Score,signature and note of Judge one	Team number: 10486	Score,signature and note of Judge three
Score,signature and note of Judge two	Choose: C	Score,signature and note of Judge four

Topic: **Choose and Optimization of Reasonable Travel Route**

Abstract

This article will be the best tourist attractions in Luoyang attractions selection, determined the travel route based on the selected attractions, evaluated and optimized the travel route by established a mathematical model.
According problem requires, answers will be divided into three steps. Firstly, determined the best tourist attractions, secondly according to the determined tourist attractions to identify and evaluate routes, finally optimized the reasonable travel route.
For step one, selected the value of the attractions, ticket prices, and regional conditions of attractions for the first layer index and based on this to deepen stratification, determined the weight of index in each layer. Finally got the consolidated evaluation model by linear weighting, evaluated tourist attractions in Luoyang then determined travel routes from those attractions.
For step two, depending on the selected attractions, determine the tourist routes under different attractions by using "loop" type capture method, established fuzzy evaluation model. Structured evaluation matrix R and obtained fuzzy evaluation weight matrix C. Got the ultimate function of satisfaction, brought each tourist routes corresponding fuzzy evaluation weight matrix C into Satisfaction function to score, finally evaluated and analysis the determined ten travel routes.
For step three, according to pairs evaluation and analysis of tourist routes satisfaction of step two, considering the impact of economic conditions, travel time, and the family structure of the travel route,optimized the selected tourist route, determined about travel time, the number of attractions and tourist spending three constraints, by collecting and collating the distance between attractions, attractions and other data on length of stay, and assumptions about family structure, such as travel costs and travel time by using 0-1 variables, reasonably analysis by using Lingo software, gave sound advice for families of different structure, and broaden the specific model.

Keyword: Fuzzy Comprehensive Evaluation; Fuzzy evaluation weight matrix; 0-1Variables; Satisfaction

1. Problem Restatement

Summer holiday is coming, many parents may choose to bring their children to go travel, but different families have different needs, so choosing a tourist city, comprehensively considered important factor such as itinerary, time and cost to design a tour package for families having different needs.

With people's material life got better, travel is increasingly becoming one of the important events in people's lives, Luoyang, the ancient capital of nine dynasties,is the must go place for many tourists, there is a family that want to travel to Luoyang on summer holiday, considering transportation costs, accommodation costs and meal costs,etc. Selected the best tourist attractions and draw the appropriate travel route and evaluated the travel route.

In summary, according to the meaning of the questions we need to address the following three questions:

(1) Draw the best tourist attractions in Luoyang by building models;

(2) Gather information and determine the best travel route,evaluate and analysis the travel route without considering the time and money constraints;

(3) Based on (2), get the best travel route with considering the time and money constraints.

2. Problem Analysis

2.1 Analysis of the problem A

According to the analysis of the best travel route in problem restatement, for the problem one, firstly analyzed the impact index of sightseeing, then stratified indicators and calculated weights of different index. Establish a comprehensive evaluation model[1].

Value of the attractions, ticket prices, regional conditions of attractions is the first layer index, value of the attractions include the size and quality of attractions, regional conditions of attractions include infrastructure, tourism facilities and relationships with other attractions and traffic conditions, quality of attractions include water, climate, geology and topography, flora and fauna, cultural monuments, customs, size of attractions include capacity and concentration of attractions.

According to the classification of these selected indicators, structured judgment matrix,analysis of weight calculation and consistency check, eventually structured evaluation model through linear weighted, chose different attractions,collected data of corresponding attractions, finally, deal with data of every attraction by dimensionless processing, got different attractions weighted score by comprehensive evaluation model, ranked attractions based the scores on different attractions, then determined the tourism value of every attraction.

2.2 Analysis of the problem B

According substantial attractions ranking in problem A, captured the front seven attractions, connected four spots, five spots, six and seven attractions attractions together via a loop, selected the number of attractions, attractions quality and route stay time for Satisfaction Index, determined each proposed route evaluation value and ranking of tourist Route by using fuzzy comprehensive evaluation method[2], conducted quantitative analysis and qualitative comparison of different systems for tourist route based on fuzzy comprehensive scores.

2.3 Analysis of the problem C

According to Satisfaction analysis of the tourist route in problems B, considering the impact of economic conditions, travel time, and the family structure of the travel route, combined with the result of satisfaction analysis, reasonably optimized the travel route, set a typical family structure as an example, established the objective function of cost by using 0-1 variable and determined constraints, collected more data,Solved and analysis the results by using Lingo software, selected the appropriate travel route for instance family and Broaden the specific model.

3. Problem Assuming

(1) Evaluation and dimensionless processing can use the abstract indicators such as high, medium, low, and excellent, good, fair, poor;
(2) The average speed of the taxi is 60km / h, the average cost is 2 ¥/ km;
(3) The family will stay in hotel every night,and they need two rooms;
(4) The family have 10 hours a day for travel,including sightseeing and ride time;
(5) A trip without considering the impact of weather, traffic and other special situations;
(6) The entire tourist route is a loop;
(7) The journey will not appear the phenomenon of the repeated visit;

