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 $f\delta = \{fs_i | i = 0, 1, 2, \cdots, H\}$ be the LTSs. The fs_i elaborates a possible linguistic value, and $f\delta = \{fs_0 = exceedingly\ terrible, fs_1 = very\ terrible,$ $fs_2 = terrible, fs_3 = medium, fs_4 = well, fs_5 = very\ well, fs_6 = exceedingly\ well.\}$, 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 $\Delta^{-1}(fs_t, f\alpha,), \Delta^{-1}(fs_i, f\beta), \Delta^{-1}(fs_f, f\chi) \in [0, H]$ elaborate truth membership, indeterminacy membership and falsity membership with 2-tuple linguistic decision information, $0 \leq \Delta^{-1}(fs_\alpha, f\phi) + \Delta^{-1}(fs_\beta, f\varphi) + \Delta^{-1}(fs_\chi, f\gamma) \leq 3H$.

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:

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

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

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

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

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:

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

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:

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

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

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 $\left\{DA_1, DA_2, \ldots, DA_m\right\}$, n given attributes $\left\{GO_1, GO_2, \ldots, GO_n\right\}$, $fw = \left(fw_1, fw_2, \cdots, fw_n\right)$ 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 $F = \left[f\phi_{ij}\right]_{m\times n}$.

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

$$\tag{6}$$

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

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:

$$\begin{aligned} nf\phi_{ij} &= \left\{\left(nf_{s_{t_{ij}}}, nf\alpha\right)_j, \left(nf_s\beta\right)_{ij}, \left(nfs\chi\right)_{ij}\right\} \\ &= \left\{\left(fs_{i_{ij}}, f\alpha_i\right), \left(fs_{f_{ij}}, f\beta\right)_{ij}, \left(fs_{f_{ij}}, \chi\right)\right\}_{ij}, \end{aligned} \tag{7}$$

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 $DA_i (i = 1, 2, 3, 4, 5)$ 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).

<div align="center">

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

</div>

	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	{(fs₄, 0.07), (fs₁, 0.15), (fs₂, 0.27)}	{(fs₅, 0.03), (fs₃, 0.23), (fs₂, 0.15)}
2TLNNNIA	{(fs₂, 0.32), (fs₃, 0.14), (fs₄, 0.08)}	{(fs₁, 0.05), (fs₃, 0.16), (fs₄, 0.07)}

	SL	EP
2TLNNPIS	{(fs₅, 0.42), (fs₂, 0.07), (fs₁, 0.16)}	{(fs₄, 0.16), (fs₂, 0.24), (fs₁, 0.18)}
2TLNNNIS	{(fs₁, 0.31), (fs₂, 0.04), (fs₄, 0.03)}	{(fs₂, 0.07), (fs₃, 0.06), (fs₄, 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
DA₁	0.5902	1.0000	0.2410	0.3172
DA₂	0.4520	0.3420	0.3252	0.4020
DA₃	0.6126	0.5902	1.0000	1.0000
DA₄	0.4258	0.4020	0.3420	0.3908
DA₅	1.0000	0.3420	0.3252	0.4258

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

Alternatives	PQ	DC	SL	EP
DA₁	0.6493	0.4809	0.5488	0.5866
DA₂	0.9216	1.0000	1.0000	0.9654
DA₃	0.5733	0.4980	0.4654	0.5268
DA₄	1.0000	0.6493	0.8464	1.0000
DA₅	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 $2TLNNNIAGRD\left(\xi_i\right)$

	$2TLNNPIAGRD(\xi_i)$	$2TLNNNIAGRD(\xi_i)$
DA₁	0.3236	0.3082
DA₂	0.4420	0.5744
DA₃	0.6570	0.2912
DA₄	0.3880	0.1905
DA₅	0.4077	0.2726

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

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

	$2TLNNRRD(\xi_i)$	Order
DA₁	0.5069	2
DA₂	0.5877	1
DA₃	0.3186	5
DA₄	0.3366	4
DA₅	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
DA₁	{(fs₂, 0.23), (fs₂, 0.18), (fs₃, 0.12)}	{(fs₃, 0.17), (fs₅, 0.27), (fs₂, 0.42)}
DA₂	{(fs₅, 0.49), (fs₂, 0.12), (fs₁, 0.25)}	{(fs₅, 0.15), (fs₃, 0.29), (fs₂, 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].

References

[1] C. Parkan, M.L. Wu, On the equivalence of operational performance measurement and multiple attribute decision making, International Journal of Production Research, 35 (1997) 2963-2988.

