Evaluation on Transfer Reliability of Wuhan Comprehensive Transport Hub Based on Fuzzy Comprehensive Evaluation

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ABSTRACT: Urban Comprehensive transport hub transfer system is an important part of urban public transport network. It's functionality and high level of service is not only the needs of urban modernization, but also one of the important means to attract travelers to use public transportation to ease road congestion. The evaluation of traffic transfer system will help city managers recognize the weaknesses in city traffic and make the appropriate improvements.

In this paper, we mainly discussed the urban public transportation transfer, defined the definition of reliability, and analyzed composition and the factors influence its reliability. Before analyze the public transportation transfer in Wuhan city, it's important to statistics which Urban transport hubs are involved. After that, we should build an evaluation system. Then, according to the evaluation system, we collected the relevant data and analyzed them. Finally ,through Fuzzy Comprehensive Evaluation, we will get the evaluation result.

Introduction

In the city that public transport is the main mode of transportation, comprehensive transport hub is an important node of public transportation network. It provides the transfer and combinations of traveling ways, distribution travelers. The main function of comprehensive transport hub including the following two aspects[1].

(1)The convergence function of traffic point.

Depending on the residents travel requirements linked different lines, different means of transportation as an integral.

(2)The passenger distribution function of plane.

Comprehensive transport hub taking advantage of other hub station systems and bus lines connected thereto, to expansion the function from point to the plane.

In addition, transit hub are dense regions of urban land development and using, therefore, the city transport hubs have a positive promoting to urban transport network functions.

According to comprehensive transportation hubs' location and functions, we can Analyzed from different angles like traffic functions, the combination of transportation modes, service areas and layout forms[2]. The transport hub types divided by functions is shown as following Table 1.

Table 1. Transport hub types divided by functions

Functions	Types
Traffic functions	Outbound transportation hub, urban public transportation hub
The combination of transportation modes	Line transfer hub, means transfer hub, compound hub
service areas	Urban area class hub, downtown aera class hub, district area class hub
layout forms	Grade separation hub, plane hub

Analysis of the Meaning of Comprehensive Transport hub Transfer Reliability

Reliability refers to the ability of the system to complete its intended function within a certain time and a predetermined condition.

There are not lot to use reliability as a index in traffic area, neither a specific definition nor measure methods. There are two main methods to measure systems reliability: One is on the angel of users, in this way, the reliability of the system is defined by the user's sensory understanding of the system's reliability. The other way need to analysis the system's components. Through the reliability of these elements or units to get the system's reliability[3].

For the feature of comprehensive transportation hub, The second method can be used to define the reliability of Wuhan comprehensive transportation hub reliability, the analysis object including Inter-city bus station, railway station and airport.

The Establish of Evaluation System

With the analysis of table 1, the involved comprehensive transport hub are: 12 inter-city bus station, three railway stations and an airport in Wuhan. The railway station and airport are Wuchang Railway Station, Hankou Railway Station, Wuhan Railway Station and Tianhe Airport.

There are two kinds of transport hub transfer reliability, one is under normal condition, the other is under abnormal condition. Under the normal condition, the reliability analysis is mainly about the daily traffic. Under the abnormal condition, the reliability analysis could be divided by disaster, abnormal weather and abnormal traffic events. For different conditions, travelers have different expectations for traffic, and produce different evaluations[4]. The classify of comprehensive transport hub transfer reliability is as following Fig 1.