4. Symbol Description

Symbol	Description
A	Function expression pf attractions comprehensive evaluation model
B_i	The first layer composite indicators（i=1,2,3）
C_i	The second layer composite indicators（i=1,2,...6）
D_i	The third layer composite indicators（i=1,2,...8）
w_{Bi}	The weights of B_i
w_{Ci}	The weights of C_i
w_{Di}	The weights of D_i
$\lambda_{\max}$	Largest eigenvalue of judgment matrix
W	Weight set of every indicator
t_i	Stay time of attraction i
J	The total cost of the Family
J_1	The total transportation cost of the family
J_2	The cost of family in attractions
q_{ij}	The total transportation cost from attraction i to attraction j
p_{ij}	The 0-1 variable between attraction i and attraction j
r_i	The total cost in Attraction i
t_{ij}	The time from attraction i to attraction j
T_1	The total transportation time
T_2	Stay time in attraction
T	Total time of travel process
$\sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij}$	The number of attractions for the Family
n	The number of attractions
d_{ij}	Distance between attraction i and attraction j
m	The average cost of taxi ride
v	The average speed of the taxi
e_i	total consumption in attraction i
U_i	Index in tourist route evaluation(i=1,2...4)
V_i	Comment level（i=1,2...5）
a	Judgment matrix
R_{ij}	The percentage of indicators i in level j
R	Evaluation matrix
A	Satisfaction of tourist route
C	Fuzzy evaluation weight matrix

5. Establishment and solution of model

5.1 Establishment and solution of model A

5.1.1 Stratification of each index

By layering and refine indicators, the index system was eventually see Figure 1

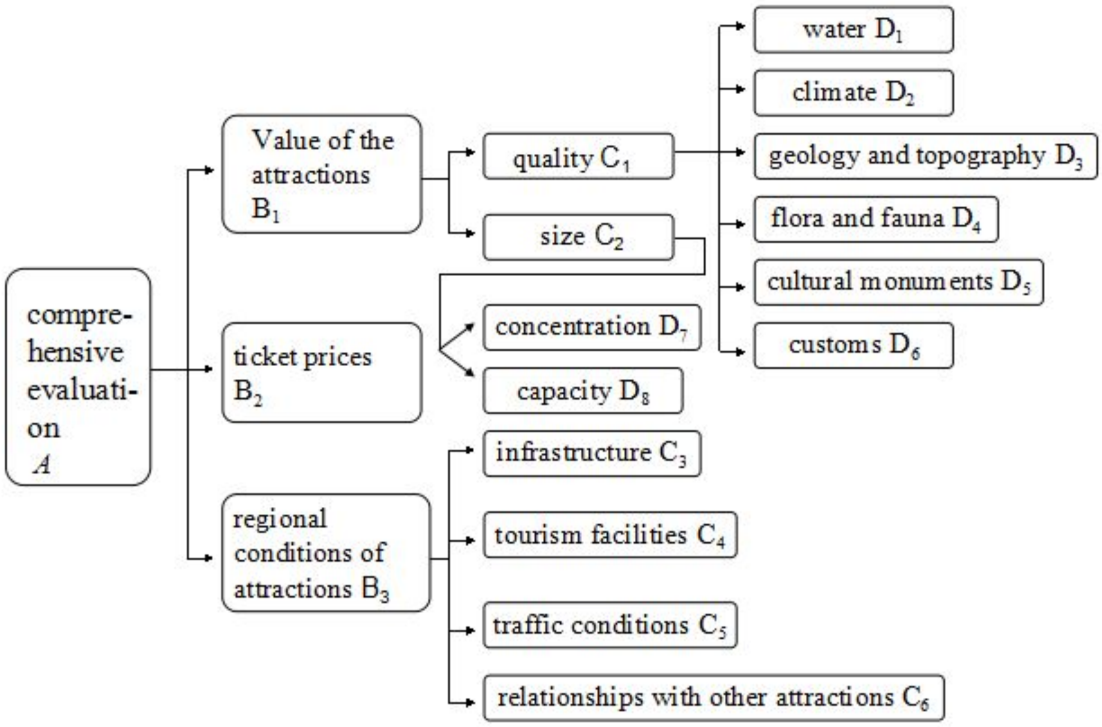

Figure1:Indicator system after stratification and refinement

5.1.2 Determination of each index

According to the index system,Listed the following judgment matrix,determined the weight of each indicator and listed corresponding weights in the following table1—7

Table1: Judgment matrix(A-B) and corresponding indicators weights

Systematic Review	Value of the attractions	ticket prices	regional conditions of attractions	W
Value of the attractions	1	2	4	0.5584
ticket prices	1/2	1	3	0.3196
regional conditions of attractions	1/4	1/3	1	0.1220

Consistency checked has solved the largest eigenvalues by Matlab:

$$CI = \frac{\lambda_{\max} - n}{n-1}, CR = \frac{CI}{RI}$$

Corresponding values random consistency index in the following Table 2:

Table 2: The corresponding values of the random consistency RI

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Based on the largest eigenvalues $\lambda_{\max} = 3.0183$

obtained CI=0.0091;RI=0.5301;CR_1=0.0173<0.1

Table3: Judgment matrix(B_1-C) and corresponding indicators weights

Value of the attractions	quality of attractions	Size of attractions	W
quality of attractions	1	5	0.8333
Size of attractions	1/5	1	0.1667

Table4: Judgment matrix(B_3-C) and corresponding indicators weights

regional conditions of attractions	infrastructure	tourism facilities	traffic conditions	relationships with other attractions	W
infrastructure	1	1/5	2	1/4	0.1401
tourism facilities	5	1	3	2	0.4372
traffic conditions	1/2	1/3	1	3	0.2114
relationships with other attractions	4	1/2	1/3	1	0.2113

Based on the largest eigenvalues $\lambda_{\max} = 5.0195$

Obtained CI=0.0049;RI=0.90;CR_1=0.0054<0.1

Table5: Judgment matrix(C_1-D) and corresponding indicators weights

quality of attractions	water	climate	geology and topography	flora and fauna	cultural monuments	customs	W
water	1	1/2	3	1/4	1/4	3	0.1218
climate	2	1	1/5	3	1/5	2	0.1340
geology and topography	1/3	5	1	3	1/2	2	0.1916
flora and fauna	4	1/3	1/3	1	5	1/3	0.2106
cultural monuments	4	5	2	1/5	1	5	0.2404
customs	1/3	1/2	1/2	3	1/5	1	0.1016

