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Information release credibility assessment based on analytical hierarchy process and fuzzy synthetic evaluation of smart expressway

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Abstract: Smart expressway has applied many new technologies and systems. There is an urgent problem to evaluate the application effects of these systems in the industry. This research first summarizes the problems existing in the field of traditional traffic information service quality evaluation and puts forward the connotation of the credibility of expressway traffic information release. This research uses variable message signs along the smart expressway as the research object and designs a set of multiple expressway traffic information service quality evaluation system. The SP survey method and analytical hierarchy process (AHP) method are used to determine the weight of the evaluation index; The membership theory based on fuzzy mathematics transforms qualitative evaluation into quantitative evaluation; The results show that a comprehensive evaluation system for the credibility of multiple expressway traffic information has not been formed at home and abroad, there are few results of application and practice in combination with actual expressway information data. This research has important reference significance for further improving the service, management and decision-making level of expressway operators and helping to realize the development goal of people enjoying good transportation services.

Keywords: intelligent transport; smart expressway; information release; AHP; fuzzy evaluation; credibility

1 Introduction

Foreign research on "service quality" developed earlier in the field of business services. Parasuraman, et al. [1] proposed a set of general standards for evaluating the quality of commercial services, including ten major factors affecting consumers' perception of service quality, and formed a SERVQUAL [2] model for the service needs and perceptions of target customers. In the field of data quality evaluation research, Kelly, et al. [3] proposed timeliness and desirability evaluation data; Vanajakshi, et al. [4] established a flow conservation model; Turner, et al. [5] used ITS data to calculate the traffic performance indicators for ITS management, and carried out the data quality control process developed based on detector data. Battelle, et al. [6] proposed methods and tools for calculating six basic data quality indicators; International organizations such as the European Union [7], the International Monetary Fund [8], the United Nations [9] and the OECD [10] have also issued corresponding guidelines and norms in data evaluation and data quality management.

In the domestic academic field, Zhang, et al. [11] compared and analyzed the commonly used data quality QKZ model and QBENCH model and put forward the relevant principles of data quality evaluation based on the measured data. Tang, et al. [12] conducted a credible evaluation study on parking lot guidance services, but mainly for the Internet of Vehicles software system. Ma [13] took the second ring road section of Beijing as an example, and used the data collected by floating vehicles and microwave detectors to evaluate the quality, which was not strong in applicability to expressways. In terms of current domestic standards and norms, the China's standard *Road traffic information service-Specification for data services quality* (GB/T 29101—2012) [14] stipulates the data quality evaluation methods, requirements and test parameters of dynamic road traffic information service; The *Interim Technical Requirements for Highway Network Operation Monitoring and Services* [15] sets out requirements on the content, release requirements and release methods of road travel information services; The China's standard *Information technology-Evaluation indicators for data quality* (GB/T 36344—2018) [16] stipulates the framework of data quality evaluation indicators.

In summary, the current research results of the quality assessment of traffic information release in the academic field are mainly based on theories, methods and models, and a complete and comprehensive multi-modal expressway traffic information credibility assessment system has not been formed at home and abroad, and there are few results in the application and practice of combining the actual information data of expressways. In addition, China's current standards and specifications have fewer requirements for the performance and quality indicators of traffic information release, and the applicability of information service specifications for expressways is not strong. Therefore, based on the existing information service quality evaluation research, this research will build a traffic information release credibility evaluation system, evaluate the corresponding highway traffic information release quality, and improve the quality of highway traffic information release accord-

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ing to the assessment results, which is of practical significance.

2 Smart expressway information release research

2.1 Information release method

According to the relevant design documents, the information release data of the smart expressway mainly includes road condition information, meteorological information, maintenance construction information, toll station status information, etc. Information release channels mainly include variable information signs, variable speed limit signs, vehicle-road coordination equipment, mobile APP, Internet navigation, official accounts/mini programs, etc. In this research, taking the smart expressway variable message sign as an example, the credibility connotation and quality evaluation system of expressway traffic information content released through variable message signs/variable message boards are studied.

Dynamic traffic control at the expressway lane level can be realized based on gantry variable message signs: real-time analysis and active prediction of the current route traffic flow operation status can be realized by automatically detecting and analyzing the traffic flow status and environmental characteristics along the line; Based on the prediction of the road operation status in the next 15 min, the lane-level speed limit value is automatically adjusted through the pre-set traffic control strategy, and the current lane speed limit value and abnormal traffic condition warning information are released through the gantry variable message sign, so as to realize the active intervention of expressway traffic flow, achieve the purpose of stabilizing the traffic flow state, reducing the driving speed difference, improving traffic efficiency and reducing the traffic accident rate.

