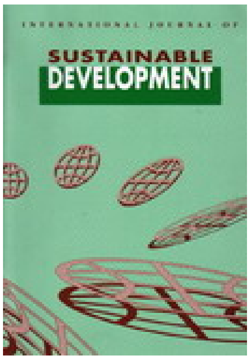

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Assessment method of urban green transportation development level based on improved matter-element extension method

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Abstract: The research objective is to overcome the problems of high information loss rate, long data processing time, and low evaluation accuracy in traditional evaluation methods, and an assessment method of urban green transportation development level based on improved matter-element extension method is proposed. According to the fitness and ordered weighted averaging (OWA) operator weight values, assessment indicators are selected and an assessment indicator system is constructed. Principal component analysis (PCA) is used to reduce the dimensionality of the assessment indicator data. An evaluation model for the development level of urban green transportation is built using the improved matter-element extension method, the dimensionality reduced data is input into the model, and the evaluation results are obtained. After testing, it was found that the maximum information retention rate of this method is 97.2%, the mean data processing time is 1.63 s, the assessment accuracy is above 97.6%.

Keywords: urban green transportation; development level; assessment method; OWA operator weight values; improved matter-element extension method.

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1 Introduction

Due to the rapid pace of urbanisation and the ongoing surge in transportation demand, urban transportation problems have become one of the important challenges facing the world. Air pollution and greenhouse gas emissions are primarily attributed to urban transportation (Forsberg and Krook-Riekkola, 2021). Vehicle exhaust emissions and traffic congestion have a serious impact on the urban environment and residents' health, so traditional transportation modes have caused serious pressure on the environment and resources. As a result, numerous countries and cities have placed significant emphasis on promoting the advancement of urban green transportation (Yang et al., 2021). In pursuit of sustainable development in urban transportation, the advancement of eco-friendly transportation endeavours to significantly lower carbon emissions (Wang et al., 2023). Urban sustainable development and transportation system improvement can be promoted through the assessment of the level of urban green transport development. Through in-depth research and assessment, targeted suggestions and guidance can be provided to urban decision-makers. Therefore, studying the assessment method of urban green transportation development level has important research significance.

Gao et al. (2022) proposes an evaluation method based on a comprehensive weighting method. Initial analysis involves identifying traffic characteristics and establishing an evaluation index system using the DPSIR model. Preprocessing of the index data is carried out to ensure accuracy and consistency. The intuitionistic fuzzy analytic hierarchy process and entropy weight method are applied to provide comprehensive weights for the evaluation indicators. Calculation results of indicator weights are obtained, aided by the chosen methods. The improved set pair analysis variable fuzzy set coupling model is employed to determine the level of development in urban green transportation. However, after processing the assessment indicator data, this method has a high rate of information loss and does not have good practical application results. Li et al. (2021) proposed an evaluation method based on grey correlation degree. Firstly, questionnaire surveys and field analysis methods were used to screen evaluation indicators, and the indicator data was processed accordingly. Secondly, a crucial step involves the establishment of a comprehensive evaluation index system, which encompasses multiple aspects, including but not limited to infrastructure, service quality, and the social landscape. Finally, the grey correlation model is combined with the cloud element model to build an evaluation model and obtain relevant evaluation results. However, the data processing time of this method is relatively long. Ma et al. (2022) proposed an evaluation method based on the DPSIR model. Firstly, analyse the driving forces of urban transportation development, determine the pressure of transportation development on the environment and society, and build an evaluation index system using the DPSIR model. Secondly, the analytic hierarchy process and entropy weight method to calculate the importance of evaluation indicators. Finally, a comprehensive evaluation model will be formulated by integrating set pair analysis and variable fuzzy sets. The processed indicator data will then be input into the model to acquire relevant evaluation results. However, during testing, it was found that this method has a low evaluation accuracy issue.

A new assessment method of urban green transportation development level based on improved matter-element extension method is proposed and its effectiveness is verified through experiments. The main research path of this algorithm is as follows:

1 Select evaluation indicators based on the conformity and ordered weighted averaging (OWA) operator weight values, and establish an evaluation index system.

2 Using principal component analysis (PCA) to reduce the dimensionality of evaluation indicator data and capture the most important information.