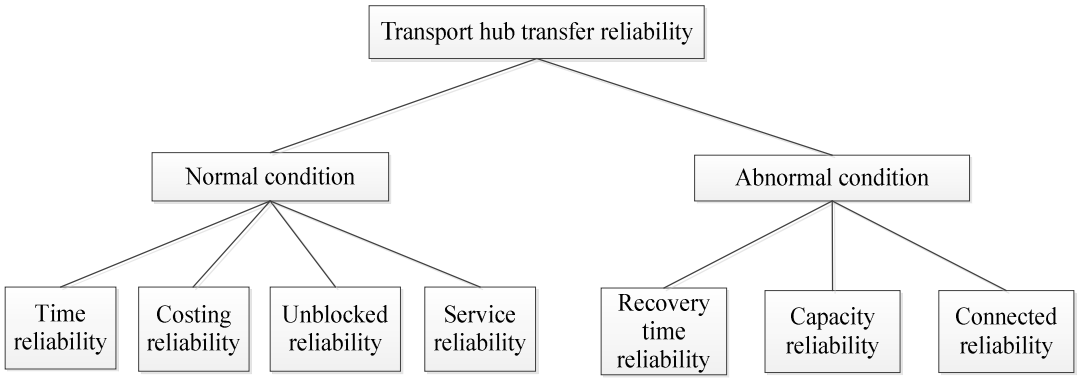

Fig 1. The classify of comprehensive transport hub transfer reliability

For the reason that abnormal conditions have strong attributions of bursting an and random, so it's

very hard to prediction accurately. This paper discuss the state of road network under normal condition only. The evaluation index and parameters as following Fig 2.

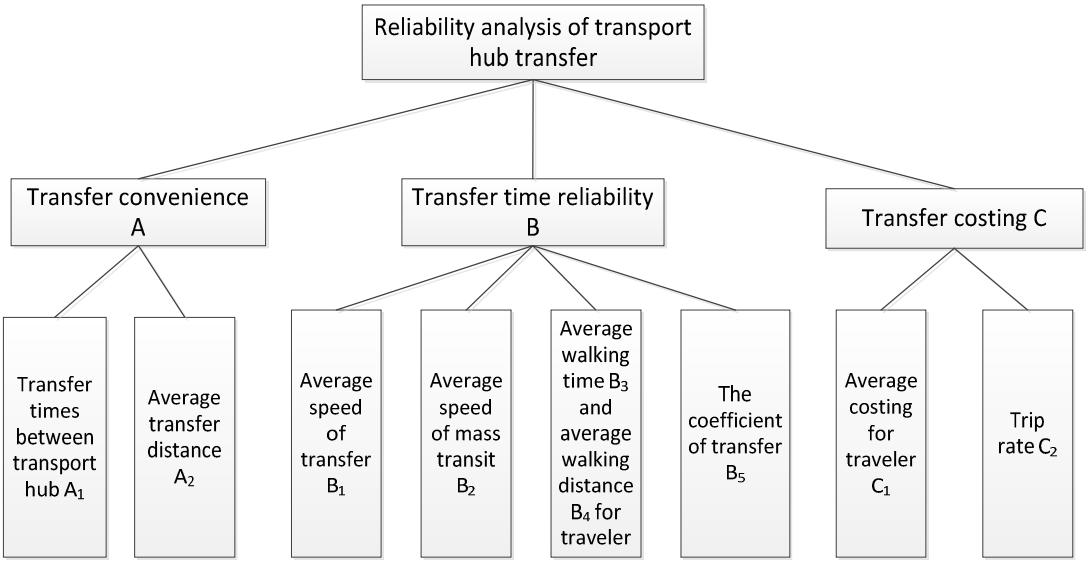

Fig 2. Reliability analysis of transport hub transfer

Because of the attribution of the analysis of comprehensive transport hub reliability, it's suitable to use fuzzy comprehensive evaluation method. Fuzzy comprehensive evaluation method is a method to deal with mathematical models which cannot be described by precisely mathematical. It is based on fuzzy mathematics, and use the theory of composition of fuzzy relation, to quantitative the factors which boundary is not clear and not easy to qualified precisely.