Table6: Judgment matrix(C_2-D) and corresponding indicators weights

size of attractions	concentration of attractions	capacity of attractions	W
concentration of attractions	1	5	0.8333
capacity of attractions	1/5	1	0.1667

Table7: Evaluation index weight distribution of attractions

comprehensive evaluation	The first layer composite indicators	W	The second layer composite indicators	W	The third layer composite indicators	W
comprehensive evaluation of attractions	Value of the attractions	0.5584	quality of attractions	0.8333	water	0.1218
					climate	0.1340
					geology and topography	0.1916
					flora and fauna	0.2106
					cultural monuments	0.2404
					customs	0.1016
			size of attractions	0.1667	concentration of attractions	0.8333
					capacity of attractions	0.1667
	ticket prices			0.3196		
	regional conditions of attractions	0.1220	infrastructure		0.1401	
			tourism facilities		0.4372	
			traffic conditions		0.2114	
			relationships with other attractions		0.2113	

5.1.3 Comprehensive evaluation model and rank of attractions

$$A = w_{D1}D_1 + w_{D2}D_2 + w_{D3}D_3 + w_{D4}D_4 + w_{D5}D_5 + w_{D6}D_6$$
$$+w_{D7}D_7 + w_{D8}D_8 + w_{B2}B_2 + w_{C3}C_3 + w_{C4}C_4 + w_{C5}C_5 + w_{C6}C_6$$

$$W = (w_{D1}, w_{D2}, w_{D3}, w_{D4}, w_{D5}, w_{D6}, w_{D7}, w_{D8}, w_{B2}, w_{C3}, w_{C4}, w_{C5}, w_{C6})$$

$$W = (0.0567, 0.0624, 0.0892, 0.0980, 0.1119, 0.0473, 0.0776, 0.0155, 0.3196, 0.0171, 0.0534, 0.0258, 0.0258)$$

According to data collected and evaluated for the visitors after viewing spots,ranked the attractions,determined the relative value of the various attractions.
Lastly,according comprehensive evaluation model,result in table 8:

Table8:Attractions ranking

Ranking	Name of attractions	Open state	Ticket price
1	Longmen Grottoes	Normally open	120.0¥
2	Baiyun Mountain	Normally open	60.0¥
3	Guanlin temple	Normally open	30.0¥
4	Ji Guandong	Normally open	50.0¥
5	Baima temple	Normally open	35.0¥
6	Longtan Grand Canyon	Normally open	50.0¥
7	Flower and Fruit Mountain National Forest Park	Normally open	25.0¥

5.2 Establishment and solution of model B

5.2.1 selecte reasonable route

According to attractions selected in problem A,captured attractions by choosing Shortest path on the map,Luoyang attractions shown in Figure 2:

Capture Loop-type route, tourist route has four attractions:

Longmen Grottoes → Flower and Fruit Mountain National Forest Park → Longtan Grand Canyon→Baima temple

Longmen Grottoes→Flower and Fruit Mountain National Forest Park→Ji Guandong →Baiyun Mountain
Longmen Grottoes→Guanlin temple→Ji Guandong→Baiyun Mountain
Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon

Tourist route has five attractions:

Longmen Grottoes→Baima temple→Flower and Fruit Mountain National Forest Park →Ji Guandong→Baiyun Mountain
Longmen Grottoes→Longtan Grand Canyon→Flower and Fruit Mountain National Forest Park→Ji Guandong→Baiyun Mountain
Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon→ Flower and Fruit Mountain National Forest Park

Tourist route has six attractions:

Longmen Grottoes→Baima temple→Longtan Grand Canyon→Flower and Fruit Mountain National Forest Park→Ji Guandong→Baiyun Mountain
Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon→ Flower and Fruit Mountain National Forest Park→Ji Guandong

Tourist route has seven attractions:

Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon→ Flower and Fruit Mountain National Forest Park→Ji Guandong→Baiyun Mountain
According to the data above,different travel routes appear under different attractions therefore needed to select indicators to evaluate the various routes,found a more suitable tourist routes.

5.2.2 Determine index of evaluation

According to the tours satisfaction index,establish tourist route satisfaction evaluation system,finally selected four important quality indicators included attractions number, attractions quality,the total length of stay and spend on the route.

Table9: Symbols of Evaluation index

Symbols	U_1	U_2	U_3	U_4
Explanation	Attractions number	Attractions quality	the total length of stay	spend

Determined comment level:
V=（V_1,V_2,V_3,V_4,V_5）=(Very satisfied, satisfied, Common satisfied, very unsatisfied)
solved the weights of four indicators,weights set:

$$W=[w_1, w_2, w_3, w_4]$$

Judgment matrix a:

$$a=\begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix}$$

Solve the greatest characteristic root of Judgment matrix by using Matlab software,and solving for the W,Tested consistency of biggest characteristic root.
Discriminant matrix constructed in the following table 10:

Table 10: Discriminant matrix of indicators

	Attractions number	Attractions quality	the total length of stay	spend	W
Attractions number	1	2/3	2	2/5	0.2015
Attractions quality	3/2	1	3	3/5	0.2572
the total length of stay	1/2	1/3	1	1/5	0.1008
spend	5/2	3/4	5	1	0.4405

W $=[w_1, w_2, w_3, w_4]=[0.2015, 0.2572, 0.1008, 0.4405]$, $CR= -0.1029 < 0.1$, Passed consistency test.

5.2.2 Build evaluation matrix R

Through the analysis, calculation, summary data collected,Build evaluation matrix R, Its relationship with each index in the following table.