3 An improved matter element extension method is introduced to determine the classical and value domains. Then, an evaluation model for the development level of urban green transportation is constructed using the improved matter element extension method. The dimensionality reduction processed data is input into the model to obtain the evaluation results.

2 Assessment of the development level of urban green transportation

2.1 Construction of assessment indicator system

Ensuring the comprehensiveness and accuracy of the assessment requires a careful selection of indicators in evaluating the development level of urban green transportation. When selecting indicators, evaluators should discuss and participate with relevant stakeholders to ensure that the selected indicators meet their needs and concerns. At the same time, evaluators should also flexibly adjust and optimise the selection of indicators based on specific urban characteristics and assessment objectives. The meaning of indicator screening criteria is shown in Table 1.

Assuming there is a decision matrix $D=\left\{d_{ij}\right\}_{m\times n}$, d_{ij} that represents the degree of compliance of one indicator with respect to another indicator. Then the aggregate function is expressed by the following formula:

$$F_{wa}\left(D\right)=D\cdot W^{T} \tag{1}$$

In formula (1), $W=\left[w_1,w_2,...,w_n\right]$ represents the criterion weight matrix and matrix transposition.

Table 1 Meaning of indicator screening criteria

Indicator screening criteria	*Specific meanings*
Rationality	Measurement indicators are crucial tools for accurately evaluating and measuring the degree of progress in the development of environmentally friendly urban transportation systems
Necessity	The dominance of measuring indicators on the development level of urban green transportation
Independence	Measure the degree of dependence of indicators on other indicators
Collectability	Convenience of obtaining measurement indicator values
Promotability	Measure the potential of indicators that can be optimised

The aggregation function based on the OWA operator is represented by the following formula:

$$F_{owa}\left(D\right)=D_{order}\cdot W_{owa}^{T} \tag{2}$$

In formula (2), D_{order} is the compliance vector, W_{owa} is the weight matrix of the OWA operator. The OWA operator generating function is represented by the following formula:

$$f\left(x\right)=\begin{cases}\frac{4}{3}x,0\leq x\leq 0.6\\ \frac{1}{2}\left(x+1\right),0.6<x\leq 1\end{cases} \tag{3}$$

The calculation of the weight value for the OWA operator is performed using the following formula:

$$\omega_{j}=f\left(\frac{j}{n}\right)-f\left(\frac{j-1}{n}\right) \tag{4}$$

Retain the assessment indicators of urban green transportation development level with higher weight values of the OWA operator, discard the assessment indicators with lower weight values, and achieve the screening of assessment indicators of urban green transportation development level (Guo et al., 2022). Combined with relevant principles, establish an assessment indicator system of urban green transportation development level. The principles followed during the construction of the indicator system are as follows:

1 *Comprehensive principle*: The assessment index system should comprehensively consider multiple aspects of urban green transportation, including environmental, economic, and social factors. By employing this approach, the evaluation of the development level of urban green transportation can be conducted in a comprehensive manner, effectively mitigating the inherent limitations and biases associated with relying solely on a single indicator.

2 *The principle of quantifiability and measurability*: Assessment indicators should have quantifiability and measurability, and can be evaluated through data collection and analysis. This can ensure the objectivity and comparability of the assessment results, making it easier to compare and analyse different cities or time periods (Song et al., 2021).

3 *Feasibility principle*: To ensure the feasibility and operability of the assessment process, it is important to base assessment indicators on existing data and available information. The collection and calculation of these indicators should be achievable in real-world situations and must be continuously updated and monitored.

4 *The principle of interpretability*: Assessment indicators should provide clear explanations and understanding, so that the assessment results can be widely understood and accepted. The definition and calculation method of indicators should be clear and consistent with the actual problems and goals of urban green transportation (Zhang and Chen, 2022).

5 *Systematic principle*: The assessment indicator system should be systematic and able to consider various aspects and interrelationships of urban green transportation. In order to establish a comprehensive evaluation framework for gauging the progress of urban green transportation, it is imperative that the indicators are interconnected. This interconnectedness will enable a holistic evaluation of various aspects and dimensions of urban green transportation.

6 *Sustainability principle*: The assessment index system must be in line with the principles of sustainable development, consistently reflecting the impact of urban green transportation on the environment, society, and economy. It should also align with the sustainable development goals, maintaining a balanced selection of indicators to foster the long-term sustainability of urban green transportation.

