay disposal. Taking Shenzhen Airport as an example, because of the weather, traffic control and other reasons, over 18 cases of large-scale flight delay occurred every year, resulting in thousands of flight delays, which caused over 100 cases of passenger disturbance. Due to the lack of effective prediction, flight delay disposal is often in a passive state, and civil aviation workers spend a lot of manpower and material resources to deal with the impact of disruption. The occurrence of passenger disturbance is affected by many factors. The existing decision-making mechanism for passenger disturbance is only based on the number of passenger aggregates, which cannot meet the practical application needs. It is an important task for civil aviation to establish a more objective prediction model for passenger disturbance to improve safety and service level.

Most research at home and abroad of passenger disturbance behaviors at terminal is analyzed from the perspective of behavioral science, psychology and system entropy theory, and solved from the economic or legal level. The prediction model for the behavior that may cause the passenger disturbance at terminal is mainly based on factors such as personnel, equipment and environment [1,2]. There are few studies on the characteristics of terminal management, and the effect of the early prediction applied to the practice of terminal management is limited. According to the experience of the field of civil aviation security, this paper analyses the reason of passenger disturbance behaviors from several aspects, gives the key factors of the cause of passenger disturbance behaviors at terminal. Based on BP neural
network, the terminal stranded passenger disturbance behavior prediction model is established, providing a decision-making reference for the civil aviation flight delay subsequent security work.

2. Passenger disturbance at terminal

2.1. Large-scale flight delays
Large-scale delays of civil aviation flights adopt a hierarchical response mechanism, which is respectively yellow, orange and red [3].

Yellow response: within the peak time period (08:00-23:00), the implementation rate of departure flights for 2 consecutive hours is less than 50% or the number of departure flights delayed for more than 1 hour is more than 5% of the scheduled departures for that day.

Orange response: within the peak time period (08:00-23:00), the implementation rate of departure flights for 3 consecutive hours is less than 50% or the number of departure flights delayed for more than 1 hour is more than 7.5% of the scheduled departures for that day.

Red response: within the peak time period (08:00-23:00), the implementation rate of departure flights for 4 consecutive hours is less than 50% or the number of departure flights delayed for more than 1 hour is more than 10% of the scheduled departures for that day.

2.2. Disturbance behaviors at terminal
Disturbance behaviors include:
(1) intentionally damaging or moving airport facilities and equipment without authorization;
(2) containment, occupation and impact at boarding gates, access gates, ticket counters, security passage, boarding counters, check-in counters, and comprehensive service counters;
(3) fights, quarrels and disturbance or physical conflicts with staff members;
(4) obstructing staff from performing their duties or inciting passengers to obstruct staff from performing their duties;
(5) forcibly breaking into aircraft, control area or other places of aviation facilities;
(6) other behaviors that affect flight security or disturb normal public order.

3. BP Neural Network
Artificial neural network (Ann) is a mathematical model based on the understanding of the working mode of brain nerves. Based on the imitation of the structure and function of brain neural network, it is an information processing system for highly nonlinear and complex logic operations. The neural network has the following characteristics: learning by using sample set, describing knowledge by standard symbol method, distributed parallel operation mechanism, etc. [4,5]. Artificial neural network has the advantages of high parallelism of information, strong self-adaptation, self-learning, self-organization, highly nonlinear global effect, good fault tolerance and associative memory function, and has been widely applied in the fields of pattern recognition, optimization, information intelligent processing, complex control and system modeling. Many kinds of neural network structures have been applied to forecasting in the fields of military, economy, transportation and geology.

3.1. BP Neural Network
Back Propagation network (BP neural network) consists of an input layer, several hidden layers and an output layer. Each layer has one or more neuron nodes. Information is transmitted from the input layer, through hidden layers, to the output layer in turn, and the connection between the layers is represented by the connection weight. The connection weight of the network is adjusted through the sample set and transmitted to each layer in the way of back propagation. The model structure diagram of BP network is shown in figure 1 [6]: the given mapping relation of input and output is realized, and BP learning algorithm is adopted to adjust the connection weight. BP algorithm is a kind of supervised learning. Based on error changes, it realizes continuous adjustment of connection weight in the direction of gradient descent relative to the error function.
4. The influence factors of disturbance behaviors of flight delay

According to the on-site guarantee experience of civil aviation, the main factors causing passenger disturbance are shown in figure 2.