Table11: Relationship between U and V

	V_1	V_2	V_3	V_4	V_5
U_1	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}
U_2	R_{21}	R_{22}	R_{23}	R_{24}	R_{25}
U_3	R_{31}	R_{32}	R_{33}	R_{34}	R_{35}
U_4	R_{41}	R_{42}	R_{43}	R_{44}	R_{45}

R_{ij} expressed the percentage of the index i in the grade j.

Fuzzy comprehensive evaluation weight matrix C:

$$C=W\circ R=\begin{bmatrix} w_1 & w_2 & w_3 & w_4 \end{bmatrix}\begin{bmatrix} R_{11} & R_{12} & R_{13} & R_{14} & R_{15} \\ R_{21} & R_{22} & R_{23} & R_{24} & R_{25} \\ R_{31} & R_{32} & R_{33} & R_{34} & R_{35} \\ R_{41} & R_{42} & R_{43} & R_{44} & R_{45} \end{bmatrix}=\begin{bmatrix} c_1 & c_2 & c_3 & c_4 & c_5 \end{bmatrix}$$

Finally established $V=(V_1,V_2,V_3,V_4,V_5)$,get fuzzy comprehensive evaluation weight matrix through weighting process, obtained the tourist route Satisfaction evaluation function:

$$A=5c_1+4c_2+3c_3+2c_4+c_5$$

5.2.3 Tourist route objective satisfaction ranking

According to the identification and Evaluation index to solved the fuzzy comprehensive evaluation of the weight matrix C.obtained scores of each tour through bringing results into a final evaluation function,Specific results and analysis as follow:

Four attractions:

Route one: Longmen Grottoes→Flower and Fruit Mountain National Forest Park→ Longtan Grand Canyon→Baima temple

Table 12:Evaluation matrix of route one

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.2	0.5	0.2	0.1	0
Attractions quality	0.1	0.3	0.4	0.2	0
the total length of stay	0.3	0.5	0.1	0.1	0
spend	0.3	0.4	0.2	0.1	0

Obtained fuzzy evaluation weight matrix C:

$$C=[0.228\ 0.405\ 0.241\ 0.126\ 0]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.228+4*0.405+3*0.241+2*0.126+1*0=3.74$$

Route two: Longmen Grottoes→Flower and Fruit Mountain National Forest Park→Ji Guandong→Baiyun Mountain

Table 13:Evaluation matrix of route two

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.2	0.5	0.2	0.1	0
Attractions quality	0.2	0.3	0.3	0.2	0
the total length of stay	0.2	0.4	0.3	0.1	0
spend	0.2	0.4	0.2	0.2	0

Obtained fuzzy evaluation weight matrix C:

$$C=[0.200\ 0.394\ 0.236\ 0.170\ 0]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.2+4*0.394+3*0.236+2*0.17+1*0=3.62$$

Route three:Longmen Grottoes→Guanlin temple→Ji Guandong→Baiyun Mountain

Table 14:Evaluation matrix of route three

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.2	0.5	0.2	0.1	0
Attractions quality	0.2	0.4	0.4	0	0
the total length of stay	0.05	0.3	0.3	0.3	0.05
spend	0.1	0.2	0.4	0.2	0.1

Obtained fuzzy evaluation weight matrix C:

$$C=[0.141\ 0.322\ 0.350\ 0.138\ 0.049]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.141+4*0.322+3*0.35+2*0.138+1*0.049=3.37$$

Route four: Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon

Table 15:Evaluation matrix of route four

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.2	0.5	0.2	0.1	0
Attractions quality	0.1	0.4	0.3	0.2	0
the total length of stay	0.4	0.4	0.1	0.1	0
spend	0.3	0.5	0.1	0.1	0

Obtained fuzzy evaluation weight matrix C:

$$C=[0.238\ 0.464\ 0.172\ 0.126\ 0]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.238+4*0.464+3*0.172+2*0.126+1*0=3.81$$

Five attractions:

Route five: Longmen Grottoes→Baima temple→Flower and Fruit Mountain National Forest Park→Ji Guandong→Baiyun Mountain

Table 16:Evaluation matrix of route five

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.2	0.6	0.1	0.1	0
Attractions quality	0.1	0.4	0.4	0.1	0
the total length of stay	0.2	0.3	0.4	0.1	0
spend	0.1	0.2	0.4	0.2	0.1

Obtained fuzzy evaluation weight matrix C:

$$C=[0.130\ 0.342\ 0.340\ 0.144\ 0.044]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.130+4*0.342+3*0.340+2*0.144+1*0.044=3.37$$

Route six: Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon→Flower and Fruit Mountain National Forest Park→Ji Guandong

Table 17:Evaluation matrix of route six

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.2	0.6	0.1	0.1	0
Attractions quality	0.1	0.4	0.4	0.1	0
the total length of stay	0.1	0.2	0.3	0.3	0.1
spend	0.05	0.1	0.3	0.4	0.15

Obtained fuzzy evaluation weight matrix C:

$$C=[0.098\ 0.262\ 0.285\ 0.278\ 0.076]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.098+4*0.262+3*0.285+2*0.278+1*0.076=3.02$$

Route seven:Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon→Flower and Fruit Mountain National Forest Park

Table 18:Evaluation matrix of route seven

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.2	0.6	0.1	0.1	0
Attractions quality	0.1	0.4	0.4	0.1	0
the total length of stay	0.3	0.4	0.2	0.1	0
spend	0.3	0.4	0.3	0	0

Obtained fuzzy evaluation weight matrix C:

$$C=[0.228\ 0.440\ 0.275\ 0.056\ 0]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.228+4*0.440+3*0.275+2*0.056+1*0=3.84$$

Six attractions:

Route eight: Longmen Grottoes→Baima temple→Longtan Grand Canyon→Flower and Fruit Mountain National Forest Park→Ji Guandong→Baiyun Mountain

