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Enhancing Multiple-Attribute Decision-Making Framework for Talent Cultivation Quality Evaluation Through Using Weighted Dual Hamy Mean and Prioritized Aggregation Operators

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Abstract: With the rapid development of the economy and the transformation and upgrading of industrial structure, universities have increased their focus on theoretical knowledge and application, actively providing practical platforms for students, enriching the connection between theoretical knowledge and practice, deepening the reform of quality education, constructing a modern education system, and ensuring that students can adapt their professional skills to the requirements of industry technology in the field of computer information. Cultivating high-quality computer information talents can not only promote better employment for students, but also promote the development of computer information education in universities. The talent cultivation quality evaluation in practical aspects of computer information major is looked as the multiple-attribute decision-making (MADM) issue. In this paper, we extended the weighted dual Hamy mean (WDHM) operator and prioritized aggregation (PA) operator to 2-tuple linguistic neutrosophic sets (2TLNSs) to propose the 2-tuple linguistic neutrosophic prioritized WDHM (2TLNPWDHM) operator. Finally, a numerical example for talent cultivation quality evaluation in practical aspects of computer information major is employed to verify the 2TLNPWDHM operator. The main contributions of this study are summarized: (1) the 2TLNPWDHM operator is built; (2) the 2TLNPWDHM operator is designed to cope with the MADM with 2TLNNs; (3) a numerical example for talent cultivation quality evaluation in practical aspects of computer information major is supplied to proof the designed method; (4) some comparative studies are utilized to verify the rationality of the 2TLNPDHM.

Keywords: Multiple-attribute decision-making (MADM); 2TLNSs; 2TLNPWDHM; talent cultivation quality evaluation; computer information major

1. Introduction

Focusing on national strategies such as Made in China 2025 and Artificial Intelligence 2.0, as well as the industrial transformation and upgrading of the old industrial base in Northeast China, as well as the demand for high-quality skilled talents in emerging industries such as the Internet of Things, big data, and cloud computing, we will promote the deep integration of emerging technologies and computer information science and technology professional knowledge, abilities, and qualities. Starting from existing professional advantages, we will integrate resources, thoroughly analyze the gap between the existing talent training programs in the field of Computer Information Science and technology and the requirements of new engineering construction, develop talent training programs that are suitable for the transformation and upgrading of traditional industries and the cultivation and development of emerging industries, clarify training objectives, scientifically design curriculum systems, increase the proportion of practical courses, improve innovation and entrepreneurship levels, and actively adapt to the requirements of new engineering construction[1, 2]. Cultivate composite high-quality new engineering talents with a solid theoretical foundation, strong practical innovation ability, and international competitiveness. Professional construction should be integrated with industry, and talent cultivation should be combined with job positions, so that computer information technology can better serve other majors. Adhere to the educational philosophy of "student-centered, outcome oriented, and continuous improvement", fully implement the fundamental task of "cultivating virtue and nurturing talents", adhere to the principle of "people-oriented", promote the "four returns", and form a "highly unified foundation and major, organic integration of theory and practice, deep integration of science and technology, close cooperation between universities and enterprises, and complementary advantages between domestic and foreign"[3, 4]. The excellent talent training model and practical talent training system for computer information science and technology promote the integration of industry and education, joint construction and sharing, and international cooperation, achieving deep integration of educational elements, and actively promoting the construction of new engineering disciplines in computer information science and technology. Construct a talent training program for computer information science and technology, continuously strengthen the construction of professional connotation, integrate ideological education, vocational quality education, and innovation and entrepreneurship education into the talent training process, scientifically construct a curriculum teaching system, and through interdisciplinary cooperation, personalized mentor system training, and school enterprise collaborative education practice mechanism innovation, build a talent training system that integrates disciplines and collaborates on education[5, 6]. Emphasize the connection between profession and industry, and face the needs of the industry; Emphasis should be placed on interdisciplinary studies, with a focus on the intersection of computer information science and technology with computer science, big data, communication, artificial intelligence, biomedical and other disciplines, and the cultivation of versatile talents should be strengthened; Emphasize the cultivation of students' innovation and entrepreneurship abilities, cultivate high-quality specialized talents with innovative abilities and awareness, entrepreneurial spirit, and the courage to engage in practice; Emphasize student-centered, personalized curriculum system with multiple modules, and implement a mentor system and small class teaching system; Implementing the fundamental task of cultivating virtue and talent, strengthening the construction of ideological and political education in the curriculum, and emphasizing the cultivation of patriotism; Based on the characteristics of interdisciplinary integration, intensive knowledge of new technologies, and strong engineering applications in the field of computer information science and technology, the positioning of cultivating innovative talents with a wide range of perspectives is clarified, and a talent training plan that applies what is learned is formed, highlighting the applicability and practicality of the discipline, and further improving the quality of talent training. Develop a student-centered and results oriented professional training program, and promote interdisciplinary training models.

