Problem Chosen	2021	Team Control Number
C	ShuWei Cup Summary Sheet	202110076198

Optimizing strategies for tourism development

Summary

Under the background of the epidemic, the development of tourism has become a hot issue of great concern to all countries. How to balance the risks and interests of all parties under the background of the epidemic is a very worthy problem to research. Based on this background, we model and analyze the development strategy of Tourism.

In response to question 1, referring to the data given in Annex 1, we searched the data of class a scenic spots in all provinces through the relevant tourism websites, including five features.See the text for the specific features.Then,the macro visual display of its geographical location is carried out. The visual analysis is carried out based on the rating of the scenic spot and its maximum daily reception number,and the corresponding distribution conclusions are obtained.

In response to question 2,we consider establishing an evaluation model to quantitatively evaluate the scenic spot. Firstly, we construct an evaluation index system with five characteristics, including geographical location, scenic spot rating, scenic spot history rating, maximum daily reception number and scenic spot congestion.Next, Preprocess Based on the collected data. After data processing, the five evaluation indexes are weighted by entropy weight method, and then the preliminary evaluation results are obtained by linear weighting. These evaluation results are divided into training set and test set, and the artificial neural network comprehensive evaluation model is trained to further improve the results of entropy weight method.After obtaining the quantitative evaluation results, we reasonably classify the scenic spots through **kmeans cluster analysis.** The quantitative results and classification results are shown in **figure 4-6 and figure 4-7 respectively**

In response to question 3, we first define the epidemic risk measure, which is related to the quantitative evaluation score in question 2 and the severity of the epidemic in the city where the scenic spot is located. Then, based on the change rate of the number of epidemic infections and the risk degree, we establish a dynamic scenic spot flow restriction model, and select the Beijing Summer Palace scenic spot for quantitative evaluation,It is concluded that in medium risk areas, the flow restriction proportion of scenic spots with superior geographical advantages and large daily reception number shall not be higher than **60%**

In response to question 4, we first quantify the three aspects given in the topic, and then consider epidemic prevention and control as constraints. Taking tourism revenue and tourist experience as objective functions, we establish a multi-objective optimization model with decision variables as the number of tourists, which is solved by Matlab genetic algorithm tool box to obtain its results $Pareto$.It is proposed that the scenic spot and the government choose the optimal solution under different situations according to different epidemic situations and economic forms.Finally, we select a scenic spot to search for its recent tourist data. Based on the distribution of these data, we analyze the results of our model by **Monte Carlo simulation** for different epidemic levels.

In response to question 5, based on the modeling and analysis results of questions 1 to 4, we provide reasonable suggestions for the government to manage different types of scenic spots.

Key words: Evaluation model;Tourism development; The neural network; Pareto plane; Multi-objective optimization

Content

1. Introduction

1.1 Background

Tourism is a compound industry with a high degree of relevance. It is not only directly related to the transportation industry, catering industry, and tourism service industry, but also closely related to most sectors of the tertiary industry. The consumption expenditure driven by the tourism industry mainly includes three parts:the expenditure of tourists on the purchase of goods and services at the tourist destination, the transportation, accommodation, catering, entertainment, leisure and other services generated during the tourism process, the construction of tourist attractions and tourism Various infrastructure costs of enterprises, etc.

However, the pandemic of the COVID-19 has had varying degrees of impact on all walks of life. Which has a greater negative impact on the tourism industry. The intentional or unintentional measures taken by some countries to prevent the spread of the epidemic have severely inhibited the development of tourism. The depression of the tourism industry will inevitably affect the labor desire of tourists and the income of tourism enterprises and government departments, which in turn will lead to economic stagnation or regression. In the context of the COVID-19, some countries have also taken the initiative to explore new tourism models, but believe that a general consensus has been reached. For a country like China with a huge population and multiple holidays of varying duration, how to weigh the interests of all parties and then propose a scientific tourism development plan in the context of the epidemic appears to be very meaningful.

1.2Work

Question 1: Refer to the data in Annex 1. Please collect the basic data of scenic spots in various provinces across the country. It is especially necessary to collect the current evaluation level of scenic spots and the maximum reception capacity per day, and visually display the distribution characteristics of these scenic spots.
Question 2: Can you use the collected attractions and reception capabilities of these scenic spots to quantitatively evaluate and classify them reasonably?
Question 3: Under the background of the epidemic situation, the current limit of each scenic spot has become a new model. Can you provide a reasonable current limit model for the scenic spot according to different epidemic levels, and give a specific quantitative analysis result using a certain scenic spot as an example?
Question 4: Can you use mathematical modeling methods to propose a quantitative model that also considers epidemic prevention and control, tourism income, and tourist experience, and conduct simulation analysis of the expected effects.
Question5: Can you provide government management with a differentiated management plan for different scenic spots during the epidemic period of no more than 2 pages?

2. Problem analysis

2.1 Data analysis

By analyzing the data given in the annex, we obtained the data characteristics of the scenic spots to be collected, including their geographical location, the current rating of scenic spots and the maximum number of daily visitors. We searched and integrated the above data of class a scenic spots in various provinces and cities through the tourism websites of various provinces and cities.

2.2 Analysis of question one

Question 1 requires us to search the data of scenic spots in all provinces of the country according to the data given in the annex. After collecting the receipts, we integrate and process the data, and consider visualizing and analyzing the distribution according to the different characteristics of scenic spots, including the rating of scenic spots and the maximum daily reception number of scenic spots.

2.3 Analysis of question two

Question 2 requires us to quantitatively evaluate and classify the collected scenic spots. First, we consider constructing an evaluation index system and further constructing an evaluation model to quantitatively evaluate the scenic spots. Then, according to the results of quantitative evaluation, the scenic spots are divided into four categories by using a priori information, and the scenic spots are reasonably classified by K-means clustering method.

2.4Analysis of question three

Question 3 requires us to consider the impact of epidemic prevention and control on tourism and establish a reasonable flow restriction model.We consider establishing a dynamic flow restriction model that can be adaptive with the change of epidemic degree. Therefore, considering the change rate of epidemic infection number, local epidemic level and risk index, we establish a dynamic flow restriction model to determine the flow restriction proportion of different epidemic degrees, and select the data of specific scenic spots for quantitative analysis.

2.5Analysis of question four

Question 4 requires us to comprehensively consider the three stakeholders of tourism development and establish a quantitative model. We consider taking the number of tourists as the decision variable and epidemic prevention and control as the constraints, establish a multi-objective optimization model aiming at the tourism revenue and tourist experience of the other two stakeholders, solve its non inferior solution plane, and preliminarily analyze the selection criteria,Then, the Monte Carlo simulation method is used to randomly simulate different epidemic levels, and the expected optimal solution selection effect is obtained.

