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Research on Evaluation of Airport Peak Service Capability Based on Interval Method

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Abstract

Based on the statistical principle of the interval method, the method of evaluating the peak service capacity of the airport based on the interval method has been improved and optimized. The focus is on the relationship between the historical peak service sorties of the airport and the selection of the envelope under the selection of different envelopes. The experimental analysis concludes that for a busy airport, under the condition that the envelope is determined, the corresponding airport peak service number does not change with the change of the sample base, that is, the estimated capacity obtained from the sample base to a specific envelope interval no effect.

Keywords

Airport, historical peak service capacity, European distance.

1. Introduction

Accurately describing the peak service capacity of an airport is the primary task of air traffic transportation demand and airspace flow management, and it is also a key indicator of the airport's ability to handle expected traffic demand. With the continuous increase of air traffic flow in my country, the contradiction between airspace capacity and flow has become increasingly prominent, causing flight delays, which has a series of chain reactions on the economy and society, and has become the focus of society. Therefore, the Chinese civil aviation authority began to pay attention to the importance of airspace capacity and peak-hour operation capability of airports in the construction and development of the civil aviation system. The evaluation concepts and requirements of airspace capacity and peak-hour airport service capabilities have also been continuously deepened. It is an important basis for the Civil Aviation Administration to formulate flight schedules through scientific and accurate methods to evaluate the airport's peak-hour operational capacity. At the same time, the airport's peak-hour capacity assessment has a critical impact on airspace capacity. Therefore, it is important to conduct an airport's peak-hour operational capacity assessment significance.

In 1993, Gilbo used the historical airport operation data to determine the relevance of the airport's take-off and landing sorties per unit time, and then proposed a method to analyze the airport's operating capacity, which later became one of the main methods for studying the airport's operating capacity[1]. The research direction of airport operation capacity evaluation based on historical data statistics. Gilbo mainly studied the frequency threshold of peak operation data and the method of the included data interval, and proposed an envelope that contains at least 3 or more historical peak observations or removes a specific percentage (0.5%, 5%, 10%). The extreme value data interval envelope method, and proposed that the envelope interval close to 95% is ideal for evaluating the historical peak service data of the airport with a single month as the sample; Kellner uses the density center of the airport takeoff and landing to determine the published operating capacity Whether it is reasonable [2], in this method, the calculation of the density center uses the arithmetic average of all historical data takeoffs and landings, which lacks a certain degree of robustness, and the relationship between the density

center and the historical peak service sorts is not clear; Wang uses The method of statistical distribution [3], based on historical data, proposed and verified that the airport hourly takeoff and landing sorties obey the Gaussian distribution, and on this basis, the airport operating capacity is evaluated, but the sample interval for obtaining the distribution is small, and the parameters of the Gaussian distribution are obtained. There is a lack of evidence for universality, and the relationship between evaluation capacity and statistics lacks basis.

In 2015, Zhao Zheng, Hu Minghua and others conducted a detailed segmentation study on large sample data [4], selecting single-month, bi-monthly, six-month, and twelve-month sample data. For different sample bases, the frequency threshold is Statistics of airport peak service sorts for more than 3 samples, it is concluded that suitable frequency values should be selected for different sample sizes to draw the envelope as the airport peak service capacity, but the influence of sample base on the envelope interval and the obtained peak sorties has not been resolved.Current studies mostly focus on the evaluation of hourly peak capacity of airports based on frequency, which lacks a certain degree of universality. For different airports, the same research results cannot be shared. In 2018, Xu Chencheng, Hu Minghua, etc. used the confidence interval to evaluate the peak service capacity of the airport [5], optimized Zhao Zheng's method of screening and evaluating benchmark capacity based on frequency, and proposed that the results are not affected by the sample base.