Integrating multiple fields such as computers, communication, and computer, highlighting the penetration and integration of science and engineering[7]. Thick foundation and wide caliber, serving the main battlefield of national economic information technology; Emphasize cross cutting and strong innovation, facing major strategic needs in the field of national computer information; To cultivate scientists, engineers, and industry elites with a solid knowledge foundation and professional skills in computer information science and technology, comprehensive development in morality, intelligence, physical fitness, aesthetics, and labor, a strong sense of patriotism and social responsibility, and excellent comprehensive qualities[8]. Highlighting the education and teaching philosophy of "student-centered", closely following the development trend of computer technology, with the goal of serving the Internet of Things, big data, cloud computing, artificial intelligence and other directions, adhering to the principles of "emphasizing foundation, strengthening practice, focusing on innovation, and showcasing individuality", and closely surrounding the "gender equality" standard, constructing a curriculum system based on the basic idea of "basic platform module+characteristic innovation module+independent personalized module"[9, 10]. Increase the proportion of practical courses, strengthen the cultivation of students' practical skills, and enable talent cultivation to adapt to diverse social needs. Strengthen the construction of "golden courses", form a shared and integrated curriculum construction system, and continue to play the exemplary and leading role of high-quality courses in curriculum ideological and political education, blended teaching, and research feedback teaching[11]. Open a batch of new courses that reflect the latest developments in industry and technology, and enhance the support of the courses for professional training goals and graduation requirements[12, 13]. Strengthen the construction of practical teaching centers, invest sufficient funds to improve the hardware conditions of practical teaching; Closely cooperate with theoretical teaching and set up supporting experimental courses for important foundational and professional courses; Offering large-scale comprehensive experimental courses that are relatively independent and involve several theoretical courses[14]; Building a universal platform for basic experiments for lower grade undergraduate students, a professional experimental platform for higher grade undergraduate students, and a high-end platform for comprehensive experiments for undergraduate and graduate students; Organize students to participate in the college's series of scientific research lectures and academic seminars, expanding their scientific and technological perspectives; Encourage students to enter research teams in advance and actively participate in research training; Encourage teachers to transform research content into innovative training projects and graduation project topics, open to students, stimulate their research enthusiasm, and enhance their research practical abilities[15-17]; Strengthen extracurricular practical training, establish open laboratories, add "open innovation experimental projects" and "college student innovation and entrepreneurship training projects", actively organize students to participate in various levels of "science and technology competitions", replace practice with competitions, apply what is learned, and improve students' innovation awareness and hands-on practical ability at multiple levels and aspects. By participating in practical activities such as scientific research projects, various subject competitions, and college student innovation and entrepreneurship training programs, we can quickly enhance students' innovation and practical abilities, cultivate high-quality innovation and entrepreneurship talents for the computer information science and technology industry, and truly achieve a training model that combines theory and practice[16].

Decision making is one of the most common activities in daily life [18-21]. The key to information driven MADM lies in the management of decision information, including the expression, transformation and integration of information[22-24]. When using MADM theory to solve decision-making issues, it is first necessary to portray the decision information through an appropriate way [25-29]. Then, Zadeh [30] devised the fuzzy sets(FSs) to portray uncertain information. Smarandache [31] devised the neutrosophic sets (NSs). The SVNSs [32] and INSs [33] were devised for uncertain MADM. Wang et al. [34] came up with the 2TLNSs which the portrayed information is portrayed through 2TLs[35-37]. The 2TLNSs

[34] integrate the advantages of the single-values neutrosophic sets (SVNSs) [38] and 2-tuple linguistic information representation model[35-37]. Wang et al. [39] came up with CODAS model to solve the MAGDM under 2TLNSs. Wu et al. [40] came up with the Hamy mean information models for 2TLNNs.

The talent cultivation quality evaluation in practical aspects of computer information major is looked as the MADM) issue. The PA operator [41] could prioritization relationship among the attributes and WDHM operator [40] could consider the interrelationship of the futilized arguments. The 2TLNSs [34] integrate the advantages of the single-values neutrosophic sets (SVNSs) [38] and 2-tuple linguistic model[35-37], which can effectively portray and describe uncertain information during the talent cultivation quality evaluation in practical aspects of computer information major. In order to take the full use of these two kinds of operators, in this paper, we combine the WDHM operator and PA operator with 2TLNSs to propose the 2TLNPWDHM operator. The 2TLNPWDHM could consider the prioritization among the attributes and it could also consider the relationships between the attributes and could effectively avoid the problem of information loss in the process of talent cultivation quality evaluation in practical aspects of computer information major. Then, the 2TLNPWDHM operator is utilized to handle MADM with 2TLNS. Finally, taking the talent cultivation quality evaluation in practical aspects of computer information major as an example, the proposed method is verified. The main aim and research motivation of this study are summarized as (1) the WDHM operator and PA operator are utilized to derive the 2TLNPWDHM operator under 2TLNSs; (2) the 2TLNPWDHM operator is developed for the MADM under 2TLNSs, (3) a numerical study is provided for talent cultivation quality evaluation in practical aspects of computer information major to demonstrate the 2TLNPWDHM, and (4) some comparative studies are provided to justify the 2TLNPWDHM operator.

Then, the research structure is outlined. In Sect. 2, the concept of 2TLNSs is introduced. In Sect. 3, the 2TLNPWDHM operator is designed for MADM. In Sect. 4, a numerical example is utilized to solve the talent cultivation quality evaluation in practical aspects of computer information major. Sect. 5 concludes this study.

2. Preliminaries

Wang et al. [34] constructed the 2TLNSs.

2.1. 2TLSs

Definition 1[35]. Let $ys_1, ys_2, \ldots, ys_Z$ be linguistic variables. The ys is derived:

$$ys = \begin{Bmatrix} ys_0 = extremely\ poor, ys_1 = very\ poor, ys_2 = poor, ys_3 = medium, \\ ys_4 = good, ys_5 = very\ good, ys_6 = extremely\ good. \end{Bmatrix}$$

Definition 2[35]. Let $ys = \{ys_i \,|\, i = 0,1,2,\cdots,Y\}$ and $\beta \in [0, H]$ is the linguistic symbolic value. The Δ is employed to derive the 2-tuple linguistic equivalent to β in Eq. (1)-Eq. (2):

$$\Delta\text{:}[0,Y] \to ys \times [-0.5, 0.5), \tag{1}$$

$$\Delta(\beta) = \begin{cases} ys_i,\ i = round(\beta) \\ \alpha = \beta - i, \quad \alpha \in [-0.5, 0.5) \end{cases}, \tag{2}$$

where round(.) is the round operation.