2.6Analysis of question five

Question 5 requires us to provide suggestions to the government management department. We put forward reasonable suggestions to the government management department based on the clustering results of question 2 and the quantitative analysis results of other problems.

3. Symbol and Assumptions

3. 1 Symbol Description

$No.$	$Symbol$	$Symbol\ meaning$
1	n	$Number\ of\ tourists$
2	s_i	$The\ ith\ scenic\ spot\ load\ carrying\ area$
3	S	$Comprehensive\ score\ of\ scenic\ spots$
4	w_i	$The\ first\ I\ weight\ of\ indicators$
5	$Risk$	$Risk\ degree$
6	δ	$Current\ limiting\ ratio$

3.2 Fundamental assumptions

(1) Suppose that the data we collected is true and reliable;
(2) It is assumed that the epidemic spread is slow between cities far away, that is, the potential transmission risk not in the city is not considered;
(3) Suppose that the more tourists spend, the higher the utility return they hope to get;
(4) It is assumed that the scenic spot can obtain accurate information about the change of the number of epidemic infections at the first time.

4. Model

4.1Solution to question 1

4.1.1Data collection

We have collected the characteristic data of A-level scenic spots in various provinces and cities through tourism related websites in various provinces and cities. The collected characteristics include the geographical location of the scenic spot, the maximum number of daily visitors, the rating of the scenic spot, the number of comments on the scenic spot and the ticket price of the scenic spot, and integrate the data according to different scenic spot ratings.Some data are as follows. See the annex for specific data:

Taierzhuang Ancient City	5	117.1351344	36.21406989	4.9	145	10671
	5	120.450725	36.07430586	4.9	28	20164
Mount tai	4	120.3422141	36.06293676	4.8	110	49891
	4	117.023802	36.6686757	4.9	65	22447
Qingdao Haichang Polar Ocean World	5	120.1019166	35.96689846	4.9	28	8770
	4	117.03965	36.6514074	4.9	38	6196
Qingdao Underwater World	4	120.4753972	36.11349942	4.9	28	9427
	5	120.7552086	37.83520474	4.8	70	7440
Baotu Spring Park	5	122.1480241	37.49984975	4.8	105	9285
		120.3536825	36.08563436	5	¥12	95265
Qingdao Forest Wildlife World	5	116.8550661	36.75234601	4.9	31	13651

Table 4-1

4.1.2Distribution feature visualization

Based on the longitude and latitude characteristics of the data, we first visualize the scenic spot data according to the geographical location. We import the data into kepler.gl to adjust the parameters for visualization. The results are as follows:

Figure 4-1

Then we analyze the distribution of scenic spots based on different characteristics of scenic spots. First, we conduct visual analysis through different scenic spot ratings. We import the data into Matlab, set parameter conditions, and represent different scenic spot ratings through different colors. The results are as follows:

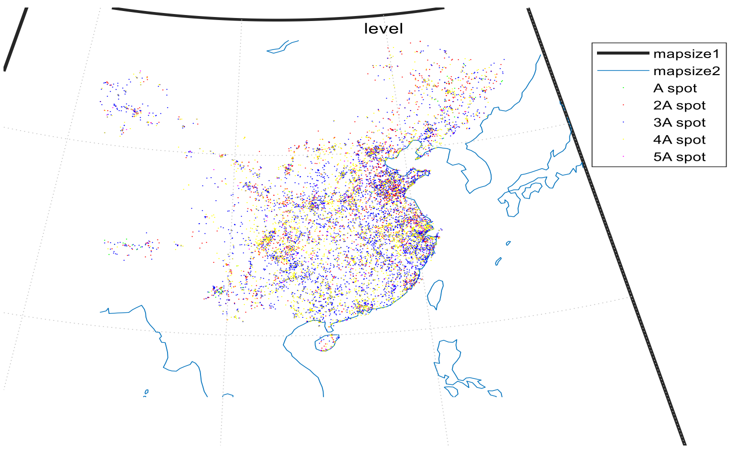

Figure 4-2

Then, based on the characteristics of the maximum daily number of visitors, we set the following conditions to divide the scenic spots into five categories:

1.The number of receptions is greater than or equal to 10000;
2.The number of receptions is greater than or equal to 50000;
3.The number of receptions is greater than or equal to 100000;
4.The number of receptions is greater than or equal to 300000;
5.other;
The visualization results are as follows:

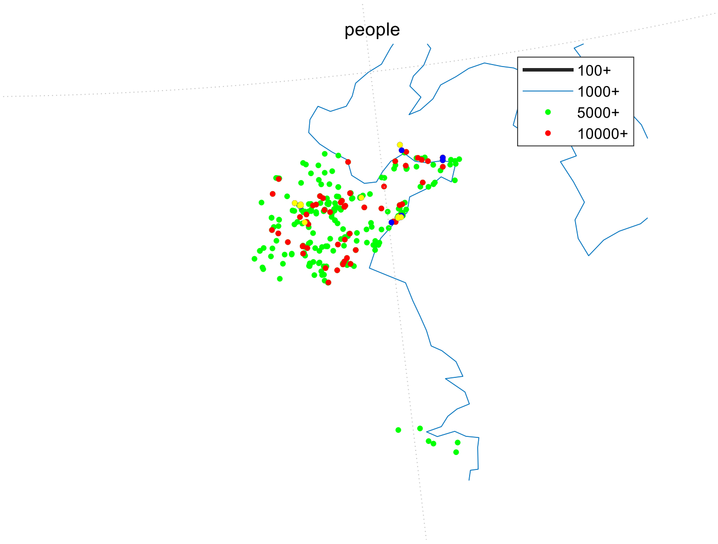

Figure 4-3

In the figure, we only retain the 500 scenic spots with the largest daily reception for visualization. It can be seen that most scenic spots with large reception are concentrated in East China.

4.1.3 Conclusion

Based on the visual analysis of the geographical location of scenic spots based on the different characteristics of scenic spots, we get the following conclusions: scenic spots with high scenic spot rating and large number of visitors are basically distributed in the capital Beijing and coastal developed cities, such as Shenzhen, Shanghai and other regions, and most of them are also distributed in East China, such as Shandong.In border areas such as Tibet and Inner Mongolia, there are few high rated scenic spots and scenic spots with large daily reception.

4.2Problem two modeling and solving

4.2.1 Data processing and linear weighted preliminary evaluation model

In view of the requirements for quantitative evaluation of scenic spots in question 2, we consider establishing a scenic spot evaluation model. Based on the collected data, firstly, we build the underlying evaluation index system. According to the requirements and the most typical scenic spot characteristics at present, we select the following five indexes as the evaluation indexes: geographical location, scenic spot history score, scenic spot rating, maximum daily receptionThe crowding degree of the scenic spot.

For the evaluation index of geographical location, we define it as the distance between the scenic spot and the downtown center, that is, on the plane:

$$d = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

For the historical score of the scenic spot, we collected the historical evaluation and scoring data of the scenic spot through the commonly used tourism software such as meituan and Ctrip as the evaluation index.The higher the historical score of the scenic spot, the better the experience of tourists.

