Neutrosophic Sets and Systems

Volume 53

Article 4

6-15-2023

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Recommended Citation

Liu, Yaping; Huicong Wang; Dong Li; and Yanqi Hou. "Method for Comprehensive Evaluation of Urban Smart Traffic Management System Based on the 2-tuple Linguistic Neutrosophic Numbers." *Neutrosophic Sets and Systems* 53, 1 (2023). https://digitalrepository.unm.edu/nss_journal/vol53/iss1/4

Neutrosophic Sets and Systems, Vol. 53, 2023
University of New Mexico

Method for Comprehensive Evaluation of Urban Smart Traffic Management System Based on the 2-tuple Linguistic Neutrosophic Numbers

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Abstract: In the process of the rapid development of big data and the Internet of Things in recent years, in order to create a "strong transportation" construction goals, intelligent transportation projects have become the key carrier of the development of China's transportation industry, the national and local transportation level, economic development and the improvement of people's living standards have an important role. However, although the construction of intelligent transportation projects around the world is in full swing, but the actual operation effect is not ideal. The comprehensive evaluation of urban smart traffic management systems (USTMS) is a classical MADM issues. In this paper, the MADM issues are studied with defined 2-tuple linguistic neutrosophic sets (2TLNSs). Then, connected traditional GRA with 2TLNSs, the 2TLNN-GRA method is elaborated for MADM. Finally, an example for comprehensive evaluation of USTMS was given and some comparisons was elaborated the 2TLNN-GRA method

Keywords: Multiple attribute decision making (MADM); 2TLNS; GRA method; Urban smart traffic management system(USTMS)

1. Introduction

Generally speaking, decision making refers to making a decision based on the realization of conditions, whether it is a major decision made by the state or corporate policy, or a decision made by people in ordinary daily life[1-3]. Therefore, decision making is widely elaborated in various fields of life and production, and has gained more and more attention, such as a company needs to improve a new product, a government department bidding activity, or an individual's choice of occupation or the purchase of goods, all of which are of decision making significance[4-7]. In fact, human beings inevitably face a variety of complex decision-making problems, involving artificial intelligence and other fields, network data, granularity of computing[8-11]. Nowadays, decision making is one of the quite common activities in people's daily life, which aims at ranking a limited number of alternatives by the decision maker according to the value of the evaluation index of each alternative[12-16]. Multi-Attribute Decision Making (MADM) is a branch of decision making that is considered as a cognitive-based human activity. The first step in decision-making is to build mathematical models to describe the uncertain information from different levels, and MADM is one of the processes to find the best solution among all feasible alternatives[17-19]. According to certain attributes, decision information of all alternatives, their corresponding values are represented by some precise value, however, it is believed that most real-life decisions are made in environments with inaccurate or imprecise goals and constraints, which are inherently ambiguous and thus cannot represent preferences with precise values, and most decision makers, due to time decision pressure and lack of full data, may have limited information processing capabilities [20-27]. To cope with this situation, fuzzy set theory has been widely used to deal with uncertainty and vague information [28-32]. After the successful application of fuzzy set decision theory, researchers have worked on the extensions and applications of fuzzy set theory, among which intuitionistic fuzzy sets(IFSs) [33-43]and neutrosophic sets (NSs) [44-55] theory is one of the most important extensions and has been fully applied to MADM. Furthermore, Wang, Wei and Wei [56] devised the 2TLNSs which fuzzy decision information are elaborated with 2TLs[57-63].

With the acceleration of China's urbanization process, urban population, housing and industrial agglomeration on a large scale, urban traffic problems are becoming more and more prominent: traffic congestion is serious, resulting in increased travel time and huge energy consumption; traffic safety problems are serious, accidents are frequent; vehicle emissions and environmental pollution and traffic noise pollution more serious; the increase in vehicle ownership brings parking facilities gradually intensify the contradiction between supply and demand, etc.. Intelligent transportation is proposed in this context, but whether the development of intelligent transportation in a city meets the target requirements requires a complete evaluation system to judge. At present, the concept of intelligent transportation, the technology required for intelligent transportation, intelligent transportation evaluation system and standards are not in-depth research, how to develop intelligent transportation, how to establish an appropriate intelligent transportation evaluation system is an urgent issue to be solved. The problems of comprehensive evaluation of USTMS are MADM problems. In this elaborated paper, the 2TLNN-GRA is constructed based on GRA [64-70] and 2TLNSs. Finally, an example for comprehensive evaluation of USTMS was given and some comparisons were elaborated the 2TLNN-GRA. In order to conduct so, the reminder of such paper elaborates. The definition of 2TLNNSs is elaborated in Sec. 2. The 2TLNN-GRA is elaborated for MADM are elaborated in Sec. 3. An example for comprehensive evaluation of USTMS is elaborated the 2TLNN-GRA in Sec. 4. Sec. 5 lists the conclusions.