Definition 3[35]. Let $ys = \{ys_i \,|\, i = 0,1,2,\cdots,Y\}$ be a LTSs and (ys_i, α) be a 2-tuple. The function Δ^{-1} returns the numerical information $\beta \in [0, Y] \subset R$ in Eq. (3)-Eq.(4).

$$\Delta^{-1}: \ ys \times [-0.5, 0.5) \to [0, Y], \tag{3}$$

$$\Delta^{-1}(ys_i, \alpha) = i + \alpha = \beta, \tag{4}$$

2.2. SVNSs

Definition 4[32]. The SVNSs is derived in Eq. (5):

$$y\beta = \left\{ \left(o, \phi_\beta(y), \varphi_\beta(y), \gamma_\beta(y) \right) \middle| y \in \Theta \right\} \tag{5}$$

where $\phi_\beta(y), \varphi_\beta(y), \gamma_\beta(y) \in [0,1]$ represent TM, IM and FM, $0 \le \phi_\beta(y) + \varphi_\beta(y) + \gamma_\beta(y) \le 3$.

2.3. 2TLNSs

Definition 5 [34]. Let $ys = \{ys_i \mid i = 0,1,2,\cdots,Y\}$. If $y\delta = \left\langle (ys_t, y\xi), (ys_i, y\psi), (ys_f, y\zeta) \right\rangle$ is defined for $ys_t, ys_i, ys_f \in ys$, $y\xi, y\psi, y\zeta \in [0, 0.5)$, where $(ys_t, y\xi), (ys_i, y\psi), (ys_f, y\zeta)$ depict the TM, IM and FM by 2TLSs, then the 2TLNSs are designed in Eq. (6):

$$y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(ys_{f_j}, y\zeta_j\right) \right\rangle \tag{6}$$

where $0 \le \Delta^{-1}\left(ys_{t_j}, y\xi_j\right) \le Y, 0 \le \Delta^{-1}\left(ys_{i_j}, y\psi_j\right) \le Y, 0 \le \Delta^{-1}\left(ys_{f_j}, y\zeta_j\right) \le Y$, and $0 \le \Delta^{-1}\left(ys_{t_j}, y\xi_j\right) + \Delta^{-1}\left(ys_{i_j}, y\psi_j\right) + \Delta^{-1}\left(ys_{f_j}, y\zeta_j\right) \le 3Y.$

Definition 6 [34]. Let $y\delta = \left\langle (ys_t, y\xi), (ys_i, y\psi), (ys_f, y\zeta) \right\rangle$. The score function $SF(y\delta)$ and accuracy function $AF(y\delta)$ are designed in Eq. (7)- Eq. (8):

$$SF(y\delta) = \frac{\left(2Z + \Delta^{-1}(ys_t, y\xi) - \Delta^{-1}(ys_i, y\psi) - \Delta^{-1}(ys_f, y\zeta)\right)}{3Y}, SF(y\delta) \in [0,1] \tag{7}$$

$$AF(y\delta) = \frac{\Delta^{-1}(ys_t, y\xi) - \Delta^{-1}(ys_f, y\zeta)}{Y}, AF(y\delta) \in [-1,1]. \tag{8}$$

Definition 7 [34]. Let $y\delta_1 = \left\langle \left(ys_{t_1}, y\xi_1\right), \left(ys_{i_1}, y\psi_1\right), \left(ys_{f_1}, y\zeta_1\right) \right\rangle$ and $y\delta_2 = \left\langle \left(ys_{t_2}, y\xi_2\right), \left(ys_{i_2}, y\psi_2\right), \left(ys_{f_2}, y\zeta_2\right) \right\rangle$, then

(1) $if \ SF(y\delta_1) \prec SF(y\delta_2)$, we have: $y\delta_1 \prec y\delta_2$;

(2) $if \quad SF\left(y\delta_1\right)=SF\left(y\delta_2\right)$ and $AF\left(y\delta_1\right)\prec AF\left(y\delta_2\right)$, we have: $y\delta_1 \prec y\delta_2$;

(3) $if \quad SF\left(y\delta_1\right)=SF\left(y\delta_2\right)$ and $AF\left(y\delta_1\right)=AF\left(y\delta_2\right)$, we have: $y\delta_1 = y\delta_2$.

Definition 8 [34]. Let $y\delta_1=\left\langle\left(ys_{t_1},y\xi_1\right),\left(ys_{i_1},y\psi_1\right),\left(ys_{f_1},y\zeta_1\right)\right\rangle$, $y\delta_2=\left\langle\left(ys_{t_2},y\xi_2\right),\left(ys_{i_2},y\psi_2\right),\left(ys_{f_2},y\zeta_2\right)\right\rangle$ and $y\delta=\left\langle\left(ys_t,y\xi\right),\left(ys_i,y\psi\right),\left(ys_f,y\zeta\right)\right\rangle$ be three 2TLNNs, then

(1) $$y\delta_1\oplus y\delta_2=\left\{\begin{array}{l}\Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{t_1},y\xi_1\right)}{Y}+\frac{\Delta^{-1}\left(ys_{t_2},y\xi_2\right)}{Y}-\frac{\Delta^{-1}\left(ys_{t_1},y\xi_1\right)}{Y}\cdot\frac{\Delta^{-1}\left(ys_{t_2},y\xi_2\right)}{Y}\right)\right),\\ \Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{i_1},y\psi_1\right)}{Y}\cdot\frac{\Delta^{-1}\left(ys_{i_2},y\psi_2\right)}{Y}\right)\right),\\ \Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{f_1},y\zeta_1\right)}{Y}\cdot\frac{\Delta^{-1}\left(ys_{f_2},y\zeta_2\right)}{Y}\right)\right)\end{array}\right\};$$