For the rating of scenic spots, we use the current rating of scenic spots as a dummy variable, with a value of 1-5

The daily maximum number of tourists received by the scenic spot reflects the number of tourists accepted by the scenic spot and the tourists' sense of experience. Based on the collected data, we participate in the establishment of the evaluation model through this index.

For the congestion degree of scenic spots, we define it as:

$$Cr = \frac{n}{s}$$

Among them,n for the number of tourists,s is the bearing area of the scenic spot.This indicator also quantifies the experience of tourists by whether they are crowded or not.

Before establishing the evaluation model, we need to standardize the data to eliminate the impact of different index dimensions on the comprehensive score.

The data standardization formula is as follows:

Positive indicators:

$$x_{ij} = \frac{x_{ij} - \min\{x_{1j}, x_{2j} \dots x_{nj}\}}{\max\{x_{1j}, x_{2j} \dots x_{nj}\} - \min\{x_{1j}, x_{2j} \dots x_{nj}\}}$$

(including: $i = 1,2 \dots n$ $\mathrm{j} = 1,2 \dots m$)

Negative indicator:

$$x_{ij} = \frac{\min\{x_{1j}, x_{2j} \dots x_{nj}\} - x_{ij}}{\max\{x_{1j}, x_{2j} \dots x_{nj}\} - \min\{x_{1j}, x_{2j} \dots x_{nj}\}}$$

After the data standardization is completed, we use matlab to detect the missing values in the data and delete the corresponding scenic spot sample data. Then, we detect and process the abnormal values of the collected data. The existence of abnormal values will make the results of the model sometimes difficult to accept. We use 3σ principle to detect and process abnormal values, the processing steps are as follows:

Based on 3σ principle, outliers are eliminated, that is, the value of the sample is represented by x:

if:

$$x < u - 3\sigma \text{ } or \text{ } x > u + 3\sigma$$

Then think x is an outlier and is eliminated. Among u is the mean,σ is the standard deviation

After standardizing the data and dealing with missing values and outliers, we get a good data structure.

Then, a linear weighted evaluation model is established:

$$S = \sum_{i=1}^{5} w_i x_i$$

Among them, w_i is the weight of each indicator, x_i is the value after standardization for each indicator.

For the weight determination method, because we have the support of data, we no longer choose the subjective weighting methods such as analytic hierarchy process, but choose the more objective entropy weight method based on the data itself to assign the index weight.

Entropy weight method is an objective weighting method, which is based on the principle that the smaller the variation degree of the index, the less the amount of information reflected, and the lower the corresponding weight, that is, we obtain the weight from the information itself.Definition of information entropy: hypothesis x represents an event X something that might happen,$p(x)$ represents the probability of this situation. We can define: $I(x) = -ln\left(p(x)\right)$,Because $0 \leq p(x) \leq 1$, so $I(x) \geq 0$, if the event X possible situations are divided intox_1, x_2, ⋯ , x_n,then we can define events X the information entropy is:

$$e_j = -\mathrm{k} \cdot \sum_{i=1}^{n} p_{ij} \cdot \ln\left(p_{ij}\right)$$

Among them, k=$\frac{1}{\ln(m)}$, where m Is the sample size.

Information redundancy calculation formula:

$$d_j = 1 - e_j$$

The final weight calculation formula is:

$$w_j = \frac{d_{ij}}{\sum_{i=1}^{n} d_{ij}}$$

After the index weight is determined by entropy weight method, we conduct a preliminary quantitative evaluation of the scenic spot through the linear weighting model. Next, we conduct the final comprehensive evaluation through the artificial neural network model based on the evaluation results of entropy weight method.

4.2.2Artificial neural network evaluation model

Artificial neural network is a deep learning method. It continuously adjusts the weight through the input data to continuously approach the output value expected by the user. It avoids the error caused by manually defining the weight, and can avoid the complexity of solving the correlation coefficient. The results obtained by the artificial neural network evaluation method will be more in line with the actual situation.

Neural network diagram:

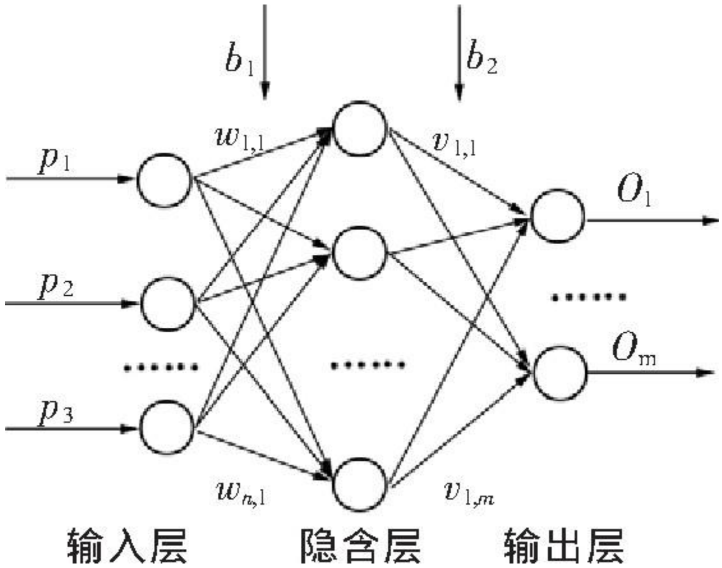

Figure 4-4

We use it here BP neural network is used to improve the evaluation results obtained by entropy weight method.

The model establishment process is as follows:

Before model input, the data is standardized first.

Model data input stage:

$$a = \sum_{i=1}^{n} w_i d_i$$

among d_i for the first i values of input variables, w_i for the first i The corresponding weights of neurons will be adjusted according to the returned results.

Action stage of hidden layer:

$$b = f_1(a)$$

among f_1 is the transfer function of the hidden layer.

Action stage of output layer:

$$y = f_2(b)$$

among f_2 is the transfer function of the output layer.

Weight adjustment:

$$w_i = w_{i-1} + c_{i-1}$$

$$c_i = -\eta \frac{\partial E}{\partial w_{ij}}$$

Among them,c is the error adjustment term for back propagation is the partial derivative of the expected value of the error to the weight multiplied by the learning rate.The final error converges to the minimum value by continuously adjusting the weight.

Establish neural network model:

$$y_t = f(\sum_{i=1}^{5} F_i)$$

Among them, f is the function of neural network training on the above selected indicators, F_i is the standardized factor value.

Parameter setting of neural network:

$net.trainParam.show$=10;

$net.trainParam.lr$=0.01;

$net.trainParam.goal$=1×10^{-5};

$net.trainParam.epochs$=1000;

$f_1 = logsig$

$f_2 = purelin$

They are the interval, learning rate, allowable error, maximum number of iterations and two transfer functions for each display of training effect.