2. Preliminaries

Wang et al. [56] elaborated the 2TLNSs.

Definition 1 [56]. Let $f\delta = \{ fs_i \mid i = 0,1,2,\cdots,H \}$ be the LTSs. The fs_i elaborates a possible linguistic value, and $f\delta = \{ fs_0 = \textit{exceedingly terrible}, fs_1 = \textit{very terrible}, fs_2 = \textit{terrible}, fs_3 = \textit{medium}, fs_4 = \textit{well}, fs_5 = \textit{very well}, fs_6 = \textit{exceedingly well.} \}$, then the 2TLNSs is described as:

$$f\delta = \left\langle \left(fs_t, f\alpha \right), \left(fs_i, f\beta \right), \left(fs_f, f\chi \right) \right\rangle \tag{1}$$

where $\Delta^{-1}\left(fs_t, f\alpha, \right), \Delta^{-1}\left(fs_i, f\beta \right), \Delta^{-1}\left(fs_f, f\chi \right) \in [0, H]$ elaborate truth membership, indeterminacy membership and falsity membership with 2-tuple linguistic decision information, $0 \le \Delta^{-1}\left(fs_\alpha, f\phi \right) + \Delta^{-1}\left(fs_\beta, f\varphi \right) + \Delta^{-1}\left(fs_\chi, f\gamma \right) \le 3H$.

Definition 2[56]. Let $f\delta_1 = \left\langle \left(fs_{t_1}, f\alpha_1, \right), \left(fs_{i_1}, f\beta_1 \right), \left(fs_{f_1}, f\chi_1 \right) \right\rangle$, $f\delta_2 = \left\langle \left(fs_{t_2}, f\alpha_2, \right), \left(fs_{i_2}, f\beta_2 \right), \left(fs_{f_2}, f\chi_2 \right) \right\rangle$, the given operation is elaborated:

$$(1)\ f\delta_1 \oplus f\delta_2 = \left\{ \begin{array}{l} \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{t_1}, f\alpha_1, \right)}{H} + \frac{\Delta^{-1}\left(fs_{t_2}, f\alpha_2, \right)}{H} - \frac{\Delta^{-1}\left(fs_{t_1}, f\alpha_1, \right)}{H} \cdot \frac{\Delta^{-1}\left(fs_{t_2}, f\alpha_2, \right)}{H} \right) \right), \\ \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{i_1}, f\beta_1 \right)}{H} \cdot \frac{\Delta^{-1}\left(fs_{i_2}, f\beta_2 \right)}{H} \right) \right), \Delta\left(k\left(\frac{\Delta^{-1}\left(fs_{f_1}, f\chi_1 \right)}{H} \cdot \frac{\Delta^{-1}\left(fs_{f_1}, f\chi_1 \right)}{H} \right) \right) \end{array} \right\};$$

$$(2)\quad f\delta_1 \otimes f\delta_2 = \left\{ \begin{array}{l} \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{t_1}, f\alpha_1, \right)}{H} \cdot \frac{\Delta^{-1}\left(fs_{t_2}, f\alpha_2, \right)}{H} \right)\right), \\ \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{i_1}, f\beta_1 \right)}{H} + \frac{\Delta^{-1}\left(fs_{i_2}, f\beta_2 \right)}{H} - \frac{\Delta^{-1}\left(fs_{i_1}, f\beta_1 \right)}{H} \cdot \frac{\Delta^{-1}\left(fs_{i_2}, f\beta_2 \right)}{H} \right)\right), \\ \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{f_1}, f\chi_1 \right)}{H} + \frac{\Delta^{-1}\left(fs_{f_2}, f\chi_2 \right)}{H} - \frac{\Delta^{-1}\left(fs_{f_1}, f\chi_1 \right)}{H} \cdot \frac{\Delta^{-1}\left(fs_{f_2}, f\chi_2 \right)}{H} \right)\right) \end{array} \right\};$$

$$(3)\, \lambda f\delta_1 = \left\{ \begin{array}{l} \Delta\left(H\left(1 - \left(1 - \frac{\Delta^{-1}\left(fs_{t_1}, f\alpha_1, \right)}{H} \right)^{\lambda} \right)\right), \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{i_1}, f\beta_1 \right)}{H} \right)^{\lambda} \right), \\ \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{f_1}, f\chi_1 \right)}{H} \right)^{\lambda} \right) \end{array} \right\}, \lambda > 0;$$

$$(4)\quad f\delta_1^{\lambda} = \left\{ \begin{array}{l} \Delta\left(H\left(\frac{\Delta^{-1}\left(fs_{t_1}, f\alpha_1, \right)}{M} \right)^{\lambda} \right), \Delta\left(H\left(1 - \left(1 - \frac{\Delta^{-1}\left(fs_{i_1}, f\beta_1 \right)}{H} \right)^{\lambda} \right)\right), \\ \Delta\left(H\left(1 - \left(1 - \frac{\Delta^{-1}\left(fs_{f_1}, f\chi_1 \right)}{H} \right)^{\lambda} \right)\right) \end{array} \right\}, \lambda > 0.$$