Table 2 illustrates the assessment index system utilised to assess the advancement of urban green transportation development.

Table 2 Assessment index system for urban green transport development level

Primary indicators	*Secondary indicators*
Environmental aspects	Carbon emissions
	Air quality index
	Noise level
	Energy saving effect
	Public transportation coverage rate
Economic aspects	Transportation costs
	Economic benefits
Social aspects	Road network density
	Security
	Health Impact
	Social equity
Technology and innovation	Proportion of new energy vehicles
	Application level of intelligent traffic management system
	Coverage of shared travel platforms
Policy and planning aspects	Sustainable transport policy
	Planning consistency

2.2 Indicator data processing based on principal component analysis

Principal component analysis, also referred to as PCA (Kobayashi et al., 2022), is a fundamental approach employed to identify and extract the most prominent attributes present in a given dataset. PCA effectively reduces the overall dimensionality while retaining the key information that best captures the underlying patterns and structure of the data (Akiba et al., 2022). Applying PCA as a method of data dimensionality reduction can help simplify the dataset, determine indicator weights, and provide convenience for visualisation and interpretation. The principal component model can be represented by the following formula:

$$F = b_1 * f_1 + b_2 * f_2 + \cdots + b_m * f_m \tag{5}$$

In formula (5), f_i represents the principal component factor, X_i represents observable random variables, a_{ij} represents the loading capacity of each factor (Zeng et al., 2022), and b_i represents the contribution rate of each principal component.

Assuming there are n sample sizes of assessment indicator, each with m indicator variables, these m indicators constitute an m-dimensional random vector $X_{ij} = (x_1, x_2, x_3, \ldots, x_m)$, forming a $n \times m$ sample statistical matrix (Liu et al., 2022), which is represented by the following formula:

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{21} & \cdots & x_{2m} \\ \cdots & \cdots & x_{ij} & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{6}$$

In formula (6), x_{ij} represents the variable parameter of the jth urban green transportation development level assessment indicator for the ith sample size. Linear transformation was performed on the assessment index variables of urban green transportation development level to obtain a new comprehensive variable (Chelouche et al., 2022), and the results are as follows:

$$\begin{cases} f_1 = u_{11} * x_1 + u_{21} * x_2 + \cdots + u_{m1} * x_m \\ f_2 = u_{12} * x_1 + u_{22} * x_2 + \cdots + u_{m2} * x_m \\ \qquad \vdots \\ f_p = u_{1p} * x_1 + u_{2p} * x_2 + \cdots + u_{mp} * x_m \end{cases} \tag{7}$$

In formula (7), $f_1, f_2, \ldots, f_p$ represents different principal components, and $p \leq m$. In general, X_{ij} represents a dimensional variable, so it needs to be dimensionless (Veeramsetty et al., 2022), and the results are as follows:

$$x_{ij}^{'} = \frac{x_{ij} - \overline{x_j}}{S_j} i = (1, 2, 3, \ldots, n), j = (1, 2, 3, \ldots, m) \tag{8}$$

In formula (8), $\overline{x_j}$ is the mean of indicator data x_{ij} is the sample standard deviation. Their calculation formulas are as follows:

$$\overline{x_j} = \frac{\sum_{j=1}^{n} x_{ij}}{n} \tag{9}$$

$$S_j = \sqrt{\frac{\sum_{i=1}^{n} \left(x_{ij} - \overline{x_j}\right)^2}{n}} j = (1, 2, 3, \ldots, m) \tag{10}$$

Consolidate the evaluation indicators pertaining to the advancement of urban green transportation into a centralised matrix, and convey the resultant outcomes as X':

$$X' = \begin{bmatrix} x_{11} - \overline{x_1} & x_{12} - \overline{x_2} & \cdots & x_{1m} - \overline{x_m} \\ x_{21} - \overline{x_1} & x_{22} - \overline{x_2} & \cdots & x_{2m} - \overline{x_m} \\ \cdots & \cdots & x_{ij} - \overline{x_j} & \cdots \\ x_{n1} - \overline{x_1} & x_{n2} - \overline{x_2} & \cdots & x_{nm} - \overline{x_m} \end{bmatrix} \tag{11}$$