K-means cluster analysis

After obtaining the comprehensive score of the scenic spot through the artificial neural network comprehensive evaluation model, we extract the scenic spot rating and the daily maximum number of visitors for cluster analysis.The K-means clustering analysis method based on Euclidean distance is used.The flow chart of K-means cluster analysis method is as follows:

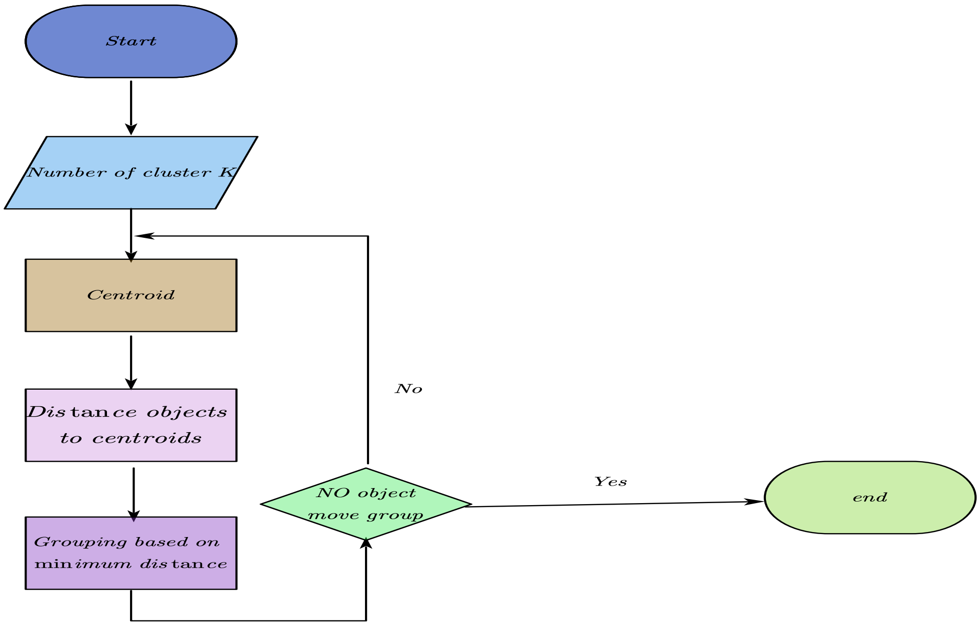

Figure 4-5

4.2.3 Solution of problem two model

Solution of evaluation model

We import the data into matlab to preprocess the data.

Then, the entropy weight method is realized by MATLAB to assign the weight of the linear weighted preliminary evaluation model. The results are as follows:

geographical position	Scenic spot rating	Scenic spot history score	Maximum daily reception	Crowding degree
0.05	0.25	0.02	0.64	0.07

Table 4-2

The weight is substituted into the linear weighted preliminary evaluation model to calculate the comprehensive score.

Then, the comprehensive score calculated based on entropy weight method is used to train the neural network model. 70% of the data is used as the training set and 30% as the test set. The parameters of the neural network are set, trained and visualized.The obtained scores before and after adjustment are visualized as follows:

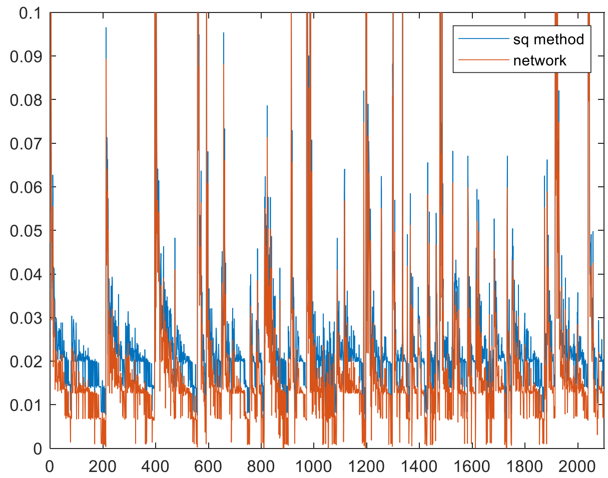

Figure 4-6

In the final quantitative evaluation results, the maximum value is 0.1533, which is Beijing Summer Palace, and the minimum value is 0.0123, which is kadinggou in Tibet Autonomous Region.It can be seen that our quantitative evaluation results are reasonable.

Cluster analysis results

Cluster analysis is carried out for the scenic spot based on the rating characteristics of the scenic spot and the characteristics of its maximum daily reception number, as follows:

$\boldsymbol{Step1}$: Using a priori information to determine the value of K, we naturally divide the scenery into good areas and large reception numbers;Poor area and large number of reception;The value of K is set to 4 because there are four types: good region, few receptions, poor region and few receptions.

$\boldsymbol{Step2}$: Import the data into Matlab for cluster analysis

$\boldsymbol{Step3}$: The obtained Clustering Visualization is as follows:

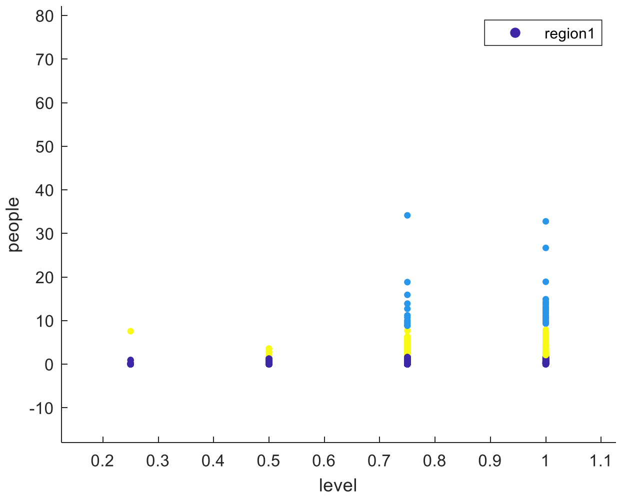

Figure 4-7

It can be seen from the above figure that there are different types of objects under the same rating level, and there are also different types of objects under the similar daily reception number. The first category includes scenic spots such as the Forbidden City in Beijing, the summer palace and Mount Tai in Shandong. Therefore, it can be seen that the classification result is reasonable.

4.3Question3:the current limit model

For the establishment of the flow restriction model of the scenic spot, we need to fully consider the epidemic situation of the city where the scenic spot is located and various characteristics of the scenic spot, and hope to establish a dynamic flow restriction model, because a static flow restriction model can not deal with the occurrence of emergencies.