Definition 3[71]. Let $f\delta_1 = \left\langle \left(fs_{t_1}, f\alpha_1, \right), \left(fs_{i_1}, f\beta_1 \right), \left(fs_{f_1}, f\chi_1 \right) \right\rangle$, $f\delta_2 = \left\langle \left(fs_{t_2}, f\alpha_2, \right), \left(fs_{i_2}, f\beta_2 \right), \left(fs_{f_2}, f\chi_2 \right) \right\rangle$, then the Euclidean distance is:

$$ED\left(f\delta_1, f\delta_2 \right) = \sqrt{ \frac{1}{3} \left(\begin{array}{l} \left| \frac{\Delta^{-1}\left(fs_{t_1}, f\alpha_1 \right) - \Delta^{-1}\left(fs_{t_2}, f\alpha_2 \right)}{H} \right|^2 + \left| \frac{\Delta^{-1}\left(fs_{i_1}, f\beta_1 \right) - \Delta^{-1}\left(fs_{i_2}, f\beta_2 \right)}{H} \right|^2 \\ + \left| \frac{\Delta^{-1}\left(fs_{f_1}, f\chi_1 \right) - \Delta^{-1}\left(fs_{f_2}, f\chi_2 \right)}{H} \right|^2 \end{array} \right) } \tag{2}$$

Definition 4[56]. Let $f\delta = \left\langle \left(fs_t, f\alpha, \right), \left(fs_i, f\beta \right), \left(fs_f, f\chi \right) \right\rangle$, the score and accuracy functions of $f\delta$ is elaborated:

$$SF\left(l\delta \right) = \frac{\left(2H + \Delta^{-1}\left(fs_t, f\alpha, \right) - \Delta^{-1}\left(fs_i, f\beta \right) - \Delta^{-1}\left(fs_f, f\chi \right) \right)}{3H}, SF\left(f\delta \right) \in \left[0,1 \right] \tag{3}$$

$$HF\left(l\delta \right) = \frac{1}{H}\left(\Delta^{-1}\left(fs_t, f\alpha, \right) - \Delta^{-1}\left(fs_f, f\chi \right) \right), HF\left(f\delta \right) \in \left[-1,1 \right] \tag{4}$$

For $f\delta_1$ and $f\delta_2$, then

$$(1)\ if\ SF\left(f\delta_1\right) \prec SF\left(f\delta_2\right),\ f\delta_1 \prec f\delta_2;$$
$$(2)\ if\ SF\left(f\delta_1\right) = SF\left(f\delta_2\right), HF\left(f\delta_1\right) \prec HF\left(f\delta_2\right),\ f\delta_1 \prec f\delta_2;$$
$$(3)\ if\ SF\left(f\delta_1\right) = SF\left(f\delta_2\right), HF\left(f\delta_1\right) = HF\left(f\delta_2\right),\ f\delta_1 = f\delta_2.$$

3. 2TLNN-GRA method for MADM

The 2TLNN-GRA is elaborated for MADM. Suppose m defined decision alternatives $\{DA_1, DA_2, \ldots, DA_m\}$, n given attributes $\{GO_1, GO_2, \ldots, GO_n\}$, $fw = \left(fw_1, fw_2, \cdots, fw_n\right)$ is weight GO_j, where $fw_j \in [0,1], \sum_{j=1}^{n} fw_j = 1$. The 2TLNN-GRA for MADM are elaborated.