[2] N. Gayathri , Dr. M. Helen , P. Mounika, Utilization of Jaccard Index Measures on Multiple Attribute Group Decision Making under Neutrosophic Environment, International Journal of Neutrosophic Science, Vol. 3 , No. 2 , (2020) : 67-77

[3] R. Bisdorff, M. Roubens, Choice procedures in pairwise comparison multiple-attribute decision making methods, in: R. Berghammer, B. Moller, G. Struth (Eds.) Relational and Kleene-Algebraic Methods in Computer Science, Springer-Verlag Berlin, Berlin, 2003, pp. 1-7.

[4] M. Riaz, H. Garg, H.M.A. Farid, R. Chinram, Multi-Criteria Decision Making Based on Bipolar Picture Fuzzy Operators and New Distance Measures, Cmes-Computer Modeling in Engineering & Sciences, 127 (2021) 771-800.

[5] H. Garg, D. Rani, Novel distance measures for intuitionistic fuzzy sets based on various triangle centers of isosceles triangular fuzzy numbers and their applications, Expert Systems with Applications, 191 (2022) 20.

[6] H. Garg, J. Vimala, S. Rajareega, D. Preethi, L. Perez-Dominguez, Complex intuitionistic fuzzy soft SWARA - COPRAS approach: An application of ERP software selection, Aims Mathematics, 7 (2022) 5895-5909.

[7] X.D. Peng, H. Garg, Intuitionistic fuzzy soft decision making method based on CoCoSo and CRITIC for CCN cache placement strategy selection, Artificial Intelligence Review, 55 (2022) 1567-1604.

[8] F.L. Ren, M.M. Kong, Z. Pei, A New Hesitant Fuzzy Linguistic TOPSIS Method for Group Multi-Criteria Linguistic Decision Making, Symmetry-Basel, 9 (2017) 19.

[9] Z.M. Zhang, Multi-criteria group decision-making methods based on new intuitionistic fuzzy Einstein hybrid weighted aggregation operators, Neural Computing & Applications, 28 (2017) 3781-3800.

[10] A. Kanchana , D.Nagarajan , Broumi Said, Neutrosophic approach to Dynamic Programming on group Decision Making problems, International Journal of Neutrosophic Science, Vol. 19 , No. 2 , (2022) : 57-65

[11] B. Ning, G. Wei, R. Lin, Y. Guo, A novel MADM technique based on extended power generalized Maclaurin symmetric mean operators under probabilistic dual hesitant fuzzy setting and its application to sustainable suppliers selection, Expert Systems with Applications, 204 (2022) 117419.

[12] H. Zhang, G. Wei, X. Chen, SF-GRA method based on cumulative prospect theory for multiple attribute group decision making and its application to emergency supplies supplier selection, Engineering Applications of Artificial Intelligence, 110 (2022) 104679.

[13] M. Zhao, H. Gao, G. Wei, C. Wei, Y. Guo, Model for network security service provider selection with probabilistic uncertain linguistic TODIM method based on prospect theory, Technological and Economic Development of Economy, 28 (2022) 638–654.

[14] S.P. Wan, D.F. Li, Fuzzy LINMAP approach to heterogeneous MADM considering comparisons of alternatives with hesitation degrees, Omega-International Journal of Management Science, 41 (2013) 925-940.

[15] S.P. Wan, D.F. Li, Possibility mean and variance based method for multi-attribute decision making with triangular intuitionistic fuzzy numbers, Journal of Intelligent & Fuzzy Systems, 24 (2013) 743-754.

[16] S.P. Wan, D.F. Li, Z.F. Rui, Possibility mean, variance and covariance of triangular intuitionistic fuzzy numbers, Journal of Intelligent & Fuzzy Systems, 24 (2013) 847-858.

[17] J. Ye, Multiple attribute group decision-making method with completely unknown weights based on

similarity measures under single valued neutrosophic environment, Journal of Intelligent & Fuzzy Systems, 27 (2014) 2927-2935.

[18] A. Fahmi, F. Amin, M. Khan, F. Smarandache, Group Decision Making Based on Triangular Neutrosophic Cubic Fuzzy Einstein Hybrid Weighted Averaging Operators, Symmetry-Basel, 11 (2019) 29.

[19] M.W. Zhao, G.W. Wei, J. Wu, Y.F. Guo, C. Wei, TODIM method for multiple attribute group decision making based on cumulative prospect theory with 2-tuple linguistic neutrosophic sets, International Journal of Intelligent Systems, 36 (2021) 1199-1222.