2.2 Standard specifications for variable message sign (VMS)

The current standard specification [17−19] makes relevant provisions on the technical requirements, coding methods, display content, classification, structure, and method of published information. Table 1 summarizes the classification of traffic information issued through variable message boards according to relevant standards.

3 Credibility connotation and evaluation system design

The credibility of traffic information proposed in this research refers to the satisfaction of travelers' perception of traffic information services. Since the collection, processing and release of information is a series of complex processes, it is inevitable that there are various influencing factors, especially non-human controllable factors such as immature equipment technical conditions and environmental uncertainty, resulting in incomplete, inaccurate, and untimely release of information, which reduces the credibility of the released traffic information and reduces the actual utility of traffic information.

In this research, the fuzzy synthetic evaluation (FSE) method is used to evaluate the credibility of traffic information, which is the process of classifying and ranking the credibility of traffic information by applying fuzzy set theory according to the given goal. In order to evaluate the credibility of various types of traffic information, this research designs a complete and comprehensive multi-expressway traffic information credibility evaluation system Q=(A, O, I, M, G, W, R) based on multiple traffic information data, combined with the existing data at home and abroad, the framework theory explored in information quality assessment and the main steps of FSE method. The evaluation process consists of the following steps:

(1) Aim (A): Identification of assessment objectives; the evaluation goal of this study is to provide users with easy-to-understand and reliable expressway traffic information through credibility assessment.

(2) Object (O): Determine the assessment object; typically, a dataset or set of information. This study evaluates the content of expressway traffic information releases.

(3) Index (I): Determine the evaluation index; the evaluation index is the concrete embodiment of the evaluation goal and the specific decomposition of the evaluation goal.

(4) Method (M): Determine the evaluation method; the evaluation method is selected according to the determined evaluation objectives and selected evaluation indicators, that is, the corresponding rules for the evaluation indicators are determined. In this study, the FSE method was chosen.

(5) Grade (G): Determine the assessment grade; in this study, a judgment set $V=\{V_\mathrm{V}, V_\mathrm{R}, V_\mathrm{F}, V_\mathrm{L}, V_\mathrm{N}\}$ is established based on the division of the credibility of highway traffic information. V_V, V_R, V_F, V_L, V_N are very credible, relatively credible, fair, less credible, not credible.

(6) Weight (W): Determine the weight of evaluation indicators; in this study, based on SP survey, Analytic Hierarchy Process (AHP) was used to determine the weights of each evaluation index.

(7) Synthesis of membership matrix (R).

4 Research on index evaluation system

4.1 Evaluation index selection

Expressway travel information includes static road travel information, dynamic road travel information and other relevant information, which is to meet the travel needs of users, provide reasonable guidance, improve traffic operation, reduce the probability and destructiveness of accidents, and ensure the normal operation of expressways. Through the analysis of the constituent factors of static road travel information, dynamic road travel information and other relevant information, based on drawing on the experience of experts and managers, and according to the principle of analytic hierarchy process, the target layer, criterion layer and factor layer of the evaluation structure are formed, and the quality evaluation index system of expressway traffic information release is constructed. Table 2 presents the three-level hierarchical structure of the traffic information release quality evaluation index system. The target layer is the quality of expressway traffic information release to be evaluated, the criterion layer is static road travel information, dynamic road travel information and other information that affect the release quality, and the factor layer is the component elements of each of the above.

The selection of the above indicators follows the following prin-

Table 1 Traffic information classification issued by VMS [17]

Categorization	Kinds of information	Specific content
Timeliness	Dynamic information	Real-time traffic status information
		Traffic accidents
		Emergencies
		Traffic control
		Traffic weather information
	Static information	Construction occupies the road
		Traffic propaganda
		Traffic violation information
		Announcement and publicity
Publishing form	Text messages	
	Graphical information	
	Image information	
Publish content	Traffic condition information	Smooth
		Slow
		Congestion
	Traffic incident information	Traffic accidents
		Traffic control
		Road construction
		Traffic weather information
		Detour recommend
	Announcement information	
	Promotional information	

Table 2 Traffic information release quality evaluation index system

Target layer	Criterion layer	Factor layer
Expressway traffic information release quality	Static road travel information	Basic expressway information
		Toll station information
		Service area information
	Dynamic road travel information	Traffic operation status information
		Emergency information
		Construction maintenance information
		Environmental information
		Facility service status information
	Other relevant information	Tolls service information
		Travel planning information
		Emergency rescue information
		Transportation, government affairs and supporting information

ciples:

(1) Scientific principles. The indicators established are qualitative or quantitative indicators that can draw clear conclusions through observation, testing, review, etc.