Step 1. Elaborate the 2TLNN-matrix $F = \left[f\phi_{ij}\right]_{m\times n}$.

$$F = \left[f\phi_{ij}\right]_{m\times n} = \begin{array}{c} \\ DA_1 \\ DA_2 \\ \vdots \\ DA_m \end{array}\!\!\begin{array}{c} \begin{array}{cccc} GO_1 & GO_2 & \cdots & \mathrm{GO}_n \end{array} \\ \begin{bmatrix} f\phi_{11} & f\phi_{12} & \cdots & f\phi_{1n} \\ f\phi_{21} & f\phi_{22} & \cdots & f\phi_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ f\phi_{m1} & f\phi_{m2} & \cdots & f\phi_{mn} \end{bmatrix} \end{array} \tag{5}$$

$$f\phi_{ij} = \left\{\left(fs_{t_{ij}}, f\alpha_{ij},\right), \left(fs_{i_{ij}}, f\beta_{ij}\right), \left(fs_{f_{ij}}, f\chi_{ij}\right)\right\} \tag{6}$$

Step 2. Elaborate normalized $F = \left[f\phi_{ij}\right]_{m\times n}$ to $NF = \left[nf\phi_{ij}\right]_{m\times n}$.

Aimed at benefit decision attributes:

$$\begin{aligned} nf\phi_{ij} &= \left\{\left(nfs_{t_{ij}}, nf\alpha_{ij}\right), \left(nfs_{i_{ij}}, nf\beta_{ij}\right), \left(nfs_{f_{ij}}, nf\chi_{ij}\right)\right\} \\ &= \left\{\left(fs_{t_{ij}}, f\alpha_{ij}\right), \left(fs_{i_{ij}}, f\beta_{ij}\right), \left(fs_{f_{ij}}, f\chi_{ij}\right)\right\}, \end{aligned} \tag{7}$$

Aimed at cost decision attributes:

$$\begin{aligned} nf\phi_{ij} &= \left\{\left(nfs_{t_{ij}}, nf\alpha_{ij}\right), \left(nfs_{i_{ij}}, nf\beta_{ij}\right), \left(nfs_{f_{ij}}, nf\chi_{ij}\right)\right\} \\ &= \left\{\begin{array}{l} \Delta\left(H - \Delta^{-1}\left(fs_{t_{ij}}, f\alpha_{ij}\right)\right), \Delta\left(H - \Delta^{-1}\left(fs_{i_{ij}}, f\beta_{ij}\right)\right), \\ \Delta\left(H - \Delta^{-1}\left(fs_{f_{ij}}, f\chi_{ij}\right)\right) \end{array}\right\} \end{aligned} \tag{8}$$

Step 3. Elaborate the 2TLNN positive ideal alternative (2TLNNPIA) and 2TLNN negative ideal alternative (2TLNNNIA) with Eq. (9-14):

$$2TLNNPIA = \left\{2TLNNPIA_j\right\} \tag{9}$$

$$2TLNNNIA = \left\{ 2TLNNNIA_j \right\} \tag{10}$$

$$2TLNNPIA_j = \left\{ \left(nfs_{t_j}^{+}, nf\alpha_j^{+} \right), \left(nfs_{i_j}^{+}, nf\beta_j^{+} \right), \left(nfs_{f_j}^{+}, nf\chi_j^{+} \right) \right\}, \tag{11}$$

$$2TLNNNIA_j = \left\{ \left(nfs_{t_j}^{-}, nf\alpha_j^{-} \right), \left(nfs_{i_j}^{-}, nf\beta_j^{-} \right), \left(nfs_{f_j}^{-}, nf\chi_j^{-} \right) \right\}, \tag{12}$$

$$\begin{aligned} & SV\left\{ \left(nfs_{t_j}^{+}, nf\alpha_j^{+} \right), \left(nfs_{i_j}^{+}, nf\beta_j^{+} \right), \left(nfs_{f_j}^{+}, nf\chi_j^{+} \right) \right\} \\ & = \max_i SV\left(\left\{ \left(nfs_{t_{ij}}, nf\alpha_{ij} \right), \left(nfs_{i_{ij}}, nf\beta_{ij} \right), \left(nfs_{f_{ij}}, nf\chi_{ij} \right) \right\} \right) \end{aligned} \tag{13}$$

$$\begin{aligned} & SV\left\{ \left(nfs_{t_j}^{-}, nf\alpha_j^{-} \right), \left(nfs_{i_j}^{-}, nf\beta_j^{-} \right), \left(nfs_{f_j}^{-}, nf\chi_j^{-} \right) \right\} \\ & = \min_i SV\left(\left\{ \left(nfs_{t_{ij}}, nf\alpha_{ij} \right), \left(nfs_{i_{ij}}, nf\beta_{ij} \right), \left(nfs_{f_{ij}}, nf\chi_{ij} \right) \right\} \right) \end{aligned} \tag{14}$$