Table 19:Evaluation matrix of route eight

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.3	0.5	0.2	0	0
Attractions quality	0.2	0.5	0.2	0.1	0
the total length of stay	0.1	0.2	0.3	0.3	0.1
spend	0.1	0.3	0.4	0.1	0.1

Obtained fuzzy evaluation weight matrix C:

$$C=[0.166\ 0.382\ 0.298\ 0.100\ 0.054]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.166+4*0.382+3*0.298+2*0.100+1*0.054=3.51$$

Route nine:Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon→Flower and Fruit Mountain National Forest Park→Ji Guandong

Table 20:Evaluation matrix of route nine

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.3	0.5	0.2	0	0
Attractions quality	0.2	0.4	0.3	0.1	0
the total length of stay	0.3	0.4	0.2	0.1	0
spend	0.3	0.4	0.2	0.1	0

Obtained fuzzy evaluation weight matrix C:

$$C=[0.274\ 0.420\ 0.226\ 0.080\ 0]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.274+4*0.420+3*0.226+2*0.080+1*0=3.89$$

Seven attractions:

Route ten:Longmen Grottoes→Guanlin temple→Baima temple→Longtan Grand Canyon→Flower and Fruit Mountain National Forest Park→Ji Guandong→Baiyun Mountain

Table 21:Evaluation matrix of route ten

	V_1	V_2	V_3	V_4	V_5
Attractions number	0.3	0.6	0.1	0	0
Attractions quality	0.3	0.4	0.3	0	0
the total length of stay	0.1	0.2	0.3	0.3	0.1
spend	0.1	0.3	0.4	0.15	0.05

Obtained fuzzy evaluation weight matrix C:

$$C=[0.192\ 0.376\ 0.304\ 0.096\ 0.032]$$

Eventually obtained satisfaction of the tourist route one A:

$$A=5*0.192+4*0.376+3*0.304+2*0.096+1*0.032=3.6$$

According to the satisfaction of quantitative solution, the ultimate satisfaction is summarized below in table 22：

Table 22 : travel route satisfaction ratings and sorting

Ranking tourist routes	Tourist route name	The route number of attractions	Satisfaction
1	Route 9	6	3.89
2	Route 7	5	3.84
3	Route 4	4	3.81
4	Route 1	4	3.74
5	Route 2	4	3.62
6	Route 10	7	3.60
7	Route 8	6	3.51
8	Route 5	5	3.37
9	Route 3	4	3.37
10	Route 6	5	3.02

5.3 Create and solve the model three

5.3.1 Establish objective function

Assuming a family of five is going to head to Luoyang for a summer tour, family structure is a child, two parents, two grandparents, developed a four-day tour program. Among it, the total cost limitation is 1500 yuan each person, the accommodation limitation is 150 yuan each day, the meals limitation is 60 yuan each person, then on the basis of its assumptions, determined objective function.

According to the analysis of the problem of three, the goal to be achieved is, in the four days of travel within their time to spend the least money to explore as many places. So we have to achive the two goals, the minimal cost and the sightseeing attractions as many as possible, according to the problem one's seven spots selected, to begin the tourist route optimization solve, firstly, to establish the objective function of the total cost.

After analysis, the total cost of travel, including transportation costs and the total cost of the tourist attractions, that is

$$\text{Min} \quad J = J_1 + J_2$$

Among: J—the total cost of the family；
J_1—the total cost of the family's transportation；
J_2—the cost of family's tourist attractions；

q_{ij} represent the necessary transportation cost of which from the attraction i to the attraction.

j, p_{ij} is the 0—1 variable that judge the family whether directly from the attraction i to the attraction j, then get the total cost of transportation :

$$J_1 = \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times q_{ij}$$

The cost of the tourist attractions of calculation including the total consumption r_i of the family in the scenic spot I, P_{ij} represent whether the family arrive the scenic spot i and scenic spot j, in the process of the actual calculation, the cost of travel is :

$$J_2^{'} = \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times \left(r_i + r_j\right)$$

And in the process of calculation, overall visit to the families of the cost calculation for two times, under normal circumstances, the cost of the tourist attractions is :

$$J_2 = \frac{1}{2} \times \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times \left(r_i + r_j\right)$$

So the travel cost and transportation cost in accordance with the above it is concluded that the objective function required is :

$$\text{Min}\ \ J = J_1 + J_2 = \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times q_{ij} + \frac{1}{2} \times \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times \left(r_i + r_j\right)$$

5.3.2 Constraints

First discuss the constraints of time, according to the hypothesis, the family time, stay in tourist attractions in the journey time and rest time for a total is four days, and the actual travel time and the time of arrival in scenic spot is 10 h a day, so the constraints of time a maximum limit is 40 h, t_{ij} represent the time needed for journey from the scenic spot i to scenic spot j, so the time required for the journey is :

$$T_1 = \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times t_{ij}$$

t_i represent the family's staying time in the scenic spot i, so according to the case that the objective function is derived, the family's total stay time in the tourist attractions is :

$$T_2 = \frac{1}{2} \times \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times \left(t_i + t_j\right)$$

So the final time constraints is :

$$T = \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times t_{ij} + \frac{1}{2} \times \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times \left(t_i + t_j\right) \le 40$$

Second, discuss the number of tourist attractions, according to the hypothesis, the travel route is circular, $\sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij}$ represent the family's tourism scenic spots, assuming that the needed tourism scenic spots is n（n=2，3，……，7）, finally can get the number of tourist attractions' constraint conditions is :

$$\sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} = n \quad (n=2, 3, \ldots\ldots, 7)$$

0—1variable's constraint is :

$$\sum_{i} p_{ij} = \sum_{j} p_{ij} \le 1 \quad (i, \ j=1, 2, \ldots\ldots, 7)$$

When $i=1$, starting from the point of departure, so $\sum_{i=1} p_{ij} = 1$, when $j=1$, travel back to the starting point, so $\sum_{j=1} p_{ij} = 1$;