Utilising the aforementioned analysis, compute the correlation coefficient matrix *R*, resulting in the following outcomes:

$$R = \frac{X'^T X'}{n-1} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mm} \end{bmatrix} \tag{12}$$

In formula (12), r_{mm} represents the correlation coefficient between the original variables x_i and x_j. According to the characteristic equation $|\lambda E - R|$ of the assessment index sample, calculate all corresponding characteristic values $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_i \geq 0$. Furthermore, the variance contribution rate and cumulative contribution rate for each principal component can be derived by employing the following formulas to calculate the results:

$$\alpha_i = \frac{\lambda_i}{m} \tag{13}$$

$$\theta = \frac{\sum_{i=1}^{k} \lambda_i}{m} \tag{14}$$

Calculate the transformation coefficient of the linear combination of various principal components composed of the assessment index variables:

$$u_{ij} = \frac{e_{ij}}{\sqrt{\theta \lambda_i}} \tag{15}$$

In formula (15), e_{ij} is the factor load of the *i*th principal component on the original variable x_j. The calculation formula for the comprehensive assessment function of the principal component is as follows:

$$f_i = u_{ij} * X'(i = 1, 2, ..., m) \tag{16}$$

The dimensionality reduction processing results of assessment index data based on PCA are as follows:

$$Z = \sum_{i=1}^{k} \alpha_i * f_i \left(i = 1, 2, ..., k \right) \tag{17}$$

2.3 Improving the matter-element extension method to build an assessment model

The matter-element extension method is a decision analysis approach grounded in fuzzy set theory. It is specifically designed to handle situations characterised by uncertainty and fuzziness. It combines the ideas of fuzzy mathematics and extension theory to solve complex multi-attribute decision-making problems. The matter-element extension method faces inherent limitations in effectively addressing uncertainties and fuzziness inherent in complex problems. Consequently, in order to surmount these challenges and enhance the precision of evaluating the progress of urban green transportation, significant advancements have been made. One such improvement involves the integration of the determination method of classical domain and value domain, which enables a more refined evaluation process. This enhancement empowers decision-makers to better understand and evaluate the multifaceted aspects of urban green transportation. The process of assessing the advancement of urban green transportation through the enhanced matter-element extension method consists of several key stages. These include determining the classical and nodal domains, computing membership degrees, calculating indicator weights, evaluating the development level of urban green transportation, and generating the final results. Firstly, the value range of urban green transportation development level is divided into four levels using the time series method, and the membership degree of each indicator relative to each level is calculated. Next, multiply the weight of the indicators by the level correlation degree of the evaluation indicators to obtain the weighted correlation degree, and establish an evaluation model. Finally, input the dimensionality reduction processed data into the model to obtain the evaluation results. Through the utilisation of the aforementioned processes, the appraisal of the extent to which urban green transportation has progressed in terms of its development level, based on the enhanced matter-element extension method, can effectively address challenges related to uncertainty and fuzziness. As a result, it provides reliable and scientific decision-making support. This systematic approach empowers decision-makers to make informed choices regarding urban green transportation development, ensuring sustainable and environmentally-friendly infrastructure for the future. Assuming that the time series of indicator C_i is $C_1, C_2, \ldots, C_n$, and the indicator level is divided into *j* levels, then:

1 After performing the necessary calculations, the length of the time series interval has been determined, and the results are as follows:

$$L = \max C_i - \min C_i \tag{18}$$

2 Calculate the average interval between time series intervals, and the results are as follows:

$$K = \frac{L}{J} = \frac{\max C_i - \min C_i}{J} \tag{19}$$

3 The calculation formula for determining the lower and upper bounds can be outlined as follows:

$$\begin{cases} C_{i1}^{l} = minC_i \\ C_{i1}^{u} = minC_i + K \end{cases} \tag{20}$$

So, the interval of the *J*th level is represented by the following formula:

$$C_{ij} = \left[minC_i + (j-1)K_i, minC_i + jK \right] \tag{21}$$

The assessment process based on the improved matter-element extension method is as follows:

1 Determine classic domain and node domain

N_j represents the *j*th assessment level in the divided classical domain, and (a_{in}, b_{in}) represents the assessment index of urban green transportation development level. The classical domain can be expressed as:

$$R_N = (N_j, C_n, V_n) = \begin{vmatrix} N_j & C_1 & (a_{i1,} b_{i1}) \\ & C_2 & (a_{i1,} b_{i2}) \\ & \vdots & \vdots \\ & C_n & (a_{in,} b_{in}) \end{vmatrix} \tag{22}$$

In the above formula, C_n represents the range of assessment indicators, and V_n represents the parameter matrix of assessment indicator range.