Step 4. Elaborate the grey rational coefficients (GRC) from the 2TLNNPIA and 2TLNNNIA as:

$$\begin{aligned} & 2TLNNPIAGRC\left(\xi_{ij} \right) \\ & = \frac{\min\limits_{1 \le i \le m} ED\left(nf\phi_{ij}, 2TLNNPIA_j \right) + \rho \max\limits_{1 \le i \le m} ED\left(nf\phi_{ij}, 2TLNNPIA_j \right)}{ED\left(nf\phi_{ij}, 2TLNNPIS_j \right) + \rho \max\limits_{1 \le i \le m} ED\left(nf\phi_{ij}, 2TLNNPIA_j \right)} \end{aligned} \tag{15}$$

$$\begin{aligned} & 2TLNNNIAGRC\left(\xi_{ij} \right) \\ & = \frac{\min\limits_{1 \le i \le m} ED\left(nf\phi_{ij}, 2TLNNNIA_j \right) + \rho \max\limits_{1 \le i \le m} ED\left(nf\phi_{ij}, 2TLNNNIA_j \right)}{ED\left(nf\phi_{ij}, 2TLNNNIA_j \right) + \rho \max\limits_{1 \le i \le m} ED\left(nf\phi_{ij}, 2TLNNNIA_j \right)} \end{aligned} \tag{16}$$

Step 5. Elaborate the grey relation degree (GRD) for 2TLNNPIA and 2TLNNNIA:

$$2TLNNPIAGRD\left(\xi_i \right) = \sum_{j=1}^{n} fw_j \, 2TLNNPIAGRC\left(\xi_{ij} \right) \tag{17}$$

$$2TLNNNIAGRD\left(\xi_i \right) = \sum_{j=1}^{n} fw_j \, 2TLNNNIAGRC\left(\xi_{ij} \right) \tag{18}$$

Step 6. Obtain the defined 2TLNN relative relational degree (2TLNNRRD) for 2TLNNPIA:

$$2TLNNRRD\left(\xi_i \right) = \frac{2TLNNNIAGRD\left(\xi_i \right)}{2TLNNPIAGRD\left(\xi_i \right) + 2TLNNNIAGRD\left(\xi_i \right)} \tag{19}$$

Step 7. The optimal alternative is obtained with higher $2TLNNRRD\left(\xi_i \right)$ value.

4. An example and comparisons

4.1. An example for comprehensive evaluation of USTMS

Since the invention of the automobile, human beings have continuously conducted research on urban transportation and its evaluation. In traditional urban transportation planning, the evaluation has focused on the ability and level of the transportation system to solve traffic problems. In the 1930s, since Greenshields proposed the traffic flow theory, people began to use speed, flow, density and other traffic indicators to analyze and study the traffic operation. The idea of traffic demand prediction theory is to make traffic trip OD generation prediction and traffic demand prediction by establishing the basic relationship between traffic and land use, combining with land use information, and then applying network analysis techniques to allocate traffic (shortest path traffic allocation and multi-path traffic allocation) and formulate road traffic planning schemes. With the continuous development of urban transportation, traffic problems also emerge, and in order to solve various traffic problems that appear at different development stages, different traffic development concepts are proposed one after another, and even multiple traffic development concepts appear at the same time in one period. The new transportation development concept is proposed and involved in the construction of transportation, there must be a corresponding evaluation system to judge the development status to better guide the practice. For example, green transportation and low-carbon transportation are proposed on the basis of serious traffic pollution and high carbon emissions from motor vehicles, both of which have in common the concept of focusing on the development of public transportation, reducing energy consumption and achieving environmentally friendly development. Their evaluation systems, in addition to traffic function evaluation, mainly focus on traffic demand, improvement of environmental quality, and rational use of resources. Intelligent transportation is a transportation development concept proposed in the context of serious traffic congestion and road resource scarcity, focusing on the use of information technology and sensors to achieve a highly efficient and intelligent transportation system. Its evaluation focuses on the level of road infrastructure development, the level of intelligence, etc. Nowadays, the evaluation of urban transportation system is very rich and contains many aspects: traffic impact evaluation, traffic function evaluation, road traffic infrastructure level evaluation, traffic economic benefit evaluation, environmental impact evaluation, traffic management evaluation, road traffic safety evaluation, etc., involving all aspects of transportation. Although the evaluation contents are various and diverse, the evaluation objects and evaluation purposes are the same. The evaluation objects are all urban traffic systems, and the evaluation purposes are to diagnose the current situation of urban traffic development and provide reference opinions for further development, so as to promote the benign development of urban traffic in the target direction. The problems of comprehensive evaluation of USTMS are classical MADM problems. In this elaborated section, we provide an example about comprehensive evaluation of USTMS with 2TLNN-GRA. Aimed at five possible USTMSs $DA_i\left(i=1,2,3,4,5\right)$ to be elaborated with four attributes:

①PQ is the information service level: The realization of intelligent transportation requires various types of IoT infrastructure, as well as various sensing equipment to collect traffic information. Therefore, the state of basic infrastructure directly affects the rapid development speed of intelligent transportation, which is the most basic content of intelligent transportation evaluation, and is also the key content of evaluation.