(2) $$y\delta_1\oplus y\delta_2=\left\{\begin{array}{l}\Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{t_1},y\xi_1\right)}{Y}\cdot\frac{\Delta^{-1}\left(ys_{t_2},y\xi_2\right)}{Y}\right)\right),\\ \Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{i_1},y\psi_1\right)}{Y}+\frac{\Delta^{-1}\left(ys_{i_2},y\psi_2\right)}{Y}-\frac{\Delta^{-1}\left(ys_{i_1},y\psi_1\right)}{Y}\cdot\frac{\Delta^{-1}\left(ys_{i_2},y\psi_2\right)}{Y}\right)\right),\\ \Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{f_1},y\zeta_1\right)}{Y}+\frac{\Delta^{-1}\left(ys_{f_2},y\zeta_2\right)}{Y}-\frac{\Delta^{-1}\left(ys_{f_1},y\zeta_1\right)}{Y}\cdot\frac{\Delta^{-1}\left(ys_{f_2},y\zeta_2\right)}{Y}\right)\right)\end{array}\right\};$$

(3) $$\alpha y\delta=\left\{\begin{array}{l}\Delta\left(Y\left(1-\left(1-\frac{\Delta^{-1}\left(ys_t,y\xi\right)}{Y}\right)^{\alpha}\right)\right),\\ \Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_i,y\psi\right)}{Y}\right)^{\alpha}\right),\Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_f,y\zeta\right)}{Y}\right)^{\alpha}\right)\end{array}\right\},\alpha>0;$$

(4) $$y\delta^{\alpha}=\left\{\begin{array}{l}\Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_t,y\xi\right)}{Y}\right)^{\alpha}\right),\Delta\left(Y\left(1-\left(1-\frac{\Delta^{-1}\left(ys_i,y\psi\right)}{Y}\right)^{\alpha}\right)\right),\\ \Delta\left(Y\left(1-\left(1-\frac{\Delta^{-1}\left(ys_f,y\zeta\right)}{Y}\right)^{\alpha}\right)\right)\end{array}\right\},\alpha>0.$$

2.4. HM techniques

The DHM technique [40] is defined.

Definition 9 [40]**.** The DHM technique is designed in Eq. (9).

$$\mathrm{DHM}^{(\rho)}\left(ya_1,ya_2,...,ya_m\right)=\left(\prod_{1\le i_1<\ldots<i_\rho\le n}\left(\frac{\sum_{j=1}^{\rho}ya_{i_j}}{\rho}\right)\right)^{\frac{1}{C_n^{\rho}}} \tag{9}$$

w where ρ is a parameter values and $\rho=1,2,\ldots,n$, $i_1,i_2,\ldots,i_\rho$ are ρ changed from $\{1,2,\ldots,n\}$, C_n^{ρ} is the binomial coefficient and $C_n^{\rho}=\frac{n!}{x!(n-x)!}$.

2.5. Prioritized Average (PA) technique

The prioritized average (PA) technique was constructed through Yager [41].

Definition 10[41]. Let $YG=\{YG_1,YG_2,\cdots,YG_n\}$ be attribute sets with prioritization order $YG_1\succ YG_2\succ YG_3\cdots\succ YG_n$, indicate attribute YG_j has a higher priority than YG_k, if $j<k$. The value $YG_j(zx)$ is the performance for YG_j, and meets $YG_j(yx)\in[0,1]$ in Eq. (10). If

$$PA\left(YG_i\left(yx\right)\right)=\sum_{j=1}^{n}yw_jYG_j\left(yx\right) \tag{10}$$

where $yw_j=\frac{YT_j}{\sum_{j=1}^{n}YT_j},YT_j=\prod_{k=1}^{j-1}YG_k\left(yx\right)\left(j=2,\cdots,n\right),YT_1=1$. Then PA is called the prioritized average (PA) technique.

3. Some Prioritized weighted DHM technique with 2TLNNs

3.1. 2TLNDHM technique

Wu et al. [40] constructed the 2TLNWDHM technique.

Definition 11 [40]. Let $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(yhs_{f_j}, y\zeta_j\right) \right\rangle$ be 2TLNNs with weight values $yw_j = (yw_1, yw_2, \ldots, yw_n)^T$, $yw_j \in [0,1]$ and $\sum_{j=1}^{n} yw_j = 1$. The 2TLNWDHM technique is studied in Eq. (11):

$$\text{2TLNWDHM}_{yw}^{(yx)}\left(y\delta_1, y\delta_2, \cdots, y\delta_n\right) = \left(\underset{1 \le i_1 < \ldots < i_{yx} \le n}{\otimes} \left(\frac{\overset{x}{\underset{j=1}{\oplus}} yw_{i_j} y\varphi_{i_j}}{yx} \right) \right)^{\frac{1}{C_n^{yx}}}$$

$$= \left\{ \begin{array}{l} \Delta\left(Y\left(\prod_{1 \le i_1 < \ldots < i_{yx} \le n} \left(1 - \left(\prod_{j=1}^{yx} \left(1 - \frac{\Delta^{-1}\left(ys_{t_j}, y\xi_j\right)}{Y} \right)^{yw_{i_j}} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right), \\ \Delta\left(Y\left(1 - \left(\prod_{1 \le i_1 < \ldots < i_{yx} \le n} \left(1 - \left(\prod_{j=1}^{yx} \left(\frac{\Delta^{-1}\left(ys_{i_j}, y\psi_j\right)}{Y} \right)^{yw_{i_j}} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right) \right), \\ \Delta\left(Y\left(1 - \left(\prod_{1 \le i_1 < \ldots < i_{yx} \le n} \left(1 - \left(\prod_{j=1}^{yx} \left(\frac{\Delta^{-1}\left(ys_{f_j}, y\zeta_j\right)}{Y} \right)^{yw_{i_j}} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right) \right) \end{array} \right\} \tag{11}$$

The 2TLNWDHM supplies three properties[40].