[20] Y.G. Xue, Y. Deng, Decision making under measure-based granular uncertainty with intuitionistic fuzzy sets, Applied Intelligence, 51 (2021) 6224-6233.

[21] O. Yakrangi, R.S.J. Pazmino, J.S. Cely, A. Rodriguez, C.G.E. Cena, P.S. Carrillo, J. De La Cueva, A. Shapiro, An Intelligent Algorithm for Decision Making System and Control of the GEMMA Guide Paradigm Using the Fuzzy Petri Nets Approach, Electronics, 10 (2021) 18.

[22] Z.Y. Yang, L.Y. Zhang, T. Li, Group decision making with incomplete interval-valued q-rung orthopair fuzzy preference relations, International Journal of Intelligent Systems, 36 (2021) 7274-7308.

[23] M. Palanikumar , Said Broumi, Square root Diophantine neutrosophic normal interval-valued sets and their aggregated operators in application to multiple attribute decision making, International Journal of Neutrosophic Science, Vol. 19 , No. 3 , (2022) : 63-

[24] S.Z. Zeng, Y.J. Hu, X.Y. Xie, Q-rung orthopair fuzzy weighted induced logarithmic distance measures and their application in multiple attribute decision making, Engineering Applications of Artificial Intelligence, 100 (2021) 7.

[25] K. Zhang, J.M. Zhan, W.Z. Wu, On Multicriteria Decision-Making Method Based on a Fuzzy Rough Set Model With Fuzzy alpha-Neighborhoods, Ieee Transactions on Fuzzy Systems, 29 (2021) 2491-2505.

[26] S.L. Zhang, F.Y. Meng, A group decision making method with intuitionistic triangular fuzzy preference relations and its application, Applied Intelligence, 51 (2021) 2556-2573.

[27] Z. Zhang, J.L. Gao, Y. Gao, W.Y. Yu, Two-sided matching decision making with multi-granular hesitant fuzzy linguistic term sets and incomplete criteria weight information, Expert Systems with Applications, 168 (2021) 12.

[28] D. Zindani, S.R. Maity, S. Bhowmik, Complex interval-valued intuitionistic fuzzy TODIM approach and its

application to group decision making, Journal of Ambient Intelligence and Humanized Computing, 12 (2021) 2079-2102.

[29] Q.T. Zuo, J.H. Guo, J.X. Ma, G.T. Cui, R.X. Yang, L. Yu, Assessment of regional-scale water resources carrying capacity based on fuzzy multiple attribute decision-making and scenario simulation, Ecological Indicators, 130 (2021) 10.

[30] S.K. De, B. Roy, K. Bhattacharya, Solving an EPQ model with doubt fuzzy set: A robust intelligent decision-making approach, Knowledge-Based Systems, 235 (2022) 17.

[31] T.K. Paul, M. Pal, C. Jana, Portfolio selection as a multicriteria group decision making in Pythagorean fuzzy environment with GRA and FAHP framework, International Journal of Intelligent Systems, 37 (2022) 478-515.

[32] J.D. Rasinger, F. Frenzel, A. Braeuning, A. Bernhard, R. Ornsrud, S. Merel, M.H.G. Berntssen, Use of (Q)SAR genotoxicity predictions and fuzzy multicriteria decision-making for priority ranking of ethoxyquin transformation products, Environment International, 158 (2022) 9.

[33] K. Atanassov, G. Gargov, Interval valued intuitionistic fuzzy-sets, Fuzzy Sets and Systems, 31 (1989) 343-349.

[34] K.T. Atanassov, More on intuitionistic fuzzy-sets, Fuzzy Sets and Systems, 33 (1989) 37-45.

[35] E. Szmidt, J. Kacprzyk, Using intuitionistic fuzzy sets in group decision making, Control and Cybernetics, 31 (2002) 1037-1053.

[36] K. Atanassov, G. Pasi, R. Yager, Intuitionistic fuzzy interpretations of multi-criteria multi-person and multi-measurement tool decision making, International Journal of Systems Science, 36 (2005) 859-868.

[37] T. Rashid, S. Faizi, Z.S. Xu, S. Zafar, ELECTRE-Based Outranking Method for Multi-criteria Decision Making Using Hesitant Intuitionistic Fuzzy Linguistic Term Sets, International Journal of Fuzzy Systems, 20 (2018) 78-92.