②DC is the transport infrastructure: Intelligent transportation is supported by a new generation of information technology, which gives transportation "wisdom" and provides people with "humanized" transportation information services. To provide people with "humanized" traffic information services, so the level of information services of intelligent transportation is the most important basis for judging the level of rapid development of intelligent transportation. The level of information service includes the strength of people's attention to traffic information, the diversity of government related departments to provide traffic information channels of diversity, real-time and accuracy, people's satisfaction with public transport services The level of information service includes people's attention to transportation information, the diversity, real-time and accuracy of transportation information channels provided by government departments, and people's satisfaction with public transportation services.

③SL is the green environmental protection level: Intelligent transportation inherits the advantages of green transportation, low-carbon transportation and sustainable transportation environment Environmentally friendly, reduce carbon emissions and other advantages to achieve green transportation and sustainable development of transportation. Therefore, the evaluation of green environment protection. The evaluation of green level is also an aspect of the evaluation of intelligent transportation.

④EP is the security condition evaluation: Nowadays, with the surge in the number of motor vehicles, traffic accidents occur and have a great threat to people's lives. The problem of traffic safety cannot be ignored at any time. Smart transportation provides real-time and accurate traffic information to travelers by improving road. The smart traffic can achieve traffic safety by improving road infrastructure, providing real-time and accurate traffic information to travelers, and improving vehicle design. Only by focusing on safety and reducing traffic accidents can intelligent transportation develop in a positive way.

The five possible USTMSs $DA_i\left(i=1,2,3,4,5\right)$ are to be elaborated with defined 2TLNNs under elaborated four attributes with $fw=\left(0.19,0.26,0.32,13\right)$. The 2TLNN-GRA is elaborated to cope with the comprehensive evaluation of USTMS.

Step 1. Elaborate the built 2TLNN-matrix $F=\left[f\phi_{ij}\right]_{m\times n}$ (See Table 1).

Table 1. 2TLNN matrix $F=\left[f\phi_{ij}\right]_{m\times n}$

	PQ	DC
DA_1	{(fs_3, 0.21), (fs_4, 0.03), (fs_2, 0.34)}	{(fs_3, 0.26), (fs_5, 0.12), (fs_2, 0.15)}
DA_2	{(fs_4, 0.07), (fs_1, 0.15), (fs_2, 0.27)}	{(fs_5, 0.03), (fs_3, 0.23), (fs_2, 0.15)}
DA_3	{(fs_3, 0.31), (fs_2, 0.04), (fs_5, 0.29)}	{(fs_1, 0.05), (fs_3, 0.16), (fs_4, 0.07)}
DA_4	{(fs_2, 0.31), (fs_4, 0.06), (fs_1, 0.19)}	{(fs_3, 0.04), (fs_5, 0.23), (fs_2, 0.37)}
DA_5	{(fs_2, 0.32), (fs_3, 0.14), (fs_4, 0.08)}	{(fs_4, 0.03), (fs_2, 0.06), (fs_1, 0.19)}
	SL	EP
DA_1	{(fs_5, 0.42), (fs_2, 0.07), (fs_1, 0.16)}	{(fs_2,0.13), (fs_4, 0.05), (fs_3, 0.03)}
DA_2	{(fs_4, 0.14), (fs_3, 0.08), (fs_1, 0.11)}	{(fs_4, 0.16), (fs_2, 0.24), (fs_1, 0.18)}

DA$_3$	{(fs$_1$, 0.31), (fs$_2$, 0.04), (fs$_4$, 0.03)}	{(fs$_2$, 0.06), (fs$_4$, 0.15), (fs$_5$, 0.17)}
DA$_4$	{(fs$_2$, 0.16), (fs$_2$, 0.12), (fs$_3$, 0.03)}	{(fs$_2$, 0.18), (fs$_4$, 0.09), (fs$_3$, 0.12)}
DA$_5$	{(fs$_2$, 0.32), (fs$_1$, 0.01), (fs$_5$, 0.05)}	{(fs$_2$, 0.07), (fs$_3$, 0.06), (fs$_4$, 0.09)}

Step 2. Normalize $F=\left[f\phi_{ij}\right]_{m\times n}$ to $NF=\left[nf\phi_{ij}\right]_{m\times n}$, for all the defined attributes are benefit, the defined decision normalization is omitted.

