The Bus Line Network Efficiency Evaluation Algorithm Based on the Theory of Fuzzy and Hierarchical Analysis

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***Abstract*—By the effect of the optimization of bus scheduling, bring forward evaluation index model to evaluate optimization results,the corresponding algorithm of the model is given. This evaluation index is included transport capacity match,average transfer time,effective time-use law.analytic hierarchy process to integrate indicators into a comprehensive evaluation index,is used and built the evaluation index model about the optimization of bus scheduling.the use of indicators model line scheduling algorithm to optimize the evaluation made a simple algorithm.The three indicators in this model belong to quantitative techmical indicators,overcome the line network optimization index can not evaluate the program for dynamic scheduling it's easy to evaluate program of bus scheduling,with strong practicality.**

Keywords-fuzzy; hierarchical analysis; bus line network

I. INTRODUCTION

It is the fuzzy aims to use modern traffic planning theory and computer technology, evaluating existing city bus line network efficiency and find out the existing problems and potential ability, Grasp the development level of bus, we use the multilevel of fuzzy to evaluate every indicator of the city public traffic system solutions and make comprehensive evaluation for this scheme.

II. SELECTION OF FACTOR SETS

On indicators of the public transport system as shown in Table 1.

TABLE I. TABLE 1 INDICATOR SYSTEM

Bus service situations	U_1	loadratio	u_{11}
		actual load rate	u_{12}
		non-zero rate	u_{13}
Customer satisfaction	U_2	safe	u_{21}
		Service attitude	u_{22}
		Vehicle appearance	u_{23}
		Punctuality rate	u_{24}
		Comfort levels	u_{25}
Line network performance	U_3	Transfer coefficient	u_{31}
		Site coverage	u_{32}
		coefficient of repeat the line	u_{33}
		non-linear coefficient	u_{34}
Economic benefits	U_4	cost per thousand kilometers	u_{41}
		passenger revenue per thousand kilometers	u_{42}
		Overall labor productivity	u_{43}
		Ratio of people and vehicles	u_{44}
		Mileage utilization	u_{45}

There are 17 evaluations in the table1 and constitute the factor set, these evaluation criteria are divided into four categories.

Set up the following factors set

Let U = { U1,U2,U3,U4} 4 kinds of factors that affect the network efficiency of urban bus lines (or indicators)

TABLE II.

U_1	U_2	U_3	U_4
Bus service situations	Customer satisfaction	Line network performance	Economic benefits

III. TO DETERMINE THE IMPORTANCE OF FACTORS

A. To Determine the Judgment Matrix

It is the most important setps to determine the importance of factors to fuzzy evaluation.We determine the matrix a_i using the largest characteristic root of the Analytic Hierarchy method.In sets U Any two elements u_i,u_j,if i=j and then we can establish the 1-9 scale to determine the importance of u_i.

TABLE III.

Scale P_{ij}	message
1	The same effection of factor u_i and u_j
3	Factor u_i own the stightly stronger effection than factor u_j
5	Factor u_i own the strong effection than factor u_j
7	Factor u_i own the obvious strong effection than factor u_j
9	Factor u_i own the absolute strong effection than factor u_j
2、4、6、8	The ratio of factor u_i and u_j located in the above two adjacent grades
1,1/2,…,1/9	The ratio of factor u_i and u_j is a Reciprocal number of P_{ij}

Before in the evaluation, the evaluators must be consider emphasis of various factors, we get the judgment matrix P by experts' comparison.

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

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B. To get maximum eigenvalue's Feature vector[1]

For A each column vector normalization so get $a_{ij} = p_{ij} / \sum_{i=1}^{n} p_{ij}$

（1） Rows of summing $a_i = \sum_{j=1}^{n} a_{ij}$

（2） $a_i = a_i / \sum_{j=1}^{n} a_i^*$, $A = (a_1, a_2, ..., a_n)^T$ is the Feature vector

（3） calculate $\lambda = \frac{1}{n} \sum_{i=1}^{n} \frac{(PA)_i}{a_i}$, make λ As the biggest characteristic root of approximation.

C. Consistency check

Judgment matrix consistency check $CR = \frac{CI}{RI}$,In this formula, CI is the index of the general consistency of judgment matrix,n is the order number of judgment matrix.RI is the average consistency index of judgment matrix.

Values such as table 4

TABLE IV. THE AVERAGE CONSISTENCY INDEX

N	RI
1	0
2	0
3	0.58
4	0.96
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

When CR<0.1,The judgment matrix has satisfied consistency. By the use of level analysis to determine the importance of various factors, ASthe same token can get judgment matrix p_1,p_2,p_3,p_4,,A_1,A_2,A_3,A_4

IV. DETERMINE DECISION COMMENTS

$V=\{V_1,V_2,V_3,V_4,V_5\}$ is the decision comments.