**Factors of disturbance behaviors**

- Depth of delay
- Scheduled departure date
- Flight current time
- Passengers density of gate
- Ground agency & service company

| Factors                      |
|------------------------------|
| Depth of delay               |
| Scheduled departure date     |
| Flight current time          |
| Passengers density of gate   |
| Ground agency & service company |

Among them:
- Depth of delay: the flight delay time. the longer the flight delays, the probability of having the passenger disturbance is higher.
- Scheduled flight departure date: from the scene security experience, scheduled flight departure date selection is important for some passengers, such as holiday eve. The flight delay is more likely to cause the mood swings.
- Current moment: scheduled flight departure time. Data from the field security cases showed that the passenger disturbance mainly occurred at noon, in the evening and in the early morning. At night, the passengers were anxious about whether they could make the trip on that day. At the same time, they were worried that the destination airport could not solve the problem of traffic and accommodation. As a result, the passengers' emotions fluctuated greatly, which could easily lead to disruptive behaviors.
- Passenger density of gates: the more the stranded passengers gather at the gate, the greater the chance of fan, and the higher the probability of the disturbance.
- Ground service company: various ground agents have differences of service level, ensuring the number of flights and the ability of passengers’ emotional control, resulting differences between the passenger destructive situation in a large-scale flight delay.
5. Establishment of prediction model

From five aspects, the depth of flight delays, flight date, flight schedules, passenger density of the gate and the airport ground service company, analysing the Shenzhen Airport flights, passengers and other related information of passenger disturbance behavior at terminal in 2016-2017, the data were quantitatively processed, the influencing factor matrix was obtained, and prediction model based on BP neural network was established.

Since the single hidden layer neural network can approach any continuous function theoretically (as long as there are enough neurons in the hidden layer), this paper uses the single hidden layer BP neural network structure to build the prediction model, as shown in figure 3.

![Error Back Propagation Diagram](image)

Figure 3. Algorithm logic structure diagram of single hidden layer BP neural network prediction model

5.1. Determination of input for the passenger disturbance prediction model

As shown in Figure 3, X1 to X5 respectively represent 5 factors affecting passenger disturbance. Data of 499 different flights in Shenzhen Airport with large flight delay in 2016-2017 were selected as training samples. The specific definition is as follows:

(1) To determine the depth of flight delay, the delay time of large-scale delays of Shenzhen Airport from 2016 to 2017 was calculated. The variable was assumed to be X1, and the value range was [0.25, 0.5, 0.75, 1], where 0.25 represents a delay of less than an hour, 0.5 represents a delay of 1-2 hours, 0.75 represents a delay of 2-3 hours and 1 represents a delay of more than 4 hours.

(2) To determine the delay time of flights, the statistics of the occurrence time of passenger disturbance events of Shenzhen Airport during large-scale flight delays in 2016-2017 were obtained. The percentage of the time periods of 24 hours is as follows: the data were converted by the normalization of maximum value, which was 9% at 2-6 o’clock, 11% at 6-10 o’clock, 16% at 10-14 o’clock, 14% at 14-18 o’clock, 27% at 18-22 o’clock, and 23% at 22-02 o’clock. The variable was assumed to be X2 and one decimal point was reserved for variable. The value range was [0.3, 0.4, 0.5, 0.6, 0.9, 1], where 0.3 represents 2-6 o’clock, 0.4 represents 6-10 o’clock, 0.5 represents 14-18 o’clock, 0.6 represents 10-14 o’clock, 0.9 represents 22-02 o’clock, and 1 represents 18-22 o’clock.
To determine the flight date, the statistics of the flight date of Shenzhen Airport during large-scale flight delays in 2016-2017 were obtained. The probability of major holidays, Mondays to Thursdays, and Fridays to Sundays, respectively, is 23%, 59%, and 87%. The above probability values are normalized as variable X3, and the value range is [0.3,0.7,1]. Among them, 0.3 represents major holidays, 0.7 represents Monday to Thursday, and 1 represents Friday to Sunday.