2 Assuming (a_{pi}, b_{pi}) represents the range of values for the assessment indicators C_i of urban green transportation development level, then the j membership degree of C_i regarding the assessment level is calculated using the following formula:

$$K_j(V_i) = \begin{cases} \dfrac{-\rho(V_i, V_{ij})}{|V_{ij}|}, V_i \in V_{ij} \\ \dfrac{\rho(V_i, V_{ij})}{\rho(V_i, V_{pi}) - \rho(V_i, V_{ij})}, V_i \notin V_{ij} \end{cases} \tag{23}$$

In formula (23), V_{ij} represents the level correlation degree of the *i*th indicator corresponding to the *j*th level.

$$V_{ij} = (b_{in} - a_{in}) \tag{24}$$

$\rho(V_i, V_{ij})$ and $\rho(V_i, V_{pj})$ represent the membership degrees of V_{ij} and V_{pj} for V_i, respectively, and their calculation formulas are as follows:

$$\rho(V_i, V_{ij}) = \left| v_i - \frac{1}{2}(a_{ij} + b_{ij}) \right| - \left| \frac{1}{2}(b_{ij} - a_{ij}) \right| \tag{25}$$

$$\rho(V_i, V_{pj}) = \left| v_i - \frac{1}{2}(a_{pi} + b_{pi}) \right| - \left| \frac{1}{2}(b_{pi} - a_{pi}) \right| \tag{26}$$

3 Index weight calculation

Evaluation index entropy value is expressed as follows:

$$e_j = -k \sum_{i=1}^{n} h_{ij} ln h_{ij} \tag{27}$$

In formula (27), h_{ij} represents the total contribution of the assessment index, and k represents a constant. The weight calculation formula for the assessment index is as follows:

$$W_j = \frac{e_j d_j}{\sum_{j=1}^{n} d_j} (j = 1, 2, \ldots, n) \tag{28}$$

In formula (28), d_j represents the value of the assessment index.

4 Assessment of the development level of urban green transportation

After calculating the weight of the assessment indicators, the level correlation degree $K_j(p)$ of the assessment element *R* is calculated, and the following relationship formula is established:

$$K_j(p) = \sum_{i=1}^{n} W_i K_j(V_i) \tag{29}$$

Compare the weighted correlation degrees and establish an assessment model. Input the dimensionality reduction data into the model to obtain the assessment results, as follows:

$$H = \frac{K_j(p) - minK_j(p)}{maxK_j(p) - minK_j(p)} \tag{30}$$

The purpose of the member function is to fuzzify the evaluation indicators during the fuzzy reasoning process. The shape of the member function determines the membership of the input values on different member functions. By defining the membership function, specific evaluation index values can be mapped to the degree of fuzzy membership, thus enabling fuzzy reasoning and fuzzy synthesis. The shape of member functions can help reflect the meaning of evaluation indicators and data characteristics, thereby affecting the accuracy and credibility of evaluation results.. Firstly, determine evaluation indicators and collect relevant data, then select suitable member function types and design initial member functions. By combining fuzzy reasoning with verification and adjustment by domain experts, the shape of the member function is continuously optimised, and data fitting and optimisation algorithms are used to tune its parameters. Finally, the final evaluation result is obtained by synthesising the fuzzy membership degrees of various evaluation indicators. This design and optimisation process aims to better adapt member functions to evaluation needs and actual situations, improve evaluation accuracy and reliability, and provide scientific support for policies and planning for urban green transportation development.