(2) Systemic principles. The indicators should be both independent and interlinked and be an organic unity that works together to target the evaluation objectives.

(3) The principle of typicality. The evaluation index has a certain typical representativeness and has a significant influence on the evaluation goal.

(4) The principle of conciseness. The selection of evaluation indicators should not be excessive, and at the same time, the omission of indicator information should be avoided, and the selection of evaluation indicators should consider the easy access of data and easy calculation.

4.2 The AHP method determines the metric weights

The basic idea of AHP method is to treat a complex decision-making system as a whole, and then divide the various factors in the complex problem into interrelated ordered levels, make them organized, and directly and effectively combine the objective judgment results of expert opinions and analysts according to the subjective judgment structure of a certain objective reality, and quantitatively describe the importance of the two-by-two comparison of the elements of the level. Then, by constructing a comparative judgment matrix, the single ranking and total ranking of these hierarchical weight vectors are calculated by using the qualitative index fuzzy quantification method, which is convenient for the evaluation and selection of subsequent schemes or behavioral decisions.

The AHP steps are shown in Fig. 1.

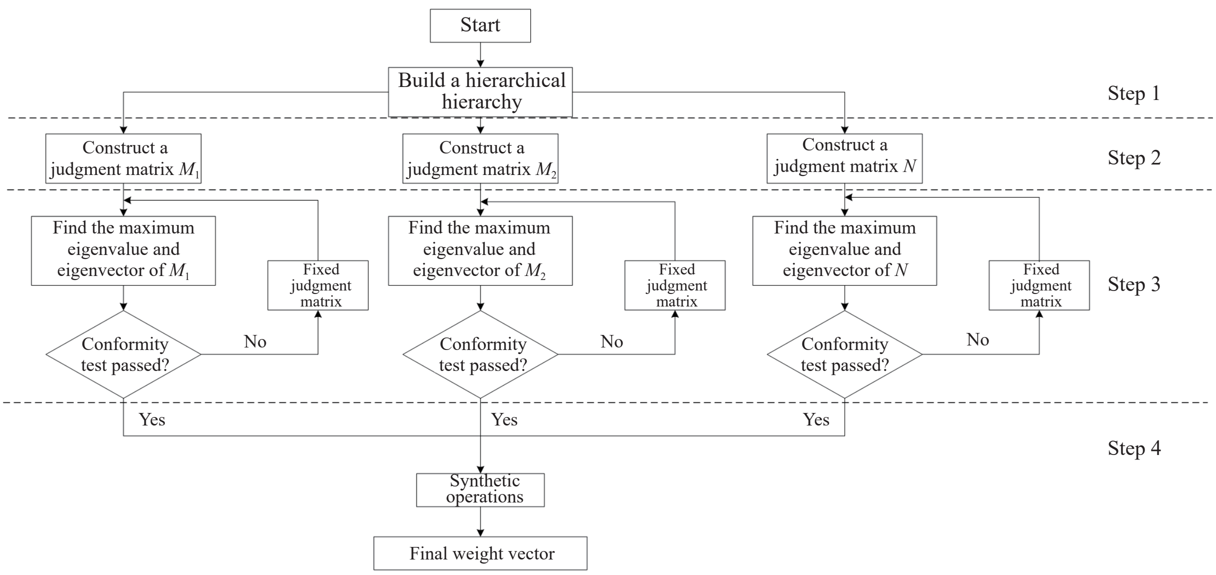

Fig. 1 AHP steps.

4.3 Fuzzy evaluation model based on AHP method AHP model

(1) Build the model hierarchy

When applying AHP to analyze a problem, it is necessary to organize and hierarchize the problem and construct a hierarchical structural model. Under this model, the complex problem is broken down into subsets (elements), which in turn form several levels according to their properties and relationships, and the scale values are shown in Table 3.