Fuzzy comprehensive evaluation is the application of the principle of fuzzy transform and the maximum membership degree principle, considering various factors and the evaluated matters, the evaluate it comprehensively. The mathematical model of this method is[5]: Determining the evaluation factors set F, evaluation set V, membership degree Yi . In the end, weight vector and judgment matrix multiple, and the result is the final evaluation. The equation of this model are as follow.

$$B = W \cdot R = (W_1,\ W_2,\ldots,\ W_m)\begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \cdots & & \cdots \\ r_{n1} & \cdots & r_{nn} \end{bmatrix} = (b_1,\ b_2,\ \cdots,\ b_n) \tag{1}$$

COMPUTATION PROCESS AND CONCLUSION

The first step of fuzzy comprehensive evaluation method is to establish evaluation set V. And there are five remarks in the evaluation set, the detail are as follows:

V=(v1,v2,v3,v4,v5)={very good, good, normal, not good, bad}

The second step is to determine weight. After discussed with teacher and referenced other documents, the weights are as follows.

U= (0.2,0.4,0.4)

U_1= (0.6,0.4)

U_2= (0.3,0.2,0.15,0.15,0.2)

U_3= (0.45,0.55)

The parameters are classified as following classification tables.

Table 2. Transfer time classification table

Evaluation grade	Very good	Good	Normal	Not good	Bad
Transfer time	<1	[1,2)	2	(3,4]	>4

Table 3. Transfer distance classification table [km]

Evaluation grade	Very good	Good	Normal	Not good	Bad
Transfer distance	<6	[6,12)	[12,20)	[20,28)	≥28

Table 4. Speed of transfer classification table [km/h]

Evaluation grade	Very good	Good	Normal	Not good	Bad
Speed of transfer	>25	[16,25)	[13,16)	[10,13)	≤10

Table 5. Speed of mass transit classification tanle [km/h]

Evaluation grade	Very good	Good	Normal	Not good	Bad
Speed of mass transit	>22	[22,17)	[17,13)	[13,9)	≤9

Table 6. Average walking distance for traveler [m]

Evaluation grade	Very good	Good	Normal	Not good	Bad
Average walking distance	<300	[300,450)	[450,650)	[650,900)	≥900

Table 7. Average walking time for traveler [Minute]

Evaluation grade	Very good	Good	Normal	Not good	Bad
Average walking time	<3	[3,6)	[6,9)	[9,12)	≥12

Table 8. The coefficient of transfer classification table

Evaluation grade	Very good	Good	Normal	Not good	Bad
coefficient of transfer	<1.3	[1.3,1.5)	[1.5,1.7)	[1.7,1.9)	≥1.9

Table 9. Average costing for traveler [Yuan]

Evaluation grade	Very good	Good	Normal	Not good	Bad
costing	<2	(2,5]	(5,7]	(7,9]	>9

Table 10. Trip rate classification table

Evaluation grade	Very good	Good	Normal	Not good	Bad
Trip rate	(0.8,1.1]	(1.1,1.4]	(1.4,1.7]	(1.7,2.0]	others

According to the classification tables above, the result of single factor evaluation are as follows.

Table 11. Result of single factor evaluation

Ranks / Parameters	Very good	Good	Normal	Not good	Bad
A_1	1	0	0	0	0
A_2	0	0	1	0	0
B_1	0	0	1	0	0
B_2	0	1	0	0	0
B_3	0	0	1	0	0
B_4	0	0	1	0	0
B_5	0	1	0	0	0
C_1	0	0	1	0	0
C_2	0	1	0	0	0

Based on the results above:

$$R_1 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}, \quad R_2 = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{bmatrix}, \quad R_3 = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{bmatrix}$$

Because of U_1= (0.6,0.4), the evaluation vector of transfer convenience is as follow:

$Y_1 = U_1 \cdot R_1$= (0.6,0,0.4,0,0)

According to the principle of maximum degree of membership, the result 0.6 means that the remark of transfer convenience is good.

Simultaneously, $Y_2 = U_2 \cdot R_2$= (0,0.4,0.6,0,0), $Y_3 = U_3 \cdot R_3$ = (0,0.55,0.45,0,0). So the remark of transfer time reliability is good and the remark of transfer costing is normal.

Finally, by U= (0.2,0.4,0.4), the evaluation vector of transfer convenience is as follows:

$Y = U \cdot R$= (0.12,0.38,0.5,0,0)

According to the principle of maximum degree of membership, the result 0.5 means that the remark of Wuhan transport hub reliability is normal.

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