3 Experimental design

3.1 Experimental scheme

To substantiate the practicality and efficacy of the evaluation method for appraising the development level of urban green transportation, which relies on the enhanced matter-element extension technique, relevant experimental tests were conducted. The specific experimental plan is as follows:

1 *Experimental data*

Data is collected through various channels, including government departments, traffic management agencies, survey questionnaires, sensors, mobile applications, etc. These data involve aspects such as traffic flow, vehicle types, exhaust emissions, public transportation usage, and bicycle lane networks. There may be errors, missing or redundancy in the collected raw data. Data cleansing encompasses a range of processes including filtering, verifying, correcting errors, and eliminating duplicates to guarantee the accuracy and integrity of data. By consolidating data from diverse sources into a cohesive dataset, data format conversion, field mapping, and standardisation are carried out to facilitate comprehensive analysis and assessment. Different lengths of sample data can affect simulation performance. For different lengths of sample data, statistics such as average, median, or weighted average are calculated to compress the data into the same length.

2 *Assessment indicators*

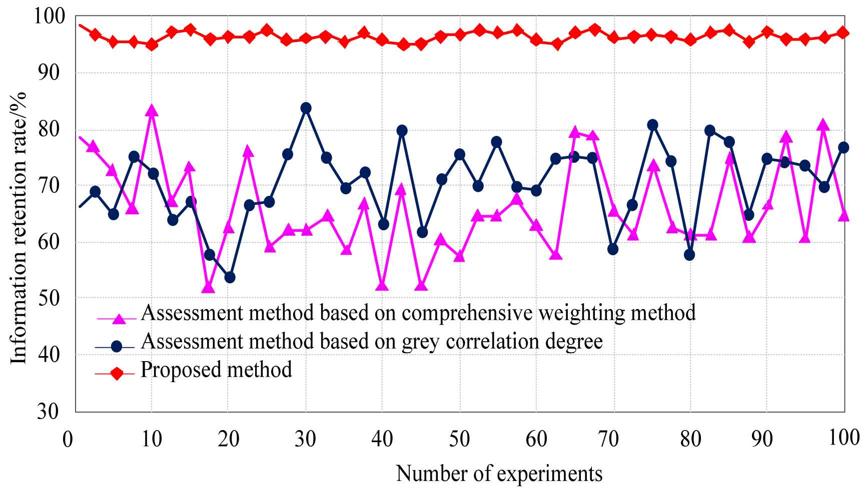
Utilising the criteria of information preservation rate, evaluation data processing duration, and assessment precision as experimental benchmarks. The information preservation rate of data serves as a vital metric for gauging the efficacy of dimensionality reduction techniques in retaining data integrity. This measure is evaluated by quantifying the similarity between the diminished dataset and the original dataset. Additionally, the processing duration of data stands as a significant gauge for assessing the efficiency and swiftness of data processing efforts. Shorter processing durations correspond to heightened operational efficiency. Evaluation precision represents an essential indicator employed to gauge the level of concordance between the evaluation outcomes and the real-world circumstances.

3.2 Experimental result

3.2.1 Information retention rate

The assessment data of urban green transportation development level underwent processing using the assessment method based on comprehensive weighting method, assessment method based on grey correlation degree, and the proposed method. The information retention rates of these three methods were subsequently compared. The comparative results are depicted in Figure 1.

Figure 1 Comparison results of information retention rates among three methods (see online version for colours)



The maximum information retention rate of the assessment method based on comprehensive weighting method is 82.8%, the maximum information retention rate of the assessment method based on grey correlation degree is 83.6%, and the maximum information retention rate of the proposed method is 97.2%.The proposed method achieves a maximum information retention rate that is 14.4% higher than the comprehensive weighting method and 13.6% higher than the grey correlation degree assessment method. The minimum information retention rate of the assessment method based on comprehensive weighting method is 51.1%, the minimum information retention rate of the assessment method based on grey correlation degree is 53.2%, and the minimum information retention rate of the proposed method is 95.7%. The proposed method exhibits a minimum information retention rate that surpasses the comprehensive weighting method by 44.6% and the grey correlation degree assessment method by 42.5%. Overall, the information retention rate of the urban green transportation development level assessment data processed by the proposed method is higher, and the data processing effect is better.

3.2.2 Data processing time

The assessment method based on comprehensive weighting method, assessment method based on grey correlation degree. Table 3 presents the data processing time associated with the assessment of urban green transportation development level using the proposed methodology.