In summary, based on Gilbo's research and combined with the domestic research methods of Zhao Zheng and Xu Chencheng, this article focuses on researching and improving the interval method, focusing on the analysis of the influence of the sample base on the evaluation capacity obtained under a specific envelope interval. In 2015, Li Yinfeng verified the airport aircraft arrival flow model that obeys the Poisson distribution [6]. In actual operation, the hourly arrival and departure sorties of the airport is the product of dividing the arrival and departure flight flow by hour. Therefore, in a fixed period of time, the peak of the number of arrivals and departures reflects the actual service capacity of the airport during that period, and a method to analyze the airport's peak hour operation capacity can be put forward accordingly. This method excavates and analyzes a large amount of historical data to find out the operating rules of the airport during peak hours. First, extract the flight flow by hour from the historical data; secondly, summarize the extracted flight flow to obtain the frequency value (the number of times the number of flights appear in different natural hours, and the number of arrivals and departures is the same) and plot the scatter points Figure, and then use the interval method to draw the envelope curve to get the airport peak hours and the maximum number of flights in and out of the airport.

2. Evaluation object selection and data preprocessing

In 1993, Gilbo proposed for the first time that in a fixed period of time, the peak of the number of arrivals and departures reflects the actual service capacity of the airport during that period, and based on this, proposed a method to analyze the airport's operating capacity. This method is an airport capacity evaluation based on historical data statistics. It has been widely recognized and used in airport operational capability analysis and effectiveness evaluation. However, there are relatively few studies using a specific percentage of data intervals to eliminate the extremes of observation. On May 9, 2017, the Air Traffic Management Office of the Civil Aviation Administration issued the latest "Technical Specification for Airport Time Capacity Assessment"[7], which clearly stipulates that "the data points enveloped by the historical peak service flight envelope are in The confidence level in the sample data is 95%-98%", which coincides with the interval method used in this article, and also puts forward new requirements for historical peak service sorts.

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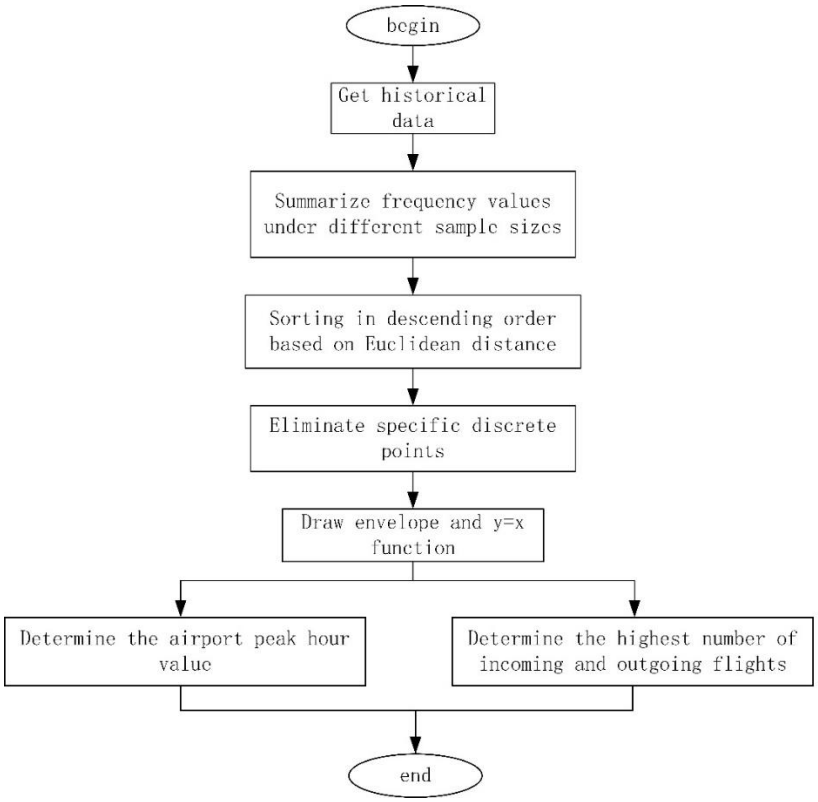
Based on the above situation, the author focused on researching and improving the interval method, expanding from the 95%-98% specified in the "Technical Specification for Airport Time Capacity Evaluation" to the 90%-98% interval, increasing the visibility of the law, and focusing on different research What is the change rule of the capacity value determined by the envelope interval under the sample size. As the interval method has certain requirements on the sample base, the evaluation effect on busy airports will be more obvious. Therefore, this paper selects the four-month historical operating data of Beijing Capital Airport as the research base, a total of about 124 days and a total of 2976 hours.