4.3.1Establishment of current limiting model

We first define the epidemic risk index:

$$Risk = grade \cdot S$$

Among them, grade is a classification variable with a value of 1-3, corresponding to low-risk areas, medium risk areas and high-risk areas respectively.S is the comprehensive score of the scenic spot solved in question 2.The higher the comprehensive score of the scenic spot, the greater the possibility of attracting tourists, and the higher the risk level, the greater the risk of epidemic spread.

The idea of establishing the current limit model is as follows: we can collect the daily maximum carrying capacity of each scenic spot, so we determine the current limit threshold, which is naturally equivalent to determining the current limit proportion under different epidemic levels. The relationship between the current limit proportion and the daily maximum carrying capacity is as follows:

$$CLn = \delta R_{max}$$

Among them,CLn is flow limit threshold, that is, when the number of tourists reaches this value, the scenic spot will no longer receive tourists;δ is current limiting ratio, R_{max} is the maximum carrying capacity of the scenic spot.

How to determine the current limit proportion, we need to consider the relevant characteristics of the scenic spot.Based on the risk indicators defined above and in combination with the dynamic changes of the current number of infected people in the city where the scenic spot is located, we define the flow restriction ratio before conversion as:

$$\delta_1 = Risk \frac{n(t)}{n(t-1)}$$

Where risk is the degree of risk and n (T) is the number of patients at t time, then the above ratio is a dynamic growth rate.

When n = 0, δ is 1, that is, the flow restriction ratio is not set, but the flow restriction ratio should be adjusted appropriately in combination with the epidemic situation in nearby areas.When $n \neq 0$ If the grade index in the risk is 3, that is, the city where the scenic spot is located is a high-risk area, it is set δ=0, that is, the scenic spot is not open to tourists.When grade$\neq$ 3,the current limiting ratio before the above conversion is mapped to 0-1 through sigmoid function as the final current limiting ratio.

The sigmoid function is defined as follows:

$$y = \frac{1}{1 + e^{-x}}$$

The diagram is as follows:

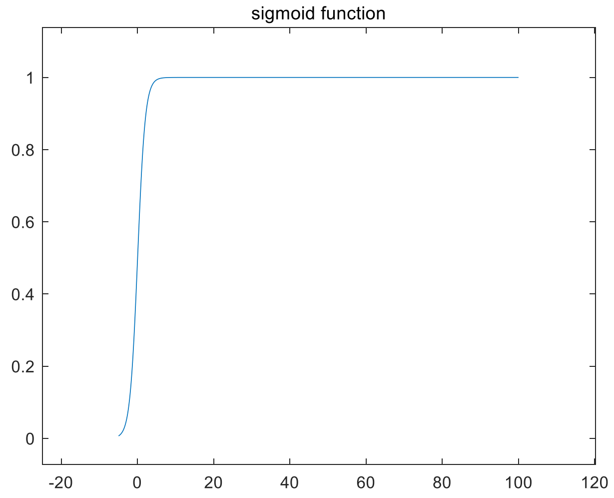

Figure 4-8

This function can map the value between 0-1, so we finally establish the current limiting proportion model as follows:

$$\delta = S(\delta_1)$$

Where S is the function of sigmoid function.

Further, we conclude that the final current limiting model is:

$$\delta = \begin{cases} 0\ , & grade = 3 \\ 1\ , & n = 0 \\ S(\delta_1), & else \end{cases}$$

After the current limiting ratio is determined, the current limiting threshold is determined according to the maximum bearing capacity of the scenic spot:

$$CLn = \delta R_{max}$$

4.3.2Select scenic spots for quantitative evaluation

Beijing Summer Palace is a 5A scenic spot, and there are a large number of visitors during each national legal holiday.Therefore, we selected the summer palace in Beijing as a popular scenic spot to quantitatively evaluate the above model.

Firstly, we collected the epidemic data of Beijing since 2020, intercepted the epidemic data in June 2020, selected the change of epidemic population from June 13 to June 14, 2020, and substituted the data into the model for calculation.Beijing is a medium risk area in the current period, i.e. grade = 2;Summer Palace R_{max}=180000 people.After solving the model of question 2, the final evaluation score of the summer palace is 0.1553, and most other scenic spots are between 0-0.1, indicating that the comprehensive evaluation of the summer palace is high and can be used as a typical representative of tourism development.

Calculated by substituting the data, the current risk of the summer palace is 0.3106, which is calculated by substituting the current limit model and mapped to 0-1 through sigmoid function to obtain the current limit proportion of the summer palace at this time δ =60%, then the current limit threshold should be 10441300 people. We believe that the Summer Palace should limit the number of tourists to less than 100000 at this time;

Then we set different growth rates of epidemic cases $\frac{n(t)}{n(t-1)}$, observe the relationship between current limiting ratio and it, and the visual results are as follows:

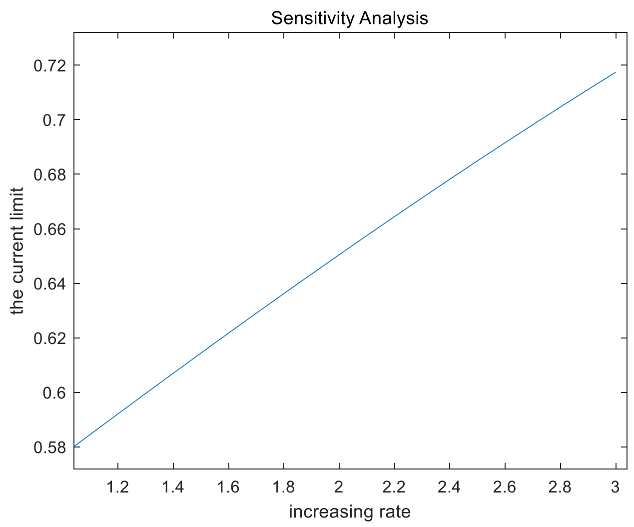

Figure 4-9

It can be seen from the figure that the proportion of current limit increases linearly with the growth rate. If the improvement of urban risk level is taken into account, that is, from medium risk area to high risk area, a sudden change of slope will occur in our figure, as shown in the figure below:

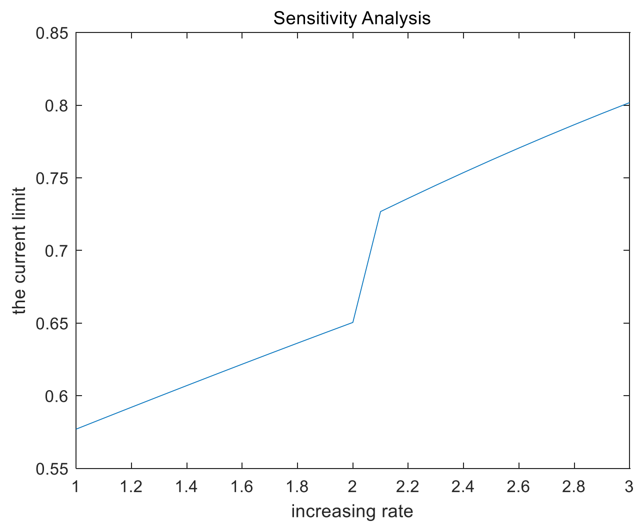

Figure 4-10

Therefore, through the typical examples of the summer palace scenic spot, we can analyze that when the epidemic level changes, our model will take corresponding change measures. It is a dynamic model, which can better quantify the flow restriction proportion that our scenic spot should take corresponding to different epidemic situations.