[38] I. Silambarasan , R. Udhayakumar , Florentin Smarandache , Said Broumi, Some Algebraic structures of Neutrosophic fuzzy sets, International Journal of Neutrosophic Science, Vol. 19 , No. 2 , (2022) : 30-41

[39] G. Sirbiladze, I. Khutsishvili, O. Badagadze, G. Tsulaia, ASSOCIATED PROBABILITY INTUITIONISTIC FUZZY WEIGHTED OPERATORS IN BUSINESS START-UP DECISION MAKING, Iranian Journal of Fuzzy Systems, 15 (2018) 1-25.

[40] T.R. Sooraj, R.K. Mohanty, B.K. Tripathy, A New Approach to Interval-Valued Intuitionistic Hesitant Fuzzy Soft Sets and Their Application in Decision Making, in: S.C. Satapathy, V. Bhateja, S. Das (Eds.) Smart

Computing and Informatics, 2018, pp. 243-253.

[41] Q.F. Wang, H.N. Sun, Interval-Valued Intuitionistic Fuzzy Einstein Geometric Choquet Integral Operator and Its Application to Multiattribute Group Decision-Making, Mathematical Problems in Engineering, (2018).

[42] S. Zhang, N.B. Wang, H. Liu, Approaches to Multiple Attribute Decision Making with the Intuitionistic Fuzzy Information and Their Applications to User Activities Reliability Evaluation, Proceedings of the National Academy of Sciences India Section a-Physical Sciences, 88 (2018) 89-94.

[43] S. Cali, S.Y. Balaman, A novel outranking based multi criteria group decision making methodology integrating ELECTRE and VIKOR under intuitionistic fuzzy environment, Expert Systems with Applications, 119 (2019) 36-50.

[44] F. Smarandache, A unifying field in logics: Neutrosophic logic, Multiple-Valued Logic, 8 (1999).

[45] H. Wang, F. Smarandache, Y. Zhang, R. Sunderraman, single-valued neutrosophic sets, Multispace and Multistructure, 4 (2010) 410-413.

[46] S. Broumi, M. Talea, F. Smarandache, A. Bakali, Ieee, Decision-Making Method based on the Interval Valued Neutrosophic Graph, in: Future Technologies Conference (FTC), Ieee, San Francisco, CA, 2016, pp. 44-50.

[47] A. Elhassouny, F. Smarandache, Ieee, Neutrosophic-simplified-TOPSIS Multi-Criteria Decision-Making using combined Simplified-TOPSIS method and Neutrosophics, in: IEEE International Conference on Fuzzy Systems (FUZZ-IEEE) held as part of IEEE World Congress on Computational Intelligence (IEEE WCCI), Ieee, Vancouver, CANADA, 2016, pp. 2468-2474.

[48] M. Teodorescu, D. Gifu, F. Smarandache, Ieee, Maintenance Operating System Uncertainties Approached through Neutrosophic Theory, in: IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Ieee, Vancouver, CANADA, 2016, pp. 2452-2459.

[49] M. Abdel-Basset, M. Mohamed, F. Smarandache, A Hybrid Neutrosophic Group ANP-TOPSIS Framework for Supplier Selection Problems, Symmetry-Basel, 10 (2018) 22.

[50] M. Abdel-Basset, M. Mohamed, F. Smarandache, An Extension of Neutrosophic AHP-SWOT Analysis for Strategic Planning and Decision-Making, Symmetry-Basel, 10 (2018) 18.

[51] M. Abdel-Basset, M. Mohamed, F. Smarandache, V. Chang, Neutrosophic Association Rule Mining Algorithm for Big Data Analysis, Symmetry-Basel, 10 (2018) 19.

[52] R.M. Hashim, M. Gulistan, F. Smarandache, Applications of Neutrosophic Bipolar Fuzzy Sets in HOPE

Foundation for Planning to Build a Children Hospital with Different Types of Similarity Measures, Symmetry-Basel, 10 (2018) 26.

[53] M.A. Al Shumrani, S. Topal, F. Smarandache, C. Ozel, Covering-Based Rough Fuzzy, Intuitionistic Fuzzy and Neutrosophic Nano Topology and Applications, Ieee Access, 7 (2019) 172839-172846.

[54] X.D. Peng, F. Smarandache, Novel neutrosophic Dombi Bonferroni mean operators with mobile cloud computing industry evaluation, Expert Systems, 36 (2019) 22.