Table 2. 2TLNN matrix $NF=\left[nf\phi_{ij}\right]_{m\times n}$

	PQ	DC
DA$_1$	{(fs$_3$, 0.21), (fs$_4$, 0.03), (fs$_2$, 0.34)}	{(fs$_3$, 0.26), (fs$_5$, 0.12), (fs$_2$, 0.15)}
DA$_2$	{(fs$_4$, 0.07), (fs$_1$, 0.15), (fs$_2$, 0.27)}	{(fs$_5$, 0.03), (fs$_3$, 0.23), (fs$_2$, 0.15)}
DA$_3$	{(fs$_3$, 0.31), (fs$_2$, 0.04), (fs$_5$, 0.29)}	{(fs$_1$, 0.05), (fs$_3$, 0.16), (fs$_4$, 0.07)}
DA$_4$	{(fs$_2$, 0.31), (fs$_4$, 0.06), (fs$_1$, 0.19)}	{(fs$_3$, 0.04), (fs$_5$, 0.23), (fs$_2$, 0.37)}
DA$_5$	{(fs$_2$, 0.32), (fs$_3$, 0.14), (fs$_4$, 0.08)}	{(fs$_4$, 0.03), (fs$_2$, 0.06), (fs$_1$, 0.19)}
	SL	EP
DA$_1$	{(fs$_5$, 0.42), (fs$_2$, 0.07), (fs$_1$, 0.16)}	{(fs$_2$,0.13), (fs$_4$, 0.05), (fs$_3$, 0.03)}
DA$_2$	{(fs$_4$, 0.14), (fs$_3$, 0.08), (fs$_1$, 0.11)}	{(fs$_4$, 0.16), (fs$_2$, 0.24), (fs$_1$, 0.18)}
DA$_3$	{(fs$_1$, 0.31), (fs$_2$, 0.04), (fs$_4$, 0.03)}	{(fs$_2$, 0.06), (fs$_4$, 0.15), (fs$_5$, 0.17)}
DA$_4$	{(fs$_2$, 0.16), (fs$_2$, 0.12), (fs$_3$, 0.03)}	{(fs$_2$, 0.18), (fs$_4$, 0.09), (fs$_3$, 0.12)}
DA$_5$	{(fs$_2$, 0.32), (fs$_1$, 0.01), (fs$_5$, 0.05)}	{(fs$_2$, 0.07), (fs$_3$, 0.06), (fs$_4$, 0.09)}

Step 3. Elaborate the 2TLNNPIA and 2TLNNNIA (See Table 3).

Table 3. The 2TLNNPIS and 2TLNNNIS

	PQ	DC
2TLNNPIA	{(fs$_4$, 0.07), (fs$_1$, 0.15), (fs$_2$, 0.27)}	{(fs$_5$, 0.03), (fs$_3$, 0.23), (fs$_2$, 0.15)}
2TLNNNIA	{(fs$_2$, 0.32), (fs$_3$, 0.14), (fs$_4$, 0.08)}	{(fs$_1$, 0.05), (fs$_3$, 0.16), (fs$_4$, 0.07)}
	SL	**EP**
2TLNNPIS	{(fs$_5$, 0.42), (fs$_2$, 0.07), (fs$_1$, 0.16)}	{(fs$_4$, 0.16), (fs$_2$, 0.24), (fs$_1$, 0.18)}
2TLNNNIS	{(fs$_1$, 0.31), (fs$_2$, 0.04), (fs$_4$, 0.03)}	{(fs$_2$, 0.07), (fs$_3$, 0.06), (fs$_4$, 0.09)}

Step 4. Compute the $2TLNNPIAGRC\left(\xi_{ij}\right)$ and $2TLNNNIAGRC\left(\xi_{ij}\right)$ (See Table 4-5).

Table 4. The $2TLNNPIAGRC\left(\xi_{ij}\right)$

Alternatives	PQ	DC	SL	EP
DA$_1$	0.5902	1.0000	0.2410	0.3172
DA$_2$	0.4520	0.3420	0.3252	0.4020
DA$_3$	0.6126	0.5902	1.0000	1.0000
DA$_4$	0.4258	0.4020	0.3420	0.3908
DA$_5$	1.0000	0.3420	0.3252	0.4258

Table 5. The $2TLNNNIAGRC\left(\xi_{ij}\right)$

Alternatives	PQ	DC	SL	EP
DA$_1$	0.6493	0.4809	0.5488	0.5866
DA$_2$	0.9216	1.0000	1.0000	0.9654
DA$_3$	0.5733	0.4980	0.4654	0.5268
DA$_4$	1.0000	0.6493	0.8464	1.0000
DA$_5$	0.5607	0.5866	0.6160	0.6090

Step 5. Compute the $2TLNNPIAGRD\left(\xi_i\right)$ and $2TLNNNIAGRD\left(\xi_i\right)$ (See Table 6):

Table 6. The $2TLNNPIAGRD\left(\xi_i\right)$ and $2TLNNNIAGRD\left(\xi_i\right)$

	$2TLNNPIAGRD(\xi_i)$	$2TLNNNIAGRD(\xi_i)$
DA_1	0.3236	0.3082
DA_2	0.4420	0.5744
DA_3	0.6570	0.2912
DA_4	0.3880	0.1905
DA_5	0.4077	0.2726

Step 6. Compute the $2TLNNRRD(\xi_i)$ (See Table 7).