4.4Establishment and solution of problem four model

4.4.1Benefit quantification

For the development of tourism, we should fully consider the three aspects of epidemic prevention and control, tourism revenue and tourist experience, and provide suggestions on the development strategy of tourism from the perspective of modeling. We should first quantify these three aspects.

From the perspective of epidemic prevention and control: we quantify the epidemic prevention and control based on the flow restriction model established in question 3. If the number of tourists is n, and if $n < CLn$, the scenic spot will receive all of them,if $n \geq CLn$,the number of tourists is adjusted according to the flow restriction model.

Then there are:

$$n^* = \begin{cases} n, n < CLn \\ CLn, n \geq CLn \end{cases}$$

Among them, n^* is the actual number of people accepted by the scenic spot.

From the perspective of tourism revenue: we set the number of tourists as n, the tourism revenue can be quantified as follows:

$$income = nP$$

Among them,P is the ticket price for the scenic spot

From the perspective of tourist experience: we use the term utility in economics to quantify the tourist experience.

Utility: utility is one of the most commonly used concepts in economics.Utility: the degree to which consumers have or consume goods or services to satisfy their desires is called the utility of goods or services.

The utility of tourists is measured from the congestion index and ticket price defined above. If the congestion of the scenic spot is too high, the experience of natural tourists will not be very good, and the utility of tourists also depends on their own consumption. For the quantification of tourist experience, we consider the congestion of the scenic spot and the ticket price of the scenic spot.

Define visitor utility:

$$U = In(\frac{P}{Cr})$$

$$Cr = \frac{n}{s}$$

P is the ticket price of the scenic spot.

4.4.2Establish a multi-objective optimization model

After quantifying the three aspects that need to be considered in the development of tourism, we consider using the modeling method to put forward suggestions on the development strategy of tourism based on the quantitative results, and we consider establishing a multi-objective optimization model

(1) Analysis of decision variables

We set the decision variable as the number of tourists. The key variable for the development of tourism is how to open the scenic spot to tourists. Among the above three quantitative indicators, the number of tourists is the bottom variable of the three indicators. Based on the number of tourists n as the decision variable, a multi-objective optimization model is established.

(2) Analysis of constraints

We consider the quantification of epidemic prevention and control as the constraint condition of the multi-objective optimization model, that is, the number of tourists in the decision variable cannot exceed the flow limit threshold calculated by the flow limit model, that is:

$$n \leq CLn$$

(3) Multi objective optimization model

After setting epidemic prevention and control as a constraint, we comprehensively consider the two factors of tourism revenue and tourist experience to establish a multi-objective optimization model:

$$\begin{cases} max: income \\ max: U \end{cases}$$

$$s.t.\ \ n \leq CLn$$

The reception of tourists in the scenic spot should not only consider their own tourism income, but also consider the experience of tourists. The crowding degree in the scenic spot should not be too high, otherwise it is not conducive to the development of their own tourism.

4.4.3Model solution:

It is difficult to find the global optimal solution for the multi-objective model,the non inferior solution $Pareto$ plane is solved, and then the optimal solution is selected through different selection criteria.

$Pareto$ dominance is one of the common methods in multi-objective planning:

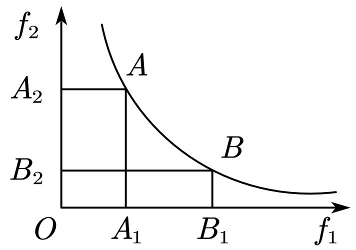

Figure 4-11 schematic diagram of non inferior solution

As shown in the figure, in this optimization problem, the objective function f_1 and f_2 is contradictory because $A_1 < B_1$ also $A_2 > B_2$ .In other words, the improvement of one objective function needs to be at the cost of the reduction of another objective function. Such a solution is called $Pareto$ non inferior solution, or $Pareto$ optimal solution.

Based on this theory, we solve the multi-objective model in the following steps:

$\boldsymbol{Step}$**1**:Firstly, the constraints on epidemic prevention and control are obtained according to different epidemic situations, that is CLn.

$\boldsymbol{Step2}$:Then the solution range of decision variables is determined according to the number of historical tourists

$\boldsymbol{Step3}$:By setting the multi-objective optimization function:$matlab$ solve its $Pareto$ Solution plane

$\boldsymbol{Step4}$:Scenic spot managers and the government choose to focus on income, epidemic prevention and control or tourist experience through the existing epidemic situation, and select the optimal solution under the corresponding situation from the Pareto solution plane.

The Pareto solution plane of the model is solved by using genetic algorithm in matlab: we also use the corresponding data of the summer palace and the epidemic situation to solve the multi-objective optimization model, establish the multi-objective function, and use the genetic algorithm heuristic search and iteration until the offspring converge. The results are as follows:

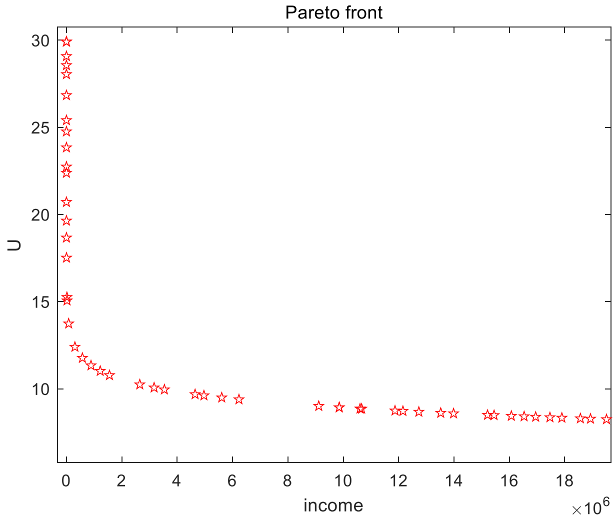

Figure 4-12

Among them, the vertical axis is utility, which reflect tourist experience, and the horizontal axis is tourism revenue. The two are opposite. Therefore, we hope that the government and scenic spot managers will choose between tourism revenue and tourist utility according to different epidemic situations and actual conditions.

For a simple example, if the evaluation of the current scenic spot is further reduced and tourists make evaluations such as too crowded, government managers can appropriately reduce the demand for tourism revenue to improve tourists sense of experience, that is, the optimal solution of the multi-objective model is northwest of the solution $Pareto$ plane.If the tourism income is too low, under the condition of ensuring a certain sense of tourists experience, the optimal solution is the southeast direction of the solution $Pareto$ plane.