Above all, what can be obtained is :

$$\sum_{i} p_{ij} = \sum_{j} p_{ij} \le 1 \quad (i, \ j=1, 2, \ldots\ldots, 7)$$

$$\sum_{i=1} p_{ij} = 1 \qquad \sum_{j=1} p_{ij} = 1$$

Due to the inability of tourists to travel back and forth between both, when $i, \ j \ge 2$, according to the question is never to appear $r_{ij} = r_{ji} = 1$, therefore, according to the question we can get the constraint conditions :

$$p_{ij} \times p_{ji} = 0 \quad (i, \ j=2, 3, \ldots\ldots, 7)$$

5.3.3Model building

According to the objective function and constraint condition, we can get a general model is :

$$\text{Min} \ J = J_1 + J_2 = \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times q_{ij} + \frac{1}{2} \times \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times \left(r_i + r_j\right)$$

The constraint :

$$\sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times t_{ij} + \frac{1}{2} \times \sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} \times \left(t_i + t_j\right) \le 40$$

$$\sum_{i=1}^{7}\sum_{j=1}^{7} p_{ij} = n \qquad (n=2, 3, \ldots\ldots, 7)$$

$$\sum_{i} p_{ij} = \sum_{j} p_{ij} \le 1 \quad (i, \ j=1, 2, \ldots\ldots, 7)$$

$$\sum_{i=1} p_{ij} = 1 \qquad \sum_{j=1} p_{ij} = 1$$

$$p_{ij} \times p_{ji} = 0 \qquad (i, \ j=2, 3, \ldots\ldots, 7)$$

5.3.4 The solution method for model

First of all, according to the model of data involved, the introduction of parameters :

d_{ij}——the distance from the scenic spot i to scenic spot j;

v——the average speed of the taxi the family take , v=60km/h;

m——the average cost of the taxi the family take, h=1.5yuan/km;

Under the condition of the above assumptions, considering the lodging and meals, the family need 2 house every night, by calculating the total accommodation and meals for 2400 yuan, the solved objective function in the end is :

$$\text{Min } J=\sum_{i=1}^{7}\sum_{j=1}^{7}p_{ij}\times q_{ij}+\frac{1}{2}\times\sum_{i=1}^{7}\sum_{j=1}^{7}p_{ij}\times\left(r_i+r_j\right)+2400$$

Through collecting and sorting of data, we can get any specific value of the distance d_{ij} of the two spots, according to the formula $t_{ij}=d_{ij}/v$, the travel time t_{ij} between two spots can be obtained , through the formula $q_{ij} = d_{ij} \times m$, can get the corresponding c_{ij} （i， j=1，2，……，7）.

Through online search data, measuring spots ’ suitable stay time, eventually determine the suitable sojourn time of the family in the scenic spot i and total consumption are shown respectively in table 23—24 :

Table 23: the suitable stay time in the senic spot i (unit :h)

t_1	t_2	t_3	t_4	t_5	t_6	t_7
5	2	2	4	7	8	8

Table 24: the total consumption in the senic spot i (unit :yuan)

e_1	e_2	e_3	e_4	e_5	e_6	e_7
850	400	425	500	500	375	550

Through data collection, and finally it is concluded that the distance between the various attractions are shown in table 25:

Table 25: the distance between two senic spots(unit :km)

distance（km）	Longmen Grottoes	Guanlin temple	Baima temple	JiGuan dong	Longtan Grand Canyon	Flower and Fruit Mountain National Forest Park	Baiyu Mountain
Longmen Grottoes	0	7	29	152	50	104	152
Guanlin temple	7	0	22	158	44	111	156
Baima temple	29	22	0	182	46	134	180
Ji Guan dong	152	158	182	0	190	111	55
Longtan Grand Canyon	50	44	46	190	0	143	189
Flower and Fruit Mountain National Forest Park	104	111	134	111	143	0	108
Baiyun Mountain	152	156	180	55	189	108	0

According to the established model as well as the collection of data, operations by using Lingo software, finally it is concluded that the results are shown in table 26 below :

Table 26: results the established model

the number of the toutist attractions n	4	5	6
The total consumption P（unit: yuan）	4762.5	5433	6170
route	1→5→3→2→1	1→2→3→5→6→1	1→2→3→5→4→6→1

According to the solution of the results, the number 1—7 represent Longmen Grottoes, Guanlin temple, Baima temple, Ji Guandong, Longtan Grand Canyon, Flower and Fruit Mountain Nationa Forest Park, Baiyun Mountain.

When the number of tourist attractions is four, have the corresponding travel route : Longmen Grottoes→Longtan Grand Canyon→Baima temple→Guanlin temple, which corresponds to the total cost of the family is 4762.5 yuan;

When the number of tourist attractions is five, have the corresponding travel route : Longmen Grottoes→Guanlin temple→Baima temple →Longtan Grand Canyon →Flower and Fruit Mountain Nationa Forest Park, which corresponds to the total cost of the family is 5433 yuan ;
When the number of tourist attractions is six, have the corresponding travel route : Longmen Grottoes→Guanlin temple→Baima temple →Longtan Grand Canyon →Ji Guandong, Longtan→Flower and Fruit Mountain Nationa Forest Park, which corresponds to the total cost of the family is 6170 yuan ;
According to reasonable travel time (4 days) for the selection of attractions, when the number of tourist attractions is seven, due to the effect of limiting factor in Lingo software, the corresponding program can't find the right solution, the number of tourist attractions into seven, cannot satisfy the constraint conditions.
According to the result of the above shows that under the condition of general family economic conditions, and the families with elderly tourist structure, using the above attractions for 4 number of travel route is more appropriate;
When economic conditions are good and have the old man's family travel structure, can choose attractions for tourism route is suitable for 4 or 5;
When economic conditions in general and no old man's family travel structure, can choose the attractions for 5 tourist routes more appropriate;
When economic conditions are good and no old man's family travel structure, can choose attractions for tourism route is suitable for 5 or 6.
Based on the above discussion, three assumptions for the model of a family travel, if not the restriction of the economic conditions, the selection of attractions for four or five tourist route is more appropriate.