(2) Build a judgment matrix

For a hierarchical model like the one shown in Fig. 1, assume that the target layer, criterion layer, and factor layer are X, Y, and Z, respectively. Among them, the Y layer has m elements, and the Z layer has n elements, and some elements of each layer are compared and judged in pairs relative to some elements of the previous layer, and the comparison value of their relative importance is obtained, and the judgment matrix of an element in the upper layer on the related elements of the lower layer is established. Let Y_k in Y and Z_{k1}, Z_{k2} in Z, ..., Z_{kp} elements are related, so Y_k is used as the evaluation criterion, and Z_{k1}, Z_{k2}, ..., Z_{kp} compares pairs to obtain the values of the elements of the judgment matrix. The ratio of the two elements Z_{ki} and Z_{kj} is recorded as $Z_{ij}^{k}Z_{ij}^{k}Z_{ij}^{k}$, and the value can

Table 3 Scale value

Scale value	Meaning
1	Indicates a comparison of two factors with the same importance
3	Indicates a comparison of two factors, with the former being slightly more important than the latter
5	Indicates a comparison of two factors, with the former being significantly more important than the latter
7	Indicates a comparison of two factors, with the former factor being strongly more important than the latter
9	Indicates a comparison of two factors, with the former being extremely important than the latter
2, 4, 6, 8	The middle of the above two adjacent judgments
Reciprocal	The comparison between factor X_i and factor X_j is judged as a_{ij}, and the judgment of factor X_j compared with factor X_i is $1/a_{ij}$

be determined according to the table. This can obtain the judgment matrix Z_k=$(Z_{ij}^k)pp$ for the Y_k elements in the Y hierarchy.

(3) Calculate the weight vector

Take the normalized eigenvector corresponding to the maximum feature root of the judgment matrix as $(Z_{k1}, Z_{k2}, \cdots, Z_{kp})$ for the weight vector of Y_k, Z_k is a positive and inverse matrix, the maximum eigen root of Z_k must be positive real and unique, and all components of its corresponding eigenvectors are positive real numbers. When the Z_k order is higher, it is difficult to calculate the eigenvalues and eigenvectors of the matrix with definitions. Therefore, the maximum feature root and feature vector can be calculated by approximation. Normalize = for each column of vectors of Z_k, and for the product of rows and open to the power of p as $\widetilde{X_{ij}^k} = \sqrt[p]{\prod_{j=1}^{p} \widetilde{X_{ij}^k}}$, $(\widetilde{X_1^k}, \widetilde{X_2^k} \cdots \widetilde{X_p^k})$ is the eigenvector (approximate) corresponding to the largest eigen root of Z_k. The maximum eigen root approximation is $\lambda_{max} = \frac{1}{p} \sum_1^p \frac{\widetilde{X_i^k}}{\widetilde{X_i^k}} Z_k$, and then normalized $\widetilde{X_i^k}$ to obtain the normalized weight vector X_k=$(X_1^k, X_2^k, \cdots, X_p^k)$, $X_i^k = \frac{\widetilde{X_{ij}^k}}{\sum_1^n \widetilde{X_i^k}}$.

(4) Consistency test

Using the eigenvector corresponding to the maximum eigenvalue as the weight vector of the influence of the compared element on the upper element, the consistency of the judgment matrix R_k must be tested. The consistency ratio metric is calculated as $CR = \frac{CI}{RI}$. where the consistency indicator $I_C = \frac{\lambda_{\max} - p}{p-1}$; R_C is a random consistency index, and the numerical order of R_k is related to P. When R_C<0.1, it is generally considered that the consistency of the judgment matrix $\boldsymbol{R_k}$ is acceptable, otherwise the elements in the judgment matrix need to be readjusted until there is satisfactory consistency.

Fuzzy evaluation model

(1) Establish a factor set

The set of factors refers to the set of factors affecting the evaluation object, which can be expressed as U={U_1, U_2,$\cdots$, U_m}, $U_i = \left\{U_{I1}, U_{I2}, \cdots, U_{Ip}\right\}$, where U_i is the i-th subset (i=1, 2, 3, $\cdots$, m); U_{ij} U_{ij} is the j-th influencing factor of the i-th subset (j=1, 2, 3, $\cdots$, p).

(2) Establish an evaluation set

The evaluation set is a set of possible evaluation results of the evaluation object, which can be expressed as V={v_1, v_2, $\cdots$, v_m}, for t evaluation elements (j=1, 2, $\cdots$, q).