According to the actual operation process, the density of boarding gate largely affects the emotional state of passengers. To determine the passenger density of boarding gate, variables are set to be X4 and the value range is [0.25,0.5,0.75]. 0.25 means that boarding gate has arranged 1-2 flights, 0.5 means that boarding gate has arranged 3-4 flights, and 0.75 means that boarding gate has arranged 5 flights or more.

The choice of ground service companies: Taking three ground service companies of Shenzhen Airport as an example, the probability of having passenger disturbance of different ground service companies is different. According to the statistics of three ground service companies in the airport within 5 years, the percentage of disturbance events is 19% of A ground service, 36% of B ground service and 45% of C ground service. After the normalization data is converted, variables are set to be X5 and the value range is [0.4,0.8,1], of which 0.4 represents A ground service, 0.8 represents B ground service and 1 represents C ground service.

5.2. Determination of predicted expected values for passenger disturbance
According to whether or not the passenger disturbance will occur as the predicted target of BP network output, that is, the variable Y is expressed, and the value range is [0.75,0.25,0.5], in which the passenger disturbance event will be quantified to be 0.75 and no to be 0.25, and the passenger's emotionally excited but non-aggressive behavior will be 0.5.

5.3. Verification data of passenger disturbance behavior
In addition, data of 106 different flights in Shenzhen Airport during 2016-2017 with large flight delays were taken as training samples to verify the prediction effect of the model.

6. System model and validation
Five input variables, namely, 5 network input layer nodes, were selected as BP neural network training by taking the depth of flight delay, the delay time of flight, flight delay date, boarding passenger density and ground service company as inputs. The prediction target of BP neural network is whether the passenger disturbance will occur, and the output layer node is set as 1. The number of nodes in the hidden layer is determined by the simulation operation effect. The expected error is 0.01, the learning rate is 0.01, and the training accuracy is 0.001. Error definition: the error between the verification output Y’ and the expectation Y can not be greater than 0.125, which means that the error is deemed to be greater than 0.125.

The results of simulation verification show that, for BP neural network with single hidden layer, with the increase of the number of neurons and the number of learning times, the accuracy of model training increases significantly, but the change slows down when it increases to a certain extent. The specific results are shown in table 1.

When 21 neurons are selected and the number of learning times is 50000, the error rate drops below 5% and the prediction accuracy is as high as 95%. At this point, the BP neural prediction error is shown in figure 4.

|The number of neurons, learning times| Root mean square error| Error over 0.125| Error Rate |
|------------------------------------|----------------------|----------------|-----------|
|[7,5000]|0.0064|8|7.77%|
|[13,10000]|0.0058|6|5.83%|
|[21,10000]|0.0055|6|5.83%|
7. Conclusion

This paper discusses the passenger disturbance behavior when there is a flight delay at terminal. Combined with the scene management experience and the situation assessment, the factors influencing passenger disturbance behavior are analyzed, namely the depth of flight delay, the flight date, the flight schedule, the passenger density of gate and the airport ground service company five influencing factors. Based on BP neural network, quantitatively processing the influence factors, prediction model of passenger disturbance behavior at terminal was established, using the Shenzhen Airport delay data in 2016-2017 for model training and validation. The results show that the built model prediction accuracy can reach above 95%. The prediction method of civil aviation flight disturbance behavior is given theoretically.

To determine the influencing factors of disturbance behaviors, mainly from the field work data statistics, after experimental verification, the influence factor of the passenger disturbance behavior at terminal has a certain practical value. In the prediction analysis of passenger disturbance of training and learning model, the factors influencing the actual operation are given priority. In the future, the training parameters should be optimized according to the physical and mental state of the passengers. The research on the selection of influencing factors should be further studied.

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