As a busy airport in my country, the Capital Airport has a relatively high daily traffic flow, and the traffic flow has reached a certain degree of saturation. Taking the Capital Airport as an example to carry out method research and regular analysis has strong representativeness. Through sorting and analyzing historical data, we can reveal the understanding of the operation process and laws of the Capital Airport. Through the analysis of different time periods, envelope ratios and different sample sizes, we can make horizontal and vertical comparisons, analyze similarities and differences, and explore interval evaluation methods. The general law.

3. Peak service capacity evaluation method based on interval

This article optimizes the traditional interval method and improves the method of drawing envelopes based on frequency values. For the convenience of research, set the hourly arrivals and departures as X and the hourly departures as Y. Based on the variables of X and Y, the relationship can be constructed: $Z=\sqrt{X^2+Y^2}$, namely the Euclidean distance of the airport's hourly arrivals and departures (Hereinafter referred to as Euclidean distance), its geometric meaning is expressed as the distance between the discrete points in the data and the origin. Therefore, this variable has the relevant information about the arrival and departure of the airport, and obtains a basis for quantitative comparison of the hourly arrival and departure data. The experiment process is as follows:



In the actual operation of the Capital Airport, an abnormal value will be generated when the upper limit of its carrying capacity is exceeded during busy hours. This value cannot represent

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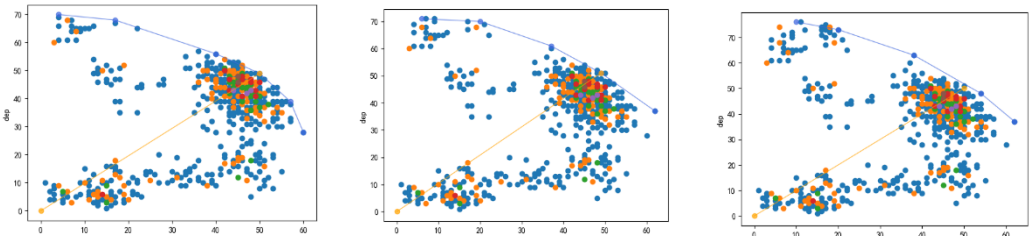
the actual operation capacity of the airport. It is necessary to start from the robustness and exclude the observation data that cannot represent the historical peak operation distribution. This is the prerequisite for drawing envelopes of different scales.

The proportion of drawing the envelope line starts from 90%. For the data volume of a single month, there are about 720 sample points. According to the ratio of 90%, there should be 648 sample points inside the envelope and 72 points outside the line. , We first calculate the Euclidean distance for the sample size of a single month, and then arrange them in descending order, excluding the top 72 sample points (that is, the 10% ratio), so we can draw the envelope interval with the envelope ratio of 90%. Finally, draw a function in the obtained scatter diagram, which intersects the boundary of the envelope at a point, which represents the peak service sorties corresponding to the airport when the arrival and departure sorties are balanced. Because the data is filtered by the Euclidean distance Z value, not only the fusion of the entry and departure experimental data is realized, but also the regular volume envelope shape is automatically formed on the outermost side of the scatter point by using the geometric meaning of the Z value. In the scatter chart, the point farthest from the X axis is defined as the largest departure flight; the point farthest from the Y axis is defined as the largest arrival flight. We select the maximum number of departure and arrival flights as the endpoints of the capacity envelope, and draw the envelope along the outside of the automatically formed envelope. The envelope can be drawn with an interval ratio of 90%, which is compared with the previous frequency value. The method of manually drawing the envelope is faster and more efficient. In the same way, other scale envelopes can be drawn.