(3) Determine the membership function

The membership degree represents the fuzzy relationship between the elements in the factor set U and the elements in the evaluation set V, where r_{ijt} ($0 \leqslant r_{ijt} \leqslant 1$) is the membership degree of the i subset j elements in U to the V grade V_t.

(4) Establish a weight set

Weight refers to the extent to which each element plays a role in the evaluation objective. Since the importance of each element to the evaluation object is different, each element should be given a corresponding weight. The determination of the weight coefficient of evaluation indicators is very important, which directly affects the results of comprehensive evaluation. This article uses analytic hierarchy to determine metric weights.

(5) Fuzzy cluster evaluation

Use the membership function to calculate the degree of membership of each indicator value. The evaluation matrix $\boldsymbol{R_i}$ of the subset U_i is obtained:

$$\boldsymbol{R_i} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1q} \\ x_{21} & x_{22} & \dots & x_{2q} \\ \dots & \dots & \dots & \dots \\ x_{p1} & x_{p2} & \dots & x_{pq} \end{bmatrix}$$

When the evaluation index system, weight vector X_i and evaluation matrix $\boldsymbol{R_t}$ are determined, the following evaluation model is established:

$$Y_t = X_t o R_t = \left\{y_{t1}, y_{t2}, \cdots, y_{tq}\right\}$$

o is the fuzzy factor. The single-factor (first level) fuzzy evaluation set Y_t is not only the evaluation set of U_t, but also constitutes the second-level comprehensive evaluation matrix $\boldsymbol{R}$:

$$\boldsymbol{R_i} = \left| \begin{array}{c} Y_1 \\ Y_2 \\ \dots \\ Y_m \end{array} \right| \begin{bmatrix} y_{11} & y_{12} & \dots & y_{1q} \\ y_{21} & y_{22} & \dots & y_{2q} \\ \dots & \dots & \dots & \dots \\ y_{m1} & y_{m2} & \dots & y_{mq} \end{bmatrix}$$

Then the second-level fuzzy evaluation model is:

$$Y = XoR = \left\{y_1, y_2, \cdots, y_q\right\}$$

(6) Processing of evaluation results

In the fuzzy comprehensive evaluation, since the evaluation result of each evaluated object is a fuzzy vector, we can directly take $\boldsymbol{Y}$ as the result. Sometimes, however, to make the results clearer, more explicit, or to facilitate further analysis, $\boldsymbol{Y}$ may be treated using the weighted average method or the maximum membership method.

5 Instance validation

5.1 Questionnaire research

In order to further improve the level of expressway information services, strengthen the construction of informatization, promote the development of expressway travel information services, better meet the needs of drivers and passengers for expressway public information, and optimize the travel experience of drivers and passengers, in March 2022, a questionnaire survey was carried out in the service area of a smart expressway, mainly through the questionnaire issued to the drivers and passengers in the above-mentioned service areas, to investigate their attention and satisfaction with different travel information services on the expressway; At the same time making full use of online research to widely distribute survey questionnaires and expand the scope of research. More than 500 questionnaires were collected online and offline, and the questionnaire results could be used to verify the credibility evaluation system of traffic information release, and the research group could input the analysis data into the fuzzy evaluation model based on the analytic hierarchy method of the aforementioned study for calculation, and output the evaluation results of the credibility of different types of information, providing reference for decision-makers to evaluate the quality of traffic information release.

5.2 Establish a fuzzy evaluation matrix

Based on the current situation of expressway information services and the operation experience of highway management personnel, combined with expert advice in the industry, fully considering the accuracy, timeliness and completeness of each dynamic information, static information and other information, the quality of highway information release is evaluated, and the index values of the evaluation system are formed. Among them, the vertical columns of the matrix represent the sub-types of dynamic, static and other traffic information, and the horizontal columns represent the evaluation set, which are V_V, V_R, V_F, V_L, and V_N. According to the results of the questionnaire survey:

Establishment of univariate evaluation matrix $\boldsymbol{R_1}$ of static road travel information:

$$\boldsymbol{R}_1 = \begin{vmatrix} 0.35 & 0.33 & 0.27 & 0.03 & 0.02 \\ 0.37 & 0.33 & 0.23 & 0.03 & 0.04 \\ 0.37 & 0.25 & 0.28 & 0.05 & 0.03 \end{vmatrix}$$