TABLE V.

Decision comments	Assessment criteria	Result interval	Norm
V_1	excellent	[100,95]	97.5
V_2	good	[94,85]	90
V_3	middle	[84,75]	80
V_4	poor	[74,65]	70
V_5	bad	[64,50]	57.5

V has five level, $V = \{V_1(\text{excellent}), V_2(\text{good}), V_3(\text{middle}), V_4(\text{poor}), V_5(\text{bad})\}$, The corresponding grading value is D_1,D_2,D_3,D_4,D_5.

TABLE VI. LINE NETWORK PERFORMANCE

assessment criteria	D_1	D_2	D_3	D_4	D_5
Average transfer number	0	0.75	1.50	1.75	2.00
line oerlap factor	1.00	1.50	1.75	2.00	2.25
nonlinear coefficient	0.60	0.70	0.80	0.90	1.00
stop coverage ratio	1.00	0.90	0.80	0.70	0.60

V. DTERMINE SUBORDINATE FUNCTION[2]

For the bigger the optimal index, use rise half keystone distribution function and to get

$$u_1 = \begin{cases} 1, x > D_1 \\ \frac{x - D_1}{D_1 - D_2}, D_2 \le x \le D_1 \\ 0, x \le D_2 \end{cases}$$

$$u_2 = \begin{cases} 0, x < D_3 \ Or \ x \ge D_1 \\ \frac{D_1 - x}{D_1 - D_2}, D_2 \le x \le D_1 \\ \frac{x - D_3}{D_2 - D_3}, D_3 \le x \le D_2 \end{cases}$$

$$u_3 = \begin{cases} 0, x < D_4 \ Or \ x \ge D_2 \\ \frac{D_2 - x}{D_2 - D_3}, D_3 \le x \le D_2 \\ \frac{x - D_3}{D_3 - D_4}, D_4 \le x \le D_3 \end{cases}$$

$$u_4 = \begin{cases} 0, x < D_5 \ Or \ x \ge D_3 \\ \frac{D_3 - x}{D_3 - D_4}, D_4 \le x \le D_3 \\ \frac{x - D_5}{D_4 - D_5}, D_5 \le x \le D_4 \end{cases}$$

$$u_5 = \begin{cases} 0, x \ge D_4 \\ \frac{D_4 - x}{D_4 - D_5}, D_5 \le x \le D_4 \\ 0, x \le D_5 \end{cases}$$

To be xiaoyue optimal index, use the drop half keystone distribution function and linear triangular function;

TABLE VII. SCORE SYSTEM

Norm	Score
E	0-0.6
D	0.6-0.7
C	0.7-0.8
B	0.8-0.9
A	0.9-1.0

VI. EVALUATION MATRIX

Set evaluation to be considered by an m a set of factors for $U=\{u_1,u_2,...,u_m\}$, N set of comments $V=\{v_1,v_2,...,v_n\}$ .In the space information quality comprehensive evaluation, evaluation set is preferable $V=\{V_1(\text{excellent}),V_2(\text{good}),V_3(\text{middle}),V_4(\text{poor}),V_5(\text{bad})\}$ But in the concrete situation, comment set V can have different selection. If use r_{ij} said the first I a factors on the first j kind of comment of membership, the factor theory field and reviews the theory of the fuzzy relation between domains available evaluation matrix R

$$R=\begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix}$$

$$0 \le r_{ij} = \mu_R\left(\mu_i,\mu_j\right) \le 1, i=1,2,\cdots,m;\ j=1,2,\cdots,n$$

VII. COMPREHENSIVE EVALUATION

A. *The primary comprehensive evaluation*

R_i is the criteria U_i is the evaluation matrix.

$$B_i=A_iR_i\ (i=1,2,3,4)$$

$$R=\begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{pmatrix}=\begin{pmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \end{pmatrix}$$

B. *Secondary comprehensive evaluation*

$$B=AR\ ,$$

$$W=BC=(b1,b2,b3,b4,b5)(97.5,90,80,70,57.5)^T$$

Finally calculated the comprehensive evaluation value of B, the score is to evaluate urban bus line network evaluation of the last score. If have to be evaluation city bus lines network the total score of all size down up, you will get all the quality of city bus lines network order.

VIII. SUMMARY

The advantages of the problem is to compare the objective gives influence bus line network efficiency index, and each index have response confirm the important degree of scheme, for the establishment of the model we adopted the hierarchy analysis and fuzzy evaluation method of combining comprehensive evaluation method. This model has a wide range of applicable scope, therefore has good robustness.The existing deficiency is: lack of some specific data, theory application more simplified. For more details of the part of the problem no more careful consideration.

REFERENCES

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