Property 1. (Idempotency) If $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(yhs_{f_j}, y\zeta_j\right) \right\rangle$ are same, then

$$\text{2TLNWDHM}_{yw}^{(yx)}\left(y\delta_1, y\delta_2, \cdots, y\delta_n\right) = y\delta \tag{12}$$

Property 2. (Monotonicity) Let $y\delta_{yx_j}$, $y\delta_{yy_j}$ be two group of 2TLNNs, if $y\delta_{yx_j} \le y\delta_{yy_j}$, for all j, then

$$\begin{aligned} &\text{2TLNWDHM}_{yw}^{(yx)}\left(y\delta_{yx_1}, y\delta_{yx_2}, \cdots, y\delta_{yx_n}\right) \\ &\le \text{2TLNWDHM}_{yw}^{(yy)}\left(y\delta_{yy_1}, y\delta_{yy_2}, \cdots, y\delta_{yy_n}\right) \end{aligned} \tag{13}$$

Property 3. (Boundedness) Let $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(yhs_{f_j}, y\zeta_j\right) \right\rangle$ be a group of 2TLNNs. If $y\delta^+ = \left(\max_j \left(ys_{t_j}, y\xi_j\right), \min_j \left(ys_{i_j}, y\psi_j\right), \min_j \left(ys_{f_j}, y\zeta_j\right)\right)$ and $y\delta^- = \left(\min_j \left(ys_{t_j}, y\xi_j\right), \max_j \left(ys_{i_j}, y\psi_j\right), \max_j \left(ys_{f_j}, y\zeta_j\right)\right)$, then

$$y\delta^- \le \text{2TLNWDHM}_{yw}^{(yx)}\left(y\delta_1, y\delta_2, \cdots, y\delta_n\right) \le y\delta^+ \tag{14}$$

3.2 The 2TLNPWDHM technique

To consider the weight information, the 2TLN prioritized weighted DHM (2TLNPWDHM) information technique is built on 2TLNWDHM [40] and PA [41].

Definition 12. Let $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(yhs_{f_j}, y\zeta_j\right) \right\rangle$ with weight values $yw_j = (yw_1, yw_2, \ldots, yw_n)^T$, $yw_j \in [0,1]$ and $\sum_{j=1}^{n} yw_j = 1$. Then

$$2TLNPWDHM_{yw}^{(yy)}(y\delta_1, y\delta_2, \ldots, y\delta_n) = \left(\underset{1 \le i_1 < \ldots < i_{yx} \le n}{\otimes} \left(\frac{\overset{yx}{\underset{j=1}{\oplus}} \dfrac{yw_j YT_{i_j}}{\sum_{i=1}^{n} yw_j YT_{i_j}} y\delta_{i_j}}{yx} \right) \right)^{\frac{1}{C_n^{yx}}} \tag{15}$$

where $YT_j = \prod_{k=1}^{j-1} yw_j SF\left(y\delta_j\right)\left(j = 2, \cdots, n\right), YT_1 = yw_j$ and $SF\left(y\delta_j\right)$ is the score functions of $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(ys_{f_j}, y\zeta_j\right) \right\rangle$.

Theorem 1. Assume $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(yhs_{f_j}, y\zeta_j\right) \right\rangle$ with weight values $yw_j = (yw_1, yw_2, \ldots, yw_n)^T$, $yw_j \in [0,1]$ and $\sum_{j=1}^{n} yw_j = 1$. The fused value by 2TLNPWDHM is in Eq. (16):

$$2TLNPWDHM_{yw}^{(yy)}(y\delta_1, y\delta_2, \ldots, y\delta_n) = \left(\underset{1\le i_1<\ldots<i_{yx}\le n}{\otimes} \left(\frac{\overset{yx}{\underset{j=1}{\oplus}} \frac{yw_j YT_{i_j}}{\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} y\delta_{i_j}}{yx} \right) \right)^{\frac{1}{C_n^{yx}}}$$

$$= \left\{ \begin{array}{l} \Delta\left(Y \left(\prod_{1\le i_1<\ldots<i_{yx}\le n} \left(1 - \left(\prod_{j=1}^{yx} \left(1 - \frac{\Delta^{-1}\left(ys_{t_j}, y\xi_j\right)}{Y} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right), \\ \Delta\left(Y \left(1 - \left(\prod_{1\le i_1<\ldots<i_{yx}\le n} \left(1 - \left(\prod_{j=1}^{x} \left(\frac{\Delta^{-1}\left(ys_{i_j}, y\psi_j\right)}{Y} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right) \right), \\ \Delta\left(Y \left(1 - \left(\prod_{1\le i_1<\ldots<i_{yx}\le n} \left(1 - \left(\prod_{j=1}^{x} \left(\frac{\Delta^{-1}\left(ys_{f_j}, y\zeta_j\right)}{Y} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right) \right) \end{array} \right\} \quad (16)$$

where $YT_j = \prod_{k=1}^{j-1} yw_j SF\left(y\delta_j\right) \left(j = 2, \cdots, n\right)$, $YT_1 = yw_j$ and $SF\left(y\delta_j\right)$ is the score functions of $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(ys_{f_j}, y\zeta_j\right) \right\rangle$.