4. Instance verification

4.1. Drawing the envelope of a single month sample

Based on the historical operating data of the Capital Airport in February 2018, draw the capacity envelopes under different envelope intervals. The sample data is about 720, and the different ratios of the envelopes are used to draw (remove singularities) the single-month peak takeoff and landing envelopes. At the same time, the peak service sorties and the incoming and outgoing peak service sorties are divided into 90%, 95%, 98% as an example:



The experimental data is shown in Table 1:

Table 1 Evaluation table of historical peak service types in a single month sample

Sample base	month	Envelope interval /%	Sorties /h	In, departure/sort	Peak approach	Peak departure
720	2	90	93	47,46	60	75
		91	94	47,47	60	75
		92	94	48,46	60	77
		93	94	47,47	60	78
		94	95	48,47	60	78
		95	97	48,49	60	78
		96	98	49,49	60	78

		97	100	50,50	60	80
		98	100	50,50	60	80
	3	90	89	44,45	58	74
		91	90	45,45	58	74
		92	91	45,46	60	74
		93	92	45,47	60	74
		94	92	46,46	60	74
		95	95	47,48	60	77
		96	95	47,48	60	77
		97	98	50,48	60	78
		98	98	49,49	65	78
	4	90	90	45,45	55	72
		91	90	45,45	55	72
		92	91	45,46	55	75
		93	92	46,46	55	75
		94	92	46,46	55	75
		95	93	46,47	55	76
		96	94	47,47	57	76
		97	96	48,48	57	86
		98	96	48,48	57	86
	5	90	86	43,43	57	70
		91	86	43,43	57	70
		92	87	43,44	57	70
		93	88	43,45	58	70
		94	88	44,44	58	70
		95	88	43,45	58	70
		96	90	45,45	58	72
		97	92	45,47	58	72
		98	93	46,47	58	72

The sorts in Table 1 are the historical peak service sorts during the sampling period; the sample base is the average number of samples in four months; the envelope interval is divided into 9 different proportions, which can be more intuitive to see the changing law of the data; Sorts refer to the number of arrivals and departures corresponding to the historical peak service sorts, and the ratio is close to one to one; at the same time, it can be seen that the maximum arrival peak and the maximum departure peak under different envelope ratios, According to the data observation of a single month, February is the busy period of Beijing Airport, and the peak service number is greater than 90; from the table, it can be seen that the peak service number is closely related to the operating environment, so the peak time of each month The number of services varies. But from the overall analysis, the average monthly peak service sorties can reflect the peak service capacity of the airport under the normal operating environment. Therefore, the average monthly peak service number is shown in Table 2:

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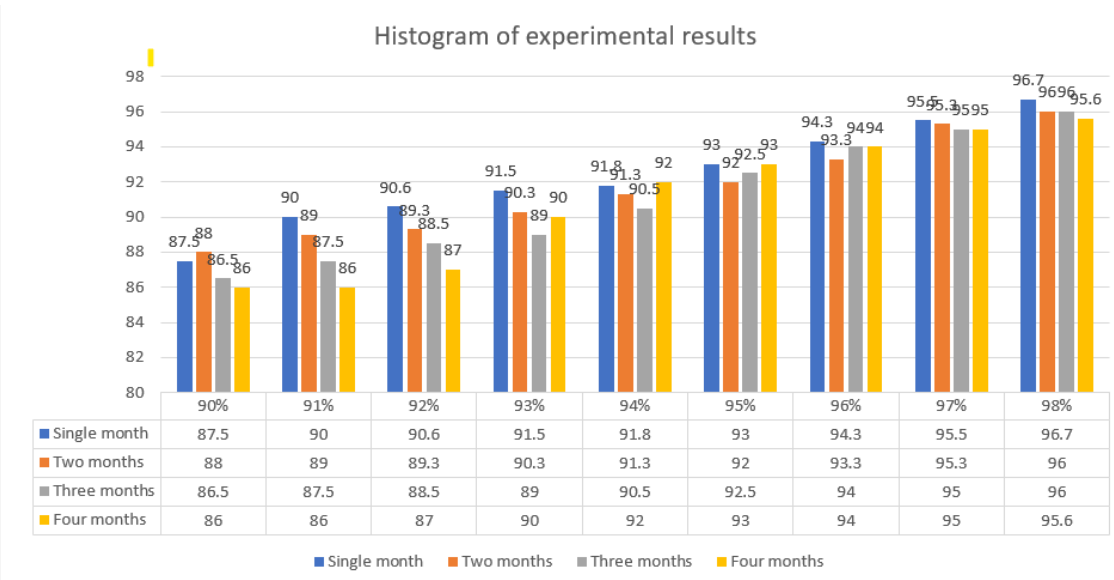
Table 2 Average number of orders in each envelope interval of a single month sample

Envelope interval /%	Average number of sorties /h	Peak approach	Peak departure
90	89.5	57.5	72.5
91	90	57.5	72.5
92	90.8	58	74.0
93	91.5	58.3	74.3
94	91.8	58.3	74.3
95	93.2	58.3	75.3
96	94.3	58.8	75.8
97	96.5	58.8	79.0
98	96.8	60	79.0

Table 2 shows the average value of airport peak sorties corresponding to different envelope ratios under a single-month data sample. In order to find the peak service order value corresponding to different envelope ratios in a single month. It can be found that when the sample size of a single month is selected, the peak value of the entry tends to be stable, while the peak value of the exit has a large amount of change.

4.2. Envelope analysis under different sample sizes

Similarly, by calculating the Euclidean distance for different sample sizes and drawing a scatter plot, the data packet lines of single month, double month, three months and four months can be obtained from 2 to 5 months.



The above is the histogram of experimental data. Through the comparison of experimental data, it can be found that under the same envelope interval ratio, their peak service sorties are close to the same value, and the fluctuation does not exceed 1 sorties. For example: when the envelope ratio is selected as 95%, under the data of one month, two months, three months, and four months, the average peak service sorties of the airport is 92 sorties, and the fluctuation value does not exceed 1 sorties; When the ratio of the winding line is 98%, under different sample sizes, the peak service sorties of Beijing Airport is 96 sorties, and the fluctuation value is 1 sorties.

It can be clearly seen from the table that under the selection of a specific envelope ratio, the estimated value of the airport's peak service sorties tends to be stable, and does not change significantly with the sample size. When the interval ratio is 90%-94%, the peak number of flights fluctuates greatly and lacks stability, but it can still be found that the peak value of the airport service peak fluctuates at a fixed value under the determination of the envelope. In the 95%-98% interval, the regularity is more obvious at this time, and the service order at the historical peak tends to be stable. In 2017, the "Airport Time Capacity Evaluation Specification" issued by the Air Traffic Control Industry Office of the Civil Aviation Administration stipulated that the historical peak service envelope was within the 95%-98% confidence interval. The results of this article are consistent with this regulation. It is consistent with Gilbo's more accurate view of the 95% envelope for assessing airport capacity in 1993.

5. Experimental conclusions

The example shows that the sample base has no effect on the evaluation capacity obtained under a specific envelope interval, and the experimental conclusions have made it clear that the 95% to 98% data interval is more suitable for evaluating historical peak service sorties and improving the evaluation of airport peak service sorties The work has guiding significance. By accurately removing the specific percentage sample value, it solves the previous defect that the frequency method needs to consider the sample base, and further optimizes the airport capacity evaluation method. Regardless of whether the sample base is large or small, the interval method can be used to screen and evaluate historical data.

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