Dynamic road travel information univariate evaluation matrix $\boldsymbol{R_2}$:

$$\boldsymbol{R}_2 = \begin{vmatrix} 0.36 & 0.25 & 0.29 & 0.07 & 0.03 \\ 0.34 & 0.20 & 0.31 & 0.08 & 0.07 \\ 0.30 & 0.23 & 0.31 & 0.10 & 0.06 \\ 0.34 & 0.25 & 0.28 & 0.06 & 0.07 \\ 0.32 & 0.25 & 0.31 & 0.07 & 0.06 \end{vmatrix}$$

Other travel information univariate evaluation matrix $\boldsymbol{R}_3$:

$$\boldsymbol{R}_3 = \begin{vmatrix} 0.34 & 0.29 & 0.27 & 0.05 & 0.05 \\ 0.35 & 0.26 & 0.28 & 0.07 & 0.04 \\ 0.28 & 0.26 & 0.33 & 0.05 & 0.08 \\ 0.32 & 0.25 & 0.31 & 0.07 & 0.06 \end{vmatrix}$$

5.3 Establish a judgment matrix

Combined with the results of the questionnaire survey, the quality of highway travel information released below the target layer X is the evaluation criterion, and the judgment matrix $\boldsymbol{Y}$ is established:

$$\boldsymbol{Y} = \begin{vmatrix} 1 & 1/5 & 3 \\ 5 & 1 & 7 \\ 1/3 & 1/7 & 1 \end{vmatrix}$$

The following static release information Y_1 at the criterion level establishes a judgment matrix $\boldsymbol{Z}_1$ for the evaluation criteria:

$$\boldsymbol{Z}_1 = \begin{vmatrix} 1 & 3 & 1/2 \\ 1/3 & 1 & 1/5 \\ 2 & 5 & 1 \end{vmatrix}$$

The following dynamic release information Y_2 at the criterion level establishes a judgment matrix $\boldsymbol{Z}_2$ for the evaluation criteria:

$$\boldsymbol{Z}_2 = \begin{vmatrix} 1 & 1/2 & 2 & 2 & 3 \\ 2 & 1 & 3 & 3 & 5 \\ 1/2 & 1/3 & 1 & 1 & 2 \\ 1/2 & 1/3 & 1 & 1 & 2 \\ 1/3 & 1/5 & 1/2 & 1/2 & 1 \end{vmatrix}$$

The following other published information Y_3 at the criterion level establishes a judgment matrix $\boldsymbol{Z}_3$ for the evaluation criteria:

$$\boldsymbol{Z}_3 = \begin{vmatrix} 1 & 1/5 & 1 & 3 \\ 5 & 1 & 5 & 6 \\ 1 & 1/5 & 1 & 3 \\ 1/3 & 1/6 & 1/3 & 1 \end{vmatrix}$$

5.4 Judgment matrix calculation

In this research, SPSS software was used for calculation, and the judgment matrix calculation results obtained are shown in Table 4, from which it can be judged that $\boldsymbol{Y}$, $\boldsymbol{Z}_1$, $\boldsymbol{Z}_2$ and $\boldsymbol{Z}_3$ meet the consistency requirements.

5.5 Fuzzy synthetic evaluation

In this research, the M (●+) (weighted average) operator was used to carry out the first-level fuzzy comprehensive evaluation. The evaluation results of various road travel information are shown in Table 5.

Table 4 Summary of judgment matrix calculation results.

Judgment matrix	Maximum feature root	The maximum feature root corresponds to the normalized weight vector	I_C	I_R	R_C
Y	λ_{max}=3.066	X=19.319%, 72.351%, 8.331%	0.033	0.52	0.063
Z_1	λ_{max1}=3.004	X_1=30.915%, 10.959%, 58.126%	0.002	0.52	0.004
Z_2	λ_{max2}=5.017	X_2=24.123%, 41.374%, 13.535%, 13.535%, 7.434%	0.004	1.12	0.004
Z_3	λ_{max3}=4.107	X_3=15.779%, 61.587%, 15.779%, 6.855%	0.036	0.89	0.004

Table 5 First-level fuzzy evaluation results of various road travel information.

Travel information		V_V	V_R	V_F	V_L	V_N
Static road	Degree of affiliation	0.368	0.287	0.275	0.042	0.028
	Degree of Affiliation Normalization	0.368	0.287	0.275	0.042	0.028
Dynamic road	Degree of affiliation	0.338	0.227	0.301	0.077	0.058
	Degree of Affiliation Normalization	0.338	0.227	0.301	0.077	0.058
Other road	Degree of affiliation	0.335	0.264	0.288	0.064	0.049
	Degree of Affiliation Normalization	0.335	0.264	0.288	0.064	0.049

The first-level evaluation model and results are shown in Table 6.