6. Analysis of the results of the model

6.1 The analysis of model one's results

According to detailed analysis of the impact indicators, obtained the weight of the last level, Obtained comprehensive evaluation model by linear weighted, because the selected index may appear a relatively abstract indicators such as climate, cultural heritage, etc. collecting data is very difficult, needed to refer netizens to collect data and evaluate attractions, divided level such as excellent, good, fair, poor and high, medium and poor for judgment, delineated score for each level and dimensionless, finally got the relative ranking of the various attractions, although the model is not precise enough, but it is a reasonable comprehensive evaluation for the various attractions.

6.2 The analysis of model two's results

Depending on the establishment of fuzzy comprehensive evaluation model of achieving a function of weight matrix and fuzzy evaluation of satisfaction, respectively, and for each of the selected tour routes solution to build the evaluation matrix R and, combined with the weight of the selected indicators, will be evaluated data to the satisfaction of scoring functions on the scenic route, evaluated the final ranking evaluation of the 10 selected tour routes.

In the light of the results of the evaluation,A moderate number of attractions of route 9 and route 7 rank the top.And a smaller number of attractions of route 4 and route 1 get the moderate evaluation.Meanwhile, the different attractions tourist routes get different levels of evaluation.Therefore, the number of attractions are not determining factors.In the various tourist routes, play a decisive role in the eventual score is the quality of various attractions cost and so on.The final ranking to the various tourist routes is the important information to enable tourists to obtain satisfactory package.

6.3 The analysis of model three's results

According to constraints in the model and results of the lingo software of runing out. Analysis the number of attractions and family to come to the tourist route of the total amount of consumption. Depending on the family structure at the same time, when considering the elderly, to ensure the pleasure of travel for the elderly and adequate strength, to minimize the number of tourist attractions.In the absence of the elderly in the family structure, under the conditions of a certain amount of capital, visit as many attractions as far as possible.A detailed analysis found in model three.Thus, to choose appropriate tourism routes for a variety of family structures qualitatively. Solution of model instance and the introduction of family travel limit the number of days, where there are different family structures, and the number of days tourism funding, can make appropriate changes to the constraint, can come up with suitable for tourist routes.

7. Summary of the model

7.1 Model A

Model of target choice, tiered reasonable, and influencing factors of comprehensive evaluation model for covering a wide range, but some fuzzy estimation and evaluation of the data, will result in the overall evaluation of the effect, but also to reflect on the overall relative to the tourist - type attractions and come to the ranking of the various attractions.

7.2 Model B

Model B depends on model with Fuzzy comprehensive evaluation. Select a measure of weight analysis of the tourist route indicators, each of the selected tour routes at the same time constructing the evaluation matrix R, find the fuzzy evaluation of weight matrix C, bring to the satisfaction of functions, to evaluate the various tourist routes.Although in constructing the evaluation matrix r have a certain subjective factors, but also with great objectivity, to be a better assessment of the various tourist routes.Although choose different scales, the corresponding evaluation will vary, but the less relative change between the scenic route 22, and model reasonable, to be a reasonable assessment of the various tourist routes.If you collect more comprehensive data, do more investigation, the results of the evaluation of the relative accuracy is better, and, after further optimization model upgrade, there will be better and more accurate assessment of the results.

7.3 Model C

Solution of model from special to general, based on a representative instance of the family.Use 0-1 variables for solving the establishment of objective functions and constraints, then the final model use lingo software to get solution. Realization of attractions number and value of the corresponding domestic consumption, and be able to make the rational planning of the route, the results of function is good, which has a good persuasion and was applied.And to the right to change the constraints and data collection for tourist line to the different family situations, the effectiveness is very strong.

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Appendix：

Programs of problem A：

```
a=[1 2 4;1/2 1 3;1/4 1/3 1];

[x,f]=eig(a)
A=x(:,1)./sum(x(:,1))
x =
    0.8527                  0.8527                  0.8527
    0.4881                 -0.2440 + 0.4227i       -0.2440 - 0.4227i
    0.1862                 -0.0931 - 0.1613i       -0.0931 + 0.1613i
f =
    3.0183                     0                        0
       0                -0.0091 + 0.2348i               0
       0                       0                -0.0091 - 0.2348i
A =
      0.5584
      0.3196
      0.1220

ri=[0,0,0.52,0.89,1.12,1.26,1.36,1.41,1.46,1.49];
f=eig(a);
[m,n]=size(a);
maxf=max(f)
ci=(maxf-m)/(m-1)
cr=ci/ri(1,m)

maxf =
      3.0183
ci =
      0.0091
cr =
      0.0176

b=[1 5;0.2 1];
[x,f]=eig(b)
A=x(:,1)./sum(x(:,1))
x =
      0.9806    -0.9806
      0.1961     0.1961
f =
       2      0
       0      0
A =
```