Table 3 Comparison results of data processing time for three methods

Number of experiments	*Data processing time/s*		
	Assessment method based on comprehensive weighting method	*Assessment method based on grey correlation degree*	*Proposed method*
10	5.66	9.63	2.63
20	5.89	8.14	1.54
30	5.74	7.69	1.47
40	3.69	8.52	1.36
50	4.87	8.41	1.25
60	7.63	8.36	1.48
70	7.14	8.17	2.11
80	7.58	7.86	1.66
90	6.66	7.49	1.47
100	5.84	7.63	1.31
Mean value	6.07	8.19	1.63

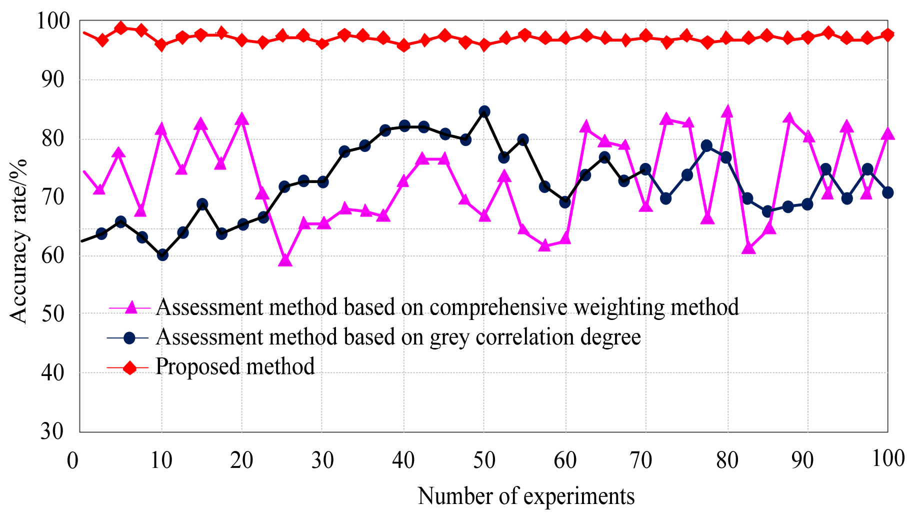
The average processing time of the assessment data for urban green transportation development level using the assessment method based on comprehensive weighting method is 6.07 s, while the average processing time of the assessment data for urban green transportation development level using the assessment method based on grey correlation degree is 8.19 s. The average processing time of the assessment data for urban green transportation development level using the proposed method is 1.63 s, which is the shortest data processing time among the three methods, respectively, compared to the assessment method based on comprehensive weighting method and assessment method based on grey correlation degree has a lower processing time of 4.44 s and 6.56 s. The results reveal that, in terms of evaluating the development level of urban green transportation, the proposed method outperforms the experimental comparison method with significantly shorter data processing time and significantly higher data processing efficiency.

3.2.3 Assessment accuracy

Figure 2 presents a visual representation of the accuracy assessment conducted utilising the comprehensive weighting method, the grey correlation degree assessment method, and the proposed methodology.

The assessment method based on the comprehensive weighting method demonstrates varying levels of accuracy, ranging from 59.2% to 83.8%, when evaluating the development level of urban green transportation. The assessment accuracy using the assessment method based on grey correlation degree varies between 60.1% and 84.7%. The assessment accuracy using the proposed method is above 97.6%, and the accuracy curve of the assessment of urban green transportation development level consistently remains higher for the assessment method based on the comprehensive weighting method compared to the assessment method based on the grey correlation degree, the fluctuation is relatively small. The results clearly indicate that the assessment method excels in terms of accuracy and stability when evaluating the development level of urban green transportation. Therefore, it can be concluded that this method is capable of achieving precise assessments of urban green transportation development.

Figure 2 Comparison results of assessment accuracy of three methods (see online version for colours)



4 Conclusion

1. Indeed, the continuous advancement of technology has paved the way for various new technologies and innovative solutions that are propelling the development of urban. These include electric vehicles, intelligent traffic management systems, and shared travel platforms. Understanding and evaluating the level of development in urban green transportation plays a pivotal role in comprehending the successful implementation and efficacy of these innovative technologies. Moreover, it serves to foster technological innovation and encourage the widespread adoption of such solutions within urban environments.
2. However, traditional methods have problems such as high information loss rate, long data processing time, and low assessment accuracy. Therefore, the paper proposes an assessment method of urban green transportation development level based on improved matter-element extension method.
3. The experimental findings demonstrate that the proposed method achieves a maximum information retention rate of 97.2%, and the average processing time of the assessment index data for urban green transportation development level is 1.63 s. The assessment accuracy is above 97.6%, indicating that the method has the characteristics of low data processing time and high assessment accuracy.