Table 6 First-level fuzzy comprehensive evaluation model and results

First-level evaluation mode	Results
$Y_1 = X_1 \text{o} \mathrm{R}_1$	{0.368, 0.287, 0.275, 0.042, 0.028}
$Y_2 = X_2 \text{o} \mathrm{R}_2$	{0.338, 0.227, 0.301, 0.077, 0.058}
$Y_3 = X_3 \text{o} \mathrm{R}_3$	{0.335, 0.264, 0.288, 0.064, 0.049}

The evaluation results of the primary matrix are composed into the secondary matrix $\boldsymbol{R}$, namely:

$$\boldsymbol{R} = \begin{vmatrix} 0.368 & 0.287 & 0.275 & 0.042 & 0.028 \\ 0.338 & 0.227 & 0.301 & 0.077 & 0.058 \\ 0.335 & 0.264 & 0.288 & 0.064 & 0.049 \end{vmatrix}$$

Then the fuzzy evaluation result of the secondary matrix is:

$$\boldsymbol{Y}=\boldsymbol{X}\text{o}\boldsymbol{R}=\{0.336, 0.246, 0.292, 0.071, 0.054\}$$

5.6 Evaluate the processing results

Using the fuzzy set to directly represent the evaluation results, assuming that the evaluation set is $\{V_V, V_R, V_F, V_L, V_N\}$={very credible, relatively credible, fair, less credible, not credible}, then the three-phase single-factor evaluation of static information, dynamic information and other information and the quality evaluation of highway public travel information release are as shown in Table 7.

In order to facilitate the analysis, the weighted average method is used to process the evaluation results: if V={100, 80, 60, 40, 20} is taken, the static information service quality evaluation result V=78.5, the dynamic information service quality evaluation result V=74.26, and the service quality evaluation result of other relevant information V=75.44. According to the processing results of the weighted average method, the release quality of static road travel information, dynamic road travel information and other related information was in the range of “fair” to “relatively credible”, among which the release quality of static road travel information was biased towards “relatively credible”, and the release quality of dynamic road travel information and other related information was slightly inferior to the release quality of static road travel information, among which the score of dynamic road travel information release quality was the lowest, which needed further improvement. The overall traffic information release quality evaluation result V=74.72, overall, the quality of expressway travel information release is biased to “relatively credible”, and there is still room for further improvement.

Table 7 Fuzzy evaluation results of various road travel information and overall release quality

Object	Grade				
	Very credible	Relatively credible	Fair	Less credible	Not credible
Static road travel information	0.368	0.287	0.275	0.042	0.028
Dynamic road travel information	0.338	0.227	0.301	0.077	0.058
Other road travel information	0.335	0.264	0.288	0.064	0.049
Quality of expressway travel information release	0.336	0.246	0.292	0.071	0.054

6 Conclusions

At present, the research results of the quality assessment of traffic information release in the academic field are mainly based on theories, methods and models, and a complete and comprehensive multi-expressway traffic information credibility assessment system has not yet been formed in China, and there are few results in the application and practice of combining the actual information data of expressways. In addition, China's current standards and norms have fewer requirements for the performance and quality indicators of traffic information releases, and the applicability of information service specifications for expressways is not strong. In this research, the credibility connotation of expressway traffic information release is proposed, and a set of multi-expressway traffic information service quality evaluation system is designed based on the variable message sign along the expressway. This research can provide an important reference for the construction of the quality assessment system of expressway traffic information release, the research and development of key technologies, and the improvement of the standard and specification system. The next stage of research will be combined with the actual data released by other information release methods of smart expressway to further analyze and verify the evaluation results, and continuously optimize the evaluation methods and apply them.

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Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

Author contribution statement

Chenyang Lü: Conceptualization, data curation, methodology, software, writing-original draft, writing-review & editing. Lei Cai: Funding acquisition, investigation and methodology. Hengbo Zhang: Software and data analysis. Xinke Wang: Formal analysis, investigation, resources.

Data availability statement

Due to the fact that the data contains the privacy of survey objects and internal project data, the data supporting the results of this research will not be shared publicly for the time being. For reasonable research needs, please contact the corresponding author for negotiation.

Use of AI statement

No generative AI tools were used.

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