Proof. From Definition 8, we could have,

$$\frac{yw_j YT_{i_j}}{\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} y\delta_{i_j} = \left\{ \begin{array}{l} \Delta\left(Y\left(1-\left(1-\frac{\Delta^{-1}\left(ys_{t_j}, y\xi_j \right)}{Z} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right) \right), \\ \Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{i_j}, y\psi_j \right)}{Y} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right), \\ \Delta\left(Y\left(\frac{\Delta^{-1}\left(ys_{f_j}, y\zeta_j \right)}{Y} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right) \end{array} \right\} \quad (17)$$

Then,

$$\bigoplus_{j=1}^{yx} \frac{yw_j YT_{i_j}}{\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} y\delta_{i_j} = \left\{ \begin{array}{l} \Delta\left(Y\left(1-\prod_{j=1}^{yx}\left(\left(1-\frac{\Delta^{-1}\left(ys_{t_j}, y\xi_j \right)}{Z} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right) \right) \right), \\ \Delta\left(Y\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{i_j}, y\psi_j \right)}{Y} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right) \right), \\ \Delta\left(Y\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{f_j}, y\zeta_j \right)}{Y} \right)^{\left(yw_j YT_{i_j}\right) / \sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right) \right) \end{array} \right\} \quad (18)$$

Thus,

$$\frac{\overset{yx}{\underset{j=1}{\oplus}} \frac{yw_j YT_{i_j}}{\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} y\delta_{i_j}}{yx} = \left\{ \begin{array}{l} \Delta\left(Y\left(1-\left(\prod_{j=1}^{yx}\left(1-\frac{\Delta^{-1}\left(ys_{t_j}, y\xi_j\right)}{Y}\right)^{\left(yw_j YT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)}\right)^{\frac{1}{yx}}\right)\right), \\ \Delta\left(Y\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{i_j}, y\psi_j\right)}{Y}\right)^{\left(yw_j YT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)}\right)^{\frac{1}{yx}}\right), \\ \Delta\left(Y\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{f_j}, y\zeta_j\right)}{Y}\right)^{\left(yw_j YT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)}\right)^{\frac{1}{yx}}\right) \end{array} \right\} \tag{19}$$

Therefore,

$$\underset{1\le i_1<\ldots<i_{yx}\le n}{\otimes}\left(\frac{\overset{yx}{\underset{j=1}{\oplus}}\frac{yw_jYT_{i_j}}{\sum_{i=1}^{n}\left(yw_jYT_{i_j}\right)}y\delta_{i_j}}{yx}\right)$$

$$=\left\{\begin{array}{l}\Delta\left(Y\left(\prod_{1\le i_1<\ldots<i_{yx}\le n}\left(1-\left(\prod_{j=1}^{yx}\left(1-\frac{\Delta^{-1}\left(ys_{t_j},y\xi_j\right)}{Y}\right)^{\left(yw_jYT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_jYT_{i_j}\right)}\right)^{\frac{1}{yx}}\right)\right)\right),\\ \Delta\left(Y\left(1-\prod_{1\le i_1<\ldots<i_{yx}\le n}\left(1-\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{i_j},y\psi_j\right)}{Y}\right)^{\left(yw_jYT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_jYT_{i_j}\right)}\right)^{\frac{1}{yx}}\right)\right)\right),\\ \Delta\left(Y\left(1-\prod_{1\le i_1<\ldots<i_{yx}\le n}\left(1-\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{f_j},y\zeta_j\right)}{Y}\right)^{\left(yw_jYT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_jYT_{i_j}\right)}\right)^{\frac{1}{yx}}\right)\right)\right)\end{array}\right\} \quad (20)$$

Thereafter,

$$2TLNPWDHM_{yw}^{(yx)}(y\delta_1, y\delta_2, \ldots, y\delta_n)$$

$$= \left(\underset{1\le i_1<\ldots<i_{yx}\le n}{\otimes} \left(\frac{\overset{yx}{\underset{j=1}{\oplus}} \frac{yw_j YT_{i_j}}{\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} y\delta_{i_j}}{yx} \right) \right)^{\frac{1}{C_n^{yx}}}$$

$$= \left\{ \begin{array}{l} \Delta\left(Y\left(\prod_{1\le i_1<\ldots<i_{yx}\le n} \left(1-\left(\prod_{j=1}^{yx} \left(1-\frac{\Delta^{-1}\left(ys_{t_j}, y\xi_j\right)}{y} \right)^{\left(yw_j YT_{i_j}\right)/\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right), \\ \Delta\left(Y\left(1-\left(\prod_{1\le i_1<\ldots<i_{yx}\le n} \left(1-\left(\prod_{j=1}^{x} \left(\frac{\Delta^{-1}\left(ys_{i_j}, y\psi_j\right)}{Y} \right)^{\left(yw_j YT_{i_j}\right)/\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right) \right), \\ \Delta\left(Y\left(1-\left(\prod_{1\le i_1<\ldots<i_{yx}\le n} \left(1-\left(\prod_{j=1}^{x} \left(\frac{\Delta^{-1}\left(ys_{f_j}, y\zeta_j\right)}{Y} \right)^{\left(yw_j YT_{i_j}\right)/\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} \right)^{\frac{1}{yx}} \right) \right)^{\frac{1}{C_n^{yx}}} \right) \right) \end{array} \right\} \quad (21)$$

Thus, (16) is fully proved.

The 2TLNPWDHM supplies three properties.