4 The findings of this study are highly significant as they offer valuable insights and practical guidance for urban policymakers, aiding them in effectively promoting and advancing the development of urban green transportation. Future research and practice should focus on solving challenges, strengthening the implementation of policies and plans, and promoting technological innovation and application to achieve a more sustainable, efficient and environmentally friendly urban transportation system.

References

Akiba, N., Nakamura, A., Sota, T., Tamaki, M. and Chandra, D.R. (2022) 'Separation of overlapping fingerprints by principal component analysis and multivariate curve resolution–alternating least squares analysis of hyperspectral imaging data', *Journal of Forensic Sciences*, Vol. 67, No. 3, pp.1208–1214.

Chelouche, S., Trache, D., Benlemir, R. and Krean, Y.P. (2022) 'Principal component analysis of FTIR data to accurately assess the real/equivalent in□service□times of homogenous solid propellant', *Propellants, Explosives, Pyrotechnics*, Vol. 47, No. 6, pp.1–17.

Forsberg, J. and Krook-Riekkola, A. (2021) 'Recoupling climate change and air quality: exploring low-emission options in urban transportation using the TIMES-city model', *Energies*, Vol. 14, No. 1, pp.1–26.

Gao, Y., Ma, Z.L. and Liu, J. (2022) 'Assessment method of national central cities' green transportation level under carbon peaking and carbon neutrality goals', *Transport Research*, Vol. 8, No. 3, pp.30–41.

Guo, F., Wang, Y. and Qian, Y. (2022) 'Computer vision-based approach for smart traffic condition assessment at the railroad grade crossing', *Advanced Engineering Informatics*, Vol. 51, No. 1, pp.101456–101471.

Kobayashi, S., Kaneko, S. and Tamaki, T. (2022) 'Principal component analysis of surface enhanced Raman scattering spectra revealing isomer-dependent electron transport in spiropyran molecular junctions: implications for nanoscale molecular electronics', *ACS Omega*, Vol. 7, No. 6, pp.5578–5583.

Li, L., Zhao, X. and Du, X.W. (2021) 'Study on comprehensive assessment of urban green transportation development', *Journal of East China Jiaotong University*, Vol. 38, No. 2, pp.51–60.

Liu, Z., Han, H.G., Dong, L.X., Liu, K. and Chen, J.X. (2022) 'Intelligent decision method of sludge bulking using recursive kernel principal component analysis and Bayesian network', *Control Engineering Practice*, Vol. 121, No. 1, pp.105038–105051.

Ma, Z.L., Gao, Y., An, T. and He, L.K. (2022) 'Research on the green transportation level measurement of national central cities based on DPSIR model: a case study of Xi'an City', *Ecological Economy*, Vol. 38, No. 4, pp.85–93+114.

Song, N.N., Pang, J.C. and Li, X.Y. (2021) 'Assessment and analysis of the development level of urban and rural transportation integration in Shandong province', *Shandong Transportation Technology*, Vol. 15, No. 6, pp.3–15.

Veeramsetty, V., Chandra, D.R. and Grimaccia, F. (2022) 'Short term electric power load forecasting using principal component analysis and recurrent neural networks', *Forecasting*, Vol. 4, No. 1, pp.1–16.

Wang, G., Xiao, C. and Dai, Q. (2023) 'Research on green traffic travel model in Wuhan based on spatial-temporal data', *Geospatial Information*, Vol. 21, No. 1, pp.20–25.

Yang, T., Peng, J., Yu, M.X., Tang, H. and Huang, J. (2021) 'Green transportation planning in new town of China: take Nanjing south new town as an example', *Urban Transport of China*, Vol. 19, No. 1, pp.58–64.

Zeng, S., Li, Y. and Li, Y. (2022) 'Research on audit opinion prediction of listed companies based on sparse principal component analysis and kernel fuzzy clustering algorithm', *Mathematical Problems in Engineering*, Vol. 22, No. 1, pp.1–13.

Zhang, A.Y. and Chen, X.B. (2022) 'Assessment of high-quality development level of urban public transport', *China Transportation Review*, Vol. 44, No. 12, pp.14–19.