Finally, we use Monte Carlo simulation method to make the number of epidemic infection $n(t)$ in random value, expected different changes of epidemic situation in the future. Based on the comprehensive score of the summer palace, a random simulation of the epidemic situation in Beijing is carried out to detect the changes in the solution of our multi-objective model, and the selection criteria for the optimal solution of the multi-objective model are put forward according to different epidemic levels.

The simulation results are as follows:

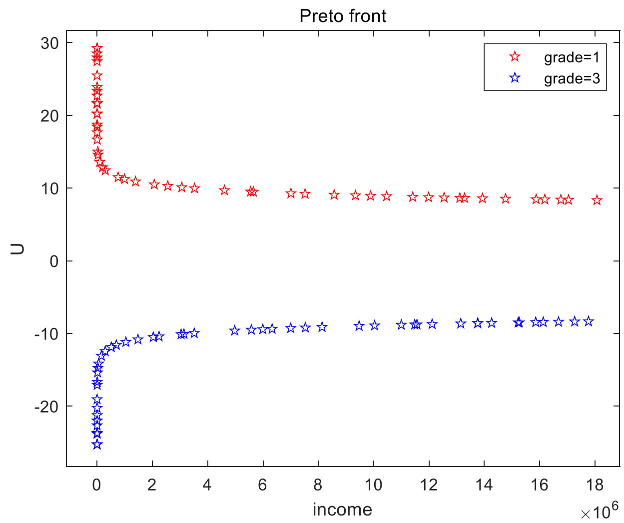

Figure 4-13

It can be seen that when the epidemic level reaches a high-risk area, the utility of tourist experience becomes negative, which shows that our model can well reflect the impact of the epidemic on tourism. When the epidemic transmission intensity is very high, the scenic spot should be blocked and not open to the outside world as much as possible. When the epidemic transmission intensity is moderate, the scenic spot should consider more tourist experience, select the optimal solution of the multi-objective optimization model from the northwest direction of the solution $Pareto$ plane is selected. When the epidemic transmission intensity is relatively weak, we can appropriately receive tourists to improve our tourism income and further drive the development of tourism, that is, the optimal solution from the southeast direction of the solution $Pareto$ plane is selected.

4.5Solution to problem 5

On the basis of solving problems 1 to 4, through the evaluation results of our quantitative model and the four types of scenic spots obtained by K-means clustering algorithm in problem 2, we provide the following differentiated management strategies for government management departments:

In question 2, we divided the scenery into good areas and large numbers of reception;Poor area and large number of reception;There are four categories: good area, few reception people, poor area and few reception people.

For scenic spots with superior areas and large daily reception, the government management department should focus on overall planning. When the epidemic situation is relatively good, based on the idea of establishing the model in question 4, grasp the main contradiction, reasonably control the number of tourists in the scenic spot, and deal with the relationship between tourism income and tourists' sense of experience, so as to maintain the development of tourism,We should also ensure the tourists sense of experience.When the epidemic occurs, such scenic spots also need to be strictly controlled. Once the epidemic spreads too fast, the government should immediately order to block the scenic spots and no longer open to tourists. When there is an epidemic, according to our model estimation, the flow restriction ratio should not be less than 60%.

For the scenic spots with superior areas and less reception, relatively speaking, they can focus on tourism income. When the epidemic is not particularly serious, they can publicize the scenic spots and make better development of regional tourism through superior regional advantages.However, while the number of tourists increases, we should also pay attention to the prevention and control measures of the epidemic, always be highly vigilant against the epidemic, and strive to maintain the sustainable development of tourism.

For scenic spots with remote areas and large number of tourists, most tourists come from local areas, so the risk of epidemic situation will be smaller than the above two types of scenic spots, that is, the risk degree in the above will be relatively low, but once the epidemic occurs, it will cause unimaginable transmission speed. Therefore, the government should pay attention to temperature detection andCheck the health code and travel code, and conduct nucleic acid detection if necessary to ensure the effectiveness of epidemic prevention and control.

For scenic spots with remote areas and few visitors, the local government needs to focus on developing their tourism potential. The government should improve its scenic spot facilities and increase the public transportation modes to reach the scenic spot as much as possible, and think about ways to attract tourists. Under the background of the epidemic, the development of tourism needs the joint cooperation of the government, the people and the scenic spot managers,Let those scenic spots that are not famous but actually have beautiful scenery get more attention.

In short, before conveying the corresponding policies to a scenic spot, the government management department should first locate which kind of scenic spot it belongs to, and carry out differentiated management according to different scenic spot categories.However, in today's severe situation of epidemic situation in the world, no matter what kind of scenic spots, we should focus on epidemic prevention and control, and then vigorously develop our tourism on the basis of epidemic prevention and control, so as to drive the development of China's tourism, transportation and catering industry.

5.Strengths and Weakness

5.1Advantages of the model

(1) Through the entropy weight method combined with neural network to quantitatively evaluate the scenic spot, the results are more in line with the actual situation.
(2) Through K-means cluster analysis, the two characteristics of scenic spot rating and daily maximum reception capacity are clustered, and more reasonable results are obtained.

(3) By detecting the growth rate of infection in different epidemic situations, a dynamic flow limiting model is established, which is easy to adjust according to different actual conditions.
(4) A multi-objective planning model is established by quantifying epidemic prevention and control, tourism revenue and tourist experience, which provides quantitative suggestions for scenic spot planning.
(5) The concept of utility in economics is introduced to quantify the passenger experience.

5.2Disadvantages of the model

(1) The current limiting model does not consider the potential transmission risk of epidemic infected persons in the vicinity of the city where the scenic spot is located.
(2) Data processing is relatively simple, and some important data may be lost.

6.References

[1] Mou Yongsheng, Xiang Huaming, Xiong Qingqing. Analysis and suggestions on current situation of flow restriction in domestic scenic spots during the epidemic period -- Taking Huangshan scenic spot as an example [J]. Modern commerce and industry, 2020, 41 (28): 2
[2] Dou Zhiwu, Li Hongwei, Xiong Qi. Research on evaluation method of Port Logistics comprehensive capacity based on entropy weight method and neural network [J]. Computer science, 2015, v.42 (S2): 563-565 + 575
[3] Lu Wenxi, Zhu tingcheng, Lu Wen Xi, et al. Evaluation of water nutritional status of South Lake in Changchun by artificial neural network [J]. Geographical Sciences, 1999, 19 (5): 4
[4] Gong Maoguo, Jiao Licheng, Yang Dongdong, et al. Research on evolutionary multi-objective optimization algorithm [J]. Journal of software, 2009 (2): 19