Property 4. (Idempotency) If $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(yhs_{f_j}, y\zeta_j\right) \right\rangle$ are same, then

$$2TLNPWDHM_{yw}^{(yx)}\left(y\delta_1, y\delta_2, \cdots, y\delta_n\right) = y\delta \quad (22)$$

Property 5. (Monotonicity) Let $y\delta_{yx_j}, y\delta_{yy_j}$ be two set of 2TLNNs, if $y\delta_{yx_j} \le y\delta_{yy_j}$, for all j, then

$$2TLNPDHM_{yw}^{(yx)}\left(y\delta_{yx_1}, y\delta_{yx_2}, \cdots, y\delta_{yx_n}\right) \le 2TLNPDHM_{yw}^{(yy)}\left(y\delta_{yy_1}, y\delta_{yy_2}, \cdots, y\delta_{yy_n}\right) \quad (23)$$

Property 6. (Boundedness) Let $y\delta_j = \left\langle \left(ys_{t_j}, y\xi_j\right), \left(ys_{i_j}, y\psi_j\right), \left(yhs_{f_j}, y\zeta_j\right) \right\rangle$ be a set of 2TLNNs. If $y\delta^+ = \left(\max_j \left(ys_{t_j}, y\xi_j\right), \min_j \left(ys_{i_j}, y\psi_j\right), \min_j \left(ys_{f_j}, y\zeta_j\right)\right)$ and $y\delta^- = \left(\min_j \left(ys_{t_j}, y\xi_j\right), \max_j \left(ys_{i_j}, y\psi_j\right), \max_j \left(ys_{f_j}, y\zeta_j\right)\right)$, then

$$y\delta^- \le 2TLNPDHM_{yw}^{(yx)} \left(y\delta_1, y\delta_2, \cdots, y\delta_n\right) \le y\delta^+ \tag{24}$$

4. Method for MADM based on the 2TLNPWDHM

Then, the MADM model is built based on 2TLNPWDHM. There are m alternatives $\{YA_1, YA_2, \ldots, YA_m\}$, n attributes $\{YT_1, YT_2, \ldots, YT_n\}$. The decision steps of MADM are proposed based on 2TLNPWDHM technique (See Figure 1).

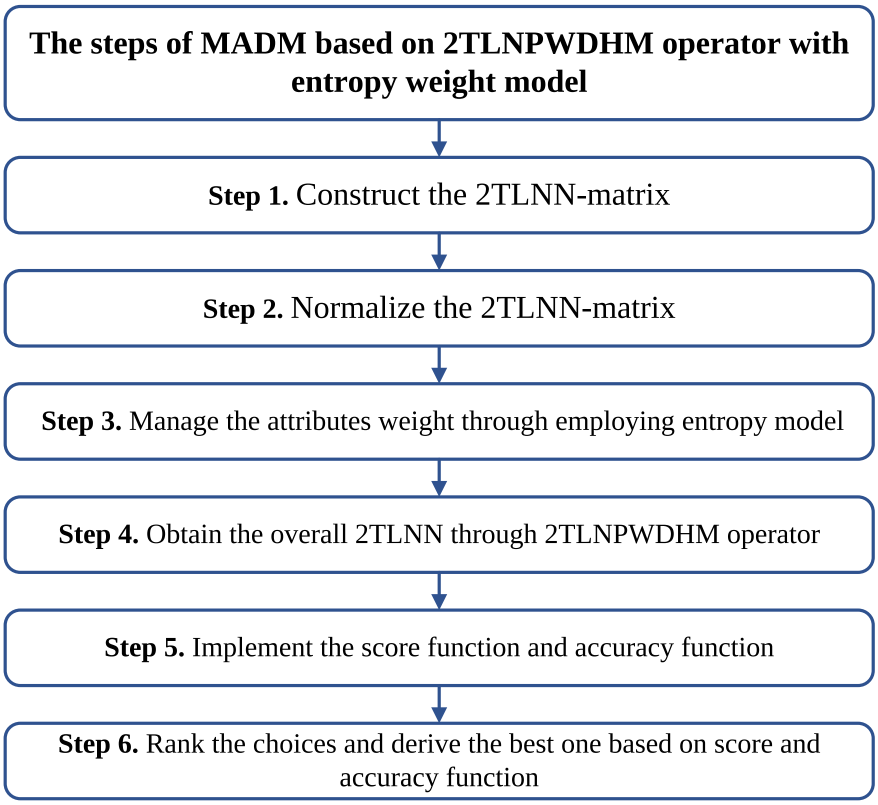

Figure 1. The steps of MADM based on 2TLNPWDHM operator with entropy model

Step 1. Establish the 2TLNN-matrix $YM = \left[y\delta_{ij}\right]_{m \times n}$ in Eq. (25):

$$YM=\left[y\delta_{ij}\right]_{m\times n}=\begin{array}{c} \\ YA_1\\ YA_2\\ \vdots\\ YA_m\end{array}\begin{array}{c}\begin{matrix} YT_1 & YT_2 & \cdots & YT_n\end{matrix}\\ \begin{bmatrix} y\delta_{11} & y\delta_{12} & \cdots & y\delta_{1n}\\ y\delta_{21} & y\delta_{22} & \cdots & y\delta_{2n}\\ \vdots & \vdots & \vdots & \vdots\\ y\delta_{m1} & y\delta_{m2} & \cdots & y\delta_{mn}\end{bmatrix}\end{array} \tag{25}$$

where $y\delta_{ij}=\left\langle\left(ys_{t_{ij}},y\xi_{ij}\right),\left(ys_{i_{ij}},y\psi_{ij}\right),\left(ys_{f_{ij}},y\zeta_{ij}\right)\right\rangle$ is the 2TLNN.

Step 2. Normalize the $YM=\left[y\delta_{ij}\right]_{m\times n}$ to $NYM=\left[y\delta_{ij}\right]_{m\times n}$ in Eq. (26)-Eq. (27).