Table 7. The $2TLNNRRD(\xi_i)$

	$2TLNNRRD(\xi_i)$	Order
DA_1	0.5069	2
DA_2	0.5877	1
DA_3	0.3186	5
DA_4	0.3366	4
DA_5	0.4144	3

Step 7. Form $2TLNNRRD(\xi_i)$, the decision order is: $DA_2 > DA_1 > DA_5 > DA_4 > DA_3$ and DA_2 is the best USTMSs.

4.2. Comparing 2TLNN-GRA with defined 2TLNNs decision operators

The 2TLNN-GRA is fully compared with 2TLNWHM and 2TLNWDHM operator[72]. The fused information values are elaborated within Table 8.

Table 8. The comparisons with 2TLNNs operators

	2TLNWHM	2TLNWDHM
DA_1	$\{(fs_2, 0.23), (fs_2, 0.18), (fs_3, 0.12)\}$	$\{(fs_3, 0.17), (fs_5, 0.27), (fs_2, 0.42)\}$
DA_2	$\{(fs_5, 0.49), (fs_2, 0.12), (fs_1, 0.25)\}$	$\{(fs_5, 0.15), (fs_3, 0.29), (fs_2, 0.21)\}$

DA_3	{(fs_5, 0.46), (fs_2, 0.16), (fs_1, 0.21)}	{(fs_4, 0.16), (fs_2, 0.09), (fs_1, 0.23)}
DA_4	{(fs_1, 0.36), (fs_2, 0.22), (fs_4, 0.08)}	{(fs_1, 0.11), (fs_3, 0.26), (fs_4, 0.29)}
DA_5	{(fs_4, 0.18), (fs_3, 0.17), (fs_1, 0.19)}	{(fs_3, 0.28), (fs_5, 0.09), (fs_2, 0.03)}

According to score of 2TLNNs, the score is elaborated in Table 9.

Table 9. Scores of given USTMSs

	2TLNWHM	2TLNWDHM
$SF(DA_1)$	0.7494	0.4464
$SF(DA_2)$	0.8678	0.6126
$SF(DA_3)$	0.7828	0.5294
$SF(DA_4)$	0.6738	0.4259
$SF(DA_5)$	0.7635	0.5108

The order is elaborated in Table 10.

Table 10. Order by 2TLNNs operators

	order
2TLNWHM operator [72]	$DA_2 > DA_3 > DA_5 > DA_1 > DA_4$
2TLNWDHM operator [72]	$DA_2 > DA_3 > DA_5 > DA_1 > DA_4$
2TLNN-GRA method	$DA_2 > DA_1 > DA_5 > DA_4 > DA_3$

Comparing the results of the 2TLNN-GRA method with 2TLNWHM & 2TLNWDHM fused operators, the obtained results are slightly different and the chosen best USTMS is same.

5. Conclusion

With the continuous development of China's economy, people's income level is increasing, and more and more families have the ability to buy private cars, which leads to a sharp increase in the number and frequency of urban motor vehicle ownership and use, and the contradiction between the effective supply and demand of people, vehicles and roads is becoming more and more prominent, resulting in urban traffic congestion and other urban traffic problems are becoming more and more obvious. The traditional methods of alleviating traffic problems are no longer applicable to the contradiction between people's traffic demand and traffic infrastructure supply in modern times. Recently, in the context of smart cities, scholars at home and abroad have started to study smart transportation, and with rapid development of new generation technologies such as cloud computing, Internet of Things, big data and 5G, more and more scholars have started to study smart transportation, which is an important part of smart cities. The comprehensive evaluation of USTMS is the MADM. In this elaborated paper, the 2TLNN-GRA is elaborated for MADM. Finally, an example for comprehensive evaluation of USTMS was given to elaborate the 2TLNN-GRA and the elaborated comparisons are also executed to elaborate the 2TLNN-GRA. In the future works, the 2TLNN-GRA shall be applied to existed risk decision [73-76], existed selection decision[77-83] and other existed MADM under different uncertain environments[84-88].

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Received: Sep 18, 2022. Accepted: Dec 20, 2022