0.8333
0.1667

```
c=[1 1/52 1/4; 5 1 3 2; 1/2 1/3 1 3; 4 1/2 1/3 1];
[x,f]=eig(c)
A=x(:,1)./sum(x(:,1))
x =
   -0.2557            -0.1967 - 0.3630i   -0.1967 + 0.3630i    0.1034
   -0.7981            -0.3069 + 0.0580i   -0.3069 - 0.0580i   -0.9903
   -0.3859             0.6258              0.6258              0.0464
   -0.3857            -0.2663 + 0.5191i   -0.2663 - 0.5191i    0.0800
f =
    5.0195                  0                   0                   0
         0            -0.5976 + 2.2294i         0                   0
         0                  0             -0.5976 - 2.2294i
0
         0                  0                   0
0.1756
A =
      0.1401
      0.4372
      0.2114
      0.2113


d=[1 1/2 3 1/4 1/4 3; 2 1 1/5 3 1/5 2; 1/3 5 1 3 1/2 2; 4 1/3 1/3 1 5 1/3; 4 5 2 1/5 1
    5; 1/3 1/2    1/2 3 1/5 1];
[x,f]=eig(d)
A=x(:,1)./sum(x(:,1))
x =
   Columns 1 through 4
   -0.2856             0.1080 - 0.2936i    0.1080 + 0.2936i    0.2606 +
0.4351i
   -0.3141             0.0812 + 0.2416i    0.0812 - 0.2416i    0.2038 -
0.3504i
   -0.4491         0.3302 + 0.0981i    0.3302 - 0.0981i    -0.6106
   -0.4938        -0.6382              -0.6382             -0.0229 + 0.0921i
   -0.5635         0.1429 - 0.4457i     0.1429 + 0.4457i   -0.2233 - 0.3709i
   -0.2381         0.1130 + 0.2816i     0.1130 - 0.2816i    0.0917 + 0.0263i
   Columns 5 through 6
     0.2606 - 0.4351i    -0.4585
     0.2038 + 0.3504i    -0.1289
   -0.6106               -0.4874
```

```
   -0.0229 - 0.0921i      -0.0631
   -0.2233 + 0.3709i       0.3779
    0.0917 - 0.0263i       0.6235
f =
   Columns 1 through 4
.6956                    0                  0                    0
   0               -1.0702 + 5.0075i        0                    0
   0                     0           -1.0702 - 5.0075i           0
   0                     0                  0            -0.8167 + 2.3965i
   0                     0                  0                    0
   0                     0                  0                    0
   Columns 5 through 6
          0                    0
          0                    0
          0                    0
          0                    0
   -0.8167 - 2.3965i           0
          0                0.0782
A =
      0.1218
      0.1340
      0.1916
      0.2106
      0.2404
      0.1016
```

Programs of problem C:

```
sets:

jingdian/1..7/:c,t,l;
links(jingdian,jingdian):r,cc,tt;
endsets
data:
t=5 2 2 2 7 8 8;
c=850 400 425 500 500 375 550;
tt=0     0.12    0.48    2.53    0.83    1.73     2.53
   0.12    0     0.37    2.63    0.73    1.85     2.6
   0.48  0.37      0     3.03    0.77    2.23     3
   2.53  2.63    3.03    0       3.17    1.85     0.92
   0.83  0.73    0.77    3.17    0       2.38     3.15
   1.73  1.85    2.23    1.85    2.38      0      1.08
```

```
2.53   2.6    3      0.92   3.15   1.08   0 ;

cc=0   10.5   43.5   228    75     156    228
10.5   0      33     237    66     166.5  234
43.5   33     0      273    69     201    270
228    237    273    0      285    166.5  82.5
75     66     69     285    0      214.5  283.5
156    166.5  201    166.5  214.5  0      162
228    234    270    82.5   283.5  162    0;

n=?;
enddata
min=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(cc(i,j)+0.5*(c(i)+c(j)))))+2400;
@for(jingdian(i):r(i,i)=0);
@for(jingdian(i)|i#ge#2:@for(jingdian(j)|j#ge#2:r(i,j)+r(j,i)<1));
a=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+0.5*(t(i)+t(j)))));
@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+0.5*(t(i)+t(j)))))<40;
@for(jingdian(i):@sum(jingdian(j):r(i,j))=@sum(jingdian(j):r(j,i)));
@for(jingdian(i)|i#eq#1:@sum(jingdian(j):r(i,j))=1);
@for(jingdian(i)|i#ne#1:@sum(jingdian(j):r(i,j))<1);
@for(links:@bin(r));
@sum(jingdian(j):@sum(jingdian(i):r(i,j)))=n;
@for(jingdian(i):@for(jingdian(j)|j#gt#1#and#j#ne#i:l(j)>=l(i)+r(i,j)-(n-2)*(1-r(i,j))+(
n-3)*r(j,i)));
@for(jingdian(i)|i#gt#1:l(i)<n-1-(n-2)*r(1,i);l(i)>1+(n-2)*r(i,1));
```

Result : (when n=6)

Due to the huge amount of data, only important results are as follows：

Global optimal solution found at iteration: 6170.000

Objective value: 6170.000

Variable	Value	Reduced Cost
N	6.000000	0.000000
R(1, 2)	1.000000	635.5000
R(2, 3)	1.000000	445.5000
R(3, 5)	1.000000	531.5000
R(5, 4)	1.000000	785.0000
R(4, 6)	1.000000	604.0000
R(6, 1)	1.000000	768.5000

Result : (when n=5)

Due to the huge amount of data, only important results are as followsGlobal optimal solution found at iteration: 5433.000

Objective value: 5433.000

Variable	Value	Reduced Cost
N	5.000000	0.000000
R(1, 2)	1.000000	635.5000
R(2, 3)	1.000000	445.5000
R(3, 5)	1.000000	531.5000
R(5, 6)	1.000000	652.0000
R(6, 1)	1.000000	768.5000

Result : (when n=4)

Due to the huge amount of data, only important results are as follows：

Global optimal solution found at iteration: 4762.500

Objective value: 4762.500

Variable	Value	Reduced Cost
N	4.000000	0.000000
R(1, 5)	1.000000	750.0000
R(5, 3)	1.000000	531.5000
R(3, 2)	1.000000	445.5000
R(2, 1)	1.000000	635.5000