7.Appendix

7.1 The code for problem number one

```
% Question pair visualizes the collected data, viewing and illustrating their distribution characteristics, including rating and number of guests characteristics
ge_data=xlsread("A 级景区分省.xlsx");
j_max=max(ge_data(:,2));
w_max=max(ge_data(:,3));
j_min=min(ge_data(:,2));
w_min=min(ge_data(:,3));
%ax1=worldmap("China");
%ax2=worldmap([w_min,w_max],[j_min,j_max]);
ax=worldmap('China');
load coast
plotm(lat, long)
[n,m]=size(ge_data);
A_point=[];
A2_point=[];
A3_point=[];
A4_point=[];
A5_point=[];
for i=1:n
    if plotdata(i,)==1
        A_point=[A_point;ge_data(i,3) ge_data(i,2)];
    end
    if ge_data(i,1)==2
        A2_point=[A2_point;ge_data(i,3) ge_data(i,2)];
    end
    if ge_data(i,1)==3
        A3_point=[A3_point;ge_data(i,3) ge_data(i,2)];
    end
    if ge_data(i,1)==4
        A4_point=[A4_point;ge_data(i,3) ge_data(i,2)];
    end
    if ge_data(i,1)==5
        A5_point=[A5_point;ge_data(i,3) ge_data(i,2)];
    end
end
%Draw points of the first type, denoted by green dots
geoshow(A_point(:,1),A_point(:,2),"DisplayType",
"point",'MarkerEdgeColor','g','Marker','.','MarkerSize',2)    %g 表示绿色
geoshow(A2_point(:,1),A2_point(:,2),"DisplayType", "point",'MarkerEdgeColor', 'r',
'Marker','.','MarkerSize',2)    %r 表示红色
```

```
geoshow(A3_point(:,1),A3_point(:,2),"DisplayType", "point",'MarkerEdgeColor', 'b',
'Marker','.','MarkerSize',2 )
geoshow(A4_point(:,1),A4_point(:,2),"DisplayType", "point",'MarkerEdgeColor', 'y',
'Marker','.','MarkerSize',2)
geoshow(A5_point(:,1),A5_point(:,2),"DisplayType", "point",'MarkerEdgeColor', 'm',
'Marker','.','MarkerSize',2 )
legend("mapsize1","mapsize2","A spot","2A spot","3A spot","4A spot","5A spot")
title("level")
```

7.2 The code for problem number two

```
%%%%1. Matlab realizes entropy weight method to determine weight
clear;clc
data=xlsread("景点数据.xlsx","Sheet3");
data(:,2)=[];
[n1,m1]=find(isnan(data));
data(n1,:)=[];
[n,m]=size(data);
A=zeros(n,m);
for j=1:m
    if j==1||j==2||j==4
    A(:,j)=(data(:,j)-min(data(:,j)))/(max(data(:,j))-min(data(:,j)));
    else
    if j==3
    A(:,j)=(max(data(:,j))-data(:,j))/(max(data(:,j))-min(data(:,j)));
    end
    end
end
for i=1:n
    for j=1:m
        if A(i,j)==0
            A(i,j)=eps;
        end
    end
end
p=zeros(n,m);
w=zeros(1,m);
d=zeros(1,m);
e=zeros(1,m);
for i=1:n
    for j=1:m
        p(i,j)=A(i,j)/sum(A(:,j));
    end
end
    K=1/log(n);
    for j=1:m
```

```
e(j)=-K*sum(p(:,j).*log(p(:,j)));
end
d=ones(1,m)-e;
for j=1:m
    w(j)=d(j)/sum(d);
end
S=w(1)*A(:,1)+w(2)*A(:,2)+w(3)*A(:,3)+w(4)*A(:,4);
S_max=max(S)

%Based on the results of entropy weight method, neural network was used for final evaluation
clear;clc
train_data=xlsread("train_data.xlsx");
[n,m]=size(train_data);
train_num=floor(0.9*n);
input=train_data(1:train_num,2:5);
output=train_data(1:train_num,1);
net=newff(input',output',[12],{'logsig','logsig'},'traingdx');
net.trainParam.show=10;
net.trainParam.lr=0.01;
net.trainParam.goal=1e-5;
net.trainParam.epochs=1000;
net=train(net,input',output');
w1=net.iw{1,1};
theta1=net.b{1};
w2=net.lw{2,1};
theta2=net.b{2};
test=train_data(train_num+1:end,2:5);
y=sim(net,test');
[n1,m1]=size(y);
x1=1:train_num;
plot(x1,output,x1,output-rand*0.01);
axis([0 train_num 0 0.1])
legend("sq method","network")
```

7.3 The code for problem number three

```
%Quantitative evaluation of problem 3

% Select the data of Beijing

%6.14-6.15 Calculation of current limiting ratio
n_t2=700*rand+25*rand;
n_t1=673*rand+25*rand;
Rmax=18;
grade=2;
```

```
    S=0.1553;
    Risk=grade*S;

    delta1=Risk*(n_t2/n_t1);
    delta=1/(1+exp(-delta1));
    CLn=delta*Rmax;
    n=1:0.1:3;
    [n1,m1]=size(n);
    for i=1:m1
       if n(i)>2
             grade=3;
       else
       end
       Risk=grade*S;
       delta2=Risk*n(i);
       delta(i)=1./(1+exp(-delta2));
    end
       plot(n,delta);
       xlabel("increasing rate");
       ylabel("the current limit");
       title("Sensitivity Analysis");
```

7.4 The code for problem number three

```
%Solution and simulation analysis of Pareto solution plane of multi-objective optimization model.

% Random constraint updating is performed by Monte Carlo simulation method。
fitnessfun=@multi_obj;
nvars=1;
n_t2=700*rand+25*rand;
n_t1=673*rand+25*rand;
Rmax=180000;
grade1=3;
S=0.1553;
Risk1=grade1*S;

delta1=Risk1*(n_t2/n_t1);
delta=1/(1+exp(-delta1));
CLn1=delta*Rmax;
lb1=[0];
ub1=[CLn1];
A=[];
b=[];
Aeq=[];
beq=[];
options.Generations=5000;
```

```
fitnessfun1=@multi_obj;
nvars=1;
n_t2=700*rand+25*rand;
n_t1=673*rand+25*rand;
Rmax=180000;
grade=1;
S=0.1553;
Risk=grade*S;

delta2=Risk*(n_t2/n_t1);
delta3=1/(1+exp(-delta2));
CLn2=delta3*Rmax;
lb=[0];
ub=[CLn2];
A=[];
b=[];
Aeq=[];
beq=[];
options.Generations=5000;
[n1,fval1]=gamultiobj(fitnessfun,nvars,A,b,Aeq,beq,lb,ub,options);
[n2,fval2]=gamultiobj(fitnessfun,nvars,A,b,Aeq,beq,lb1,ub1,options);
plot(-fval1(:,1),-fval1(:,2),"pr");
title("Pareto front");
xlabel("income")
ylabel("U")
```