[55] D. Stanujkic, D. Karabasevic, F. Smarandache, E.K. Zavadskas, M. Maksimovic, AN INNOVATIVE APPROACH TO EVALUATION OF THE QUALITY OF WEBSITES IN THE TOURISM INDUSTRY: A NOVEL MCDM APPROACH BASED ON BIPOLAR NEUTROSOPHIC NUMBERS AND THE HAMMING DISTANCE, Transformations in Business & Economics, 18 (2019) 149-162.

[56] J. Wang, G.W. Wei, Y. Wei, Models for green supplier selection with some 2-tuple linguistic neutrosophic number Bonferroni mean operators, Symmetry-Basel, 10 (2018) 36.

[57] F. Herrera, L. Martinez, An approach for combining linguistic and numerical information based on the 2-tuple fuzzy linguistic representation model in decision-making, International Journal of Uncertainty Fuzziness and Knowledge-Based Systems, 8 (2000) 539-562.

[58] F. Herrera, L. Martinez, The 2-tuple linguistic computational model. Advantages of its linguistic description, accuracy and consistency, International Journal of Uncertainty Fuzziness and Knowledge-Based Systems, 9 (2001) 33-48.

[59] F. Herrera, L. Martinez, A model based on linguistic 2-tuples for dealing with multigranular hierarchical linguistic contexts in multi-expert decision-making, Ieee Transactions on Systems Man and Cybernetics Part B-Cybernetics, 31 (2001) 227-234.

[60] E. Herrera-Viedma, A.G. Lopez-Herrera, M. Luque, C. Porcel, A fuzzy linguistic IRS model based on a 2-tuple fuzzy linguistic approach, International Journal of Uncertainty Fuzziness and Knowledge-Based Systems, 15 (2007) 225-250.

[61] R.M. Hachicha, E. Dafaoui, A. El Mhamedi, Competence evaluation approach based on 2-tuple linguistic representation model, in: IEEE 16th International Conference on Industrial Engineering and Engineering Management, Ieee, Beijing, PEOPLES R CHINA, 2009, pp. 879-884.

[62] C.M. Mi, S.F. Liu, Y.G. Dang, J.L. Wang, Z.P. Wu, Ieee, Study on 2-tuple Linguistic Assessment Method based

on Grey Cluster with Incomplete Attribute Weight Information, in: IEEE International Conference on Systems, Man and Cybernetics, Ieee, San Antonio, TX, 2009, pp. 1593-1597.

[63] J.M. Moreno, J.M.M. del Castillo, C. Porcel, E. Herrera-Viedma, A quality evaluation methodology for health-related websites based on a 2-tuple fuzzy linguistic approach, Soft Computing, 14 (2010) 887-897.

[64] J.L. Deng, Introduction to Grey System, The Journal of Grey System, 1 (1989) 1-24.

[65] Y.R. Yang, H.C. Wang, Y.H. Xin, Grey relational analysis model software quality assessment with triangular fuzzy information, International Journal of Knowledge-Based and Intelligent Engineering Systems, 21 (2017) 97-102.

[66] G.D. Sun, X. Guan, X. Yi, Z. Zhou, Grey relational analysis between hesitant fuzzy sets with applications to pattern recognition, Expert Systems with Applications, 92 (2018) 521-532.

[67] S. Diba, N.M. Xie, Sustainable supplier selection for Satrec Vitalait Milk Company in Senegal using the novel grey relational analysis method, Grey Systems-Theory and Application, 9 (2019) 262-294.

[68] H.C. Ding, M.R. Lian, X.Y. Chen, J.M. Liu, Z.C. Zhong, Y.F. Zhang, M.Y. Zhou, Research on the correlation of port logistics and regional economic growth base on gray relational analysis method, Concurrency and Computation-Practice & Experience, 31 (2019) 8.

[69] D.C. Liang, A.P. Darko, Z.S. Xu, Pythagorean Fuzzy Partitioned Geometric Bonferroni Mean and Its Application to Multi-criteria Group Decision Making with Grey Relational Analysis, International Journal of Fuzzy Systems, 21 (2019) 115-128.

[70] H.C. Huang, T.F. Tsai, Y.M. Subeq, Using grey relational analysis and grey integrated multi-objective strategy to evaluate the risk factors of falling of aboriginal elders in Taiwan, Soft Computing, 24 (2020) 8097-8112.

[71] J. Wang, G.W. Wei, M. Lu, TODIM method for multiple attribute group decision making under 2-tuple linguistic neutrosophic environment, Symmetry-Basel, 10 (2018) 486.

[72] S.J. Wu, J. Wang, G.W. Wei, Y. Wei, Research on Construction Engineering Project Risk Assessment with Some 2-Tuple Linguistic Neutrosophic Hamy Mean Operators, Sustainability, 10 (2018).

[73] H.C. Liu, J.X. You, X.J. Fan, Q.L. Lin, Failure mode and effects analysis using D numbers and grey relational projection method, Expert Systems with Applications, 41 (2014) 4670-4679.

[74] D.G. Rand, Z.G. Epstein, Risking Your Life without a Second Thought: Intuitive Decision-Making and

Extreme Altruism, Plos One, 9 (2014) 6.

[75] O. Taylan, A.O. Bafail, R.M.S. Abdulaal, M.R. Kabli, Construction projects selection and risk assessment by fuzzy AHP and fuzzy TOPSIS methodologies, Applied Soft Computing, 17 (2014) 105-116.

[76] P. Chemweno, L. Pintelon, A. Van Horenbeek, P. Muchiri, Development of a risk assessment selection methodology for asset maintenance decision making: An analytic network process (ANP) approach, International Journal of Production Economics, 170 (2015) 663-676.

[77] T. Rashid, I. Beg, S.M. Husnine, Robot selection by using generalized interval-valued fuzzy numbers with TOPSIS, Applied Soft Computing, 21 (2014) 462-468.

[78] J. Rezaei, P.B.M. Fahim, L. Tavasszy, Supplier selection in the airline retail industry using a funnel methodology: Conjunctive screening method and fuzzy AHP, Expert Systems with Applications, 41 (2014) 8165-8179.

[79] S. Shariati, A. Yazdani-Chamzini, A. Salsani, J. Tamosaitiene, Proposing a New Model for Waste Dump Site Selection: Case Study of Ayerma Phosphate Mine, Inzinerine Ekonomika-Engineering Economics, 25 (2014) 410-419.

[80] M.H. Shu, H.C. Wu, Supplier Evaluation and Selection Based on Stochastic Dominance: A Quality-Based Approach, Communications in Statistics-Theory and Methods, 43 (2014) 2907-2922.

[81] Z.F. Tan, L.W. Ju, X.B. Yu, H.J. Zhang, C. Yu, Selection Ideal Coal Suppliers of Thermal Power Plants Using the Matter-Element Extension Model with Integrated Empowerment Method for Sustainability, Mathematical Problems in Engineering, 2014 (2014) 11.

[82] L.Z. Tong, J.D. Wang, J.J. Yi, Sustainable Textile and Apparel Enterprise Supplier Selection Research, AATCC J. Res., 8 (2021) 46-53.

[83] R. Umer, M. Touqeer, A.H. Omar, A. Ahmadian, S. Salahshour, M. Ferrara, Selection of solar tracking system using extended TOPSIS technique with interval type-2 pythagorean fuzzy numbers, Optimization and Engineering, 22 (2021) 2205-2231.

[84] A. Mishra, A. Kumar, S.S. Appadoo, Commentary on "D-Intuitionistic Hesitant Fuzzy Sets and Their Application in Multiple Attribute Decision Making", Cognitive Computation, 13 (2021) 1047-1048.

[85] A. Mousazadeh, M. Kafaee, M. Ashraf, Ranking of commercial photodiodes in radiation detection using multiple-attribute decision making approach, Nucl. Instrum. Methods Phys. Res. Sect. A-Accel. Spectrom.

Dect. Assoc. Equip., 987 (2021) 5.

[86] M. Talafha, A. Alkouri, S. Alqaraleh, H. Zureigat, A. Aljarrah, Complex hesitant fuzzy sets and its applications in multiple attributes decision-making problems, Journal of Intelligent & Fuzzy Systems, 41 (2021) 7299-7327.

[87] G.L. Tang, X.Y. Zhao, Z.Y. Zhao, J.J. Yu, L. Guo, Y.H. Wang, Simulation-based Fuzzy Multiple Attribute Decision Making framework for an optimal apron layout for aRoll-on/Roll-off/Passenger terminal considering passenger service quality, Simulation-Transactions of the Society for Modeling and Simulation International, 97 (2021) 451-471.

[88] A. Varmaghani, A.M. Nazar, M. Ahmadi, A. Sharifi, S.J. Ghoushchi, Y. Pourasad, DMTC: Optimize Energy Consumption in Dynamic Wireless Sensor Network Based on Fog Computing and Fuzzy Multiple Attribute Decision-Making, Wireless Communications & Mobile Computing, 2021 (2021) 14.