For benefit attributes:

$$\begin{aligned} y\delta_{ij}&=\left\langle\left(ys_{t_{ij}},y\xi_{ij}\right),\left(ys_{i_{ij}},y\psi_{ij}\right),\left(ys_{f_{ij}},y\zeta_{ij}\right)\right\rangle\\ &=\left\langle\left(ys_{t_{ij}},y\xi_{ij}\right),\left(ys_{i_{ij}},y\psi_{ij}\right),\left(ys_{f_{ij}},y\zeta_{ij}\right)\right\rangle \end{aligned} \tag{26}$$

For cost attributes:

$$\begin{aligned} y\delta_{ij}&=\left\langle\left(ys_{t_{ij}},y\xi_{ij}\right),\left(ys_{i_{ij}},y\psi_{ij}\right),\left(ys_{f_{ij}},y\zeta_{ij}\right)\right\rangle\\ &=\left\{\begin{array}{l}\Delta\left(Y-\Delta^{-1}\left(ys_{t_{ij}},y\xi_{ij}\right)\right),\Delta\left(Y-\Delta^{-1}\left(ys_{i_{ij}},y\psi_{ij}\right)\right),\\ \Delta\left(Y-\Delta^{-1}\left(ys_{f_{ij}},y\zeta_{ij}\right)\right)\end{array}\right\} \end{aligned} \tag{27}$$

Step 3. Implement the attributes weight in line with entropy[42].

Entropy [43] is a conventional tool to implement weight values. Firstly, the normalized decision matrix NDM_{ij} is implemented in Eq. (28)- Eq. (32):

$$NDM_{ij}=\frac{\left(\begin{array}{l}SF\left\{\left(us_{t_{ij}},u\xi_{ij}\right),\left(us_{i_{ij}},u\psi_{ij}\right),\left(us_{f_{ij}},u\zeta_{ij}\right)\right\}\\ +AF\left\{\left(us_{t_{ij}},u\xi_{ij}\right),\left(us_{i_{ij}},u\psi_{ij}\right),\left(us_{f_{ij}},u\zeta_{ij}\right)\right\}\end{array}\right)}{\sum_{i=1}^{m}\left(\begin{array}{l}SF\left\{\left(us_{t_{ij}},u\xi_{ij}\right),\left(us_{i_{ij}},u\psi_{ij}\right),\left(us_{f_{ij}},u\zeta_{ij}\right)\right\}\\ +AF\left\{\left(us_{t_{ij}},u\xi_{ij}\right),\left(us_{i_{ij}},u\psi_{ij}\right),\left(us_{f_{ij}},u\zeta_{ij}\right)\right\}\end{array}\right)}, \tag{28}$$

Then, the Shannon entropy values $SEV=\left(SEV_1,SEV_2,\cdots,SEV_n\right)$ is inaugurated:

$$SEV_j=-\frac{1}{\ln m}\sum_{i=1}^{m}NDM_{ij}\ln NDM_{ij} \tag{29}$$

and $NDM_{ij}\ln NDM_{ij}=0$ if $NDM_{ij}=0$.

Then, the weights $yw=\left(yw_1, yw_2, \cdots, yw_n\right)$ is inaugurated:

$$yw_j=\frac{1-SEV_j}{\sum_{j=1}^{n}\left(1-SEV_j\right)}, \quad j=1,2,\cdots,n. \tag{30}$$

Step 3. Calculate the weight values of $YT_{ij}\left(i=1,2,\cdots,5, j=2,\cdots,4\right)$:

$$YT_{ij}=\prod_{\lambda=1}^{j-1} SF\left(y\delta_{i\lambda}\right)\left(i=1,2,\cdots,5, j=2,\cdots,4\right) \tag{31}$$

$$YT_{i1}=1, i=1,2,\cdots,5 \tag{32}$$

Step 4. Utilize $NYM=\left[y\delta_{ij}\right]_{m\times n}$ and 2TLNPWDHM to construct the overall 2TLNN $y\delta_i=\left\langle\left(ys_{t_i}, y\xi_i\right),\left(ys_{i_i}, y\psi_i\right),\left(ys_{f_i}, y\zeta_i\right)\right\rangle$ of YA_i in Eq. (33).

$$y\delta_i=\left\langle\left(ys_{t_i}, y\xi_i\right),\left(ys_{i_i}, y\psi_i\right),\left(ys_{f_i}, y\zeta_i\right)\right\rangle$$

$$=\left(\underset{1\le i_1<\ldots<i_{yx}\le n}{\otimes}\left(\frac{\overset{yx}{\underset{j=1}{\oplus}}\frac{yw_j YT_{i_j}}{\sum_{i=1}^{n}\left(yw_j YT_{i_j}\right)} y\delta_{i_j}}{yx}\right)\right)^{\frac{1}{C_n^{yx}}}$$

$$
=\left\{\begin{array}{l}
\Delta\left(Y\left(\prod_{1\le i_1<\ldots<i_{yx}\le n}\left(1-\left(\prod_{j=1}^{yx}\left(1-\frac{\Delta^{-1}\left(ys_{t_{ij}},y\xi_{ij}\right)}{Y}\right)^{\left(yw_jYT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_jYT_{i_j}\right)}\right)^{\frac{1}{yx}}\right)\right)^{\frac{1}{C_n^{yx}}}\right),\\
\Delta\left(Y\left(1-\left(\prod_{1\le i_1<\ldots<i_{yx}\le n}\left(1-\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{i_{ij}},y\psi_{ij}\right)}{Y}\right)^{\left(yw_jYT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_jYT_{i_j}\right)}\right)^{\frac{1}{yx}}\right)\right)^{\frac{1}{C_n^{yx}}}\right)\right),\\
\Delta\left(Y\left(1-\left(\prod_{1\le i_1<\ldots<i_{yx}\le n}\left(1-\left(\prod_{j=1}^{yx}\left(\frac{\Delta^{-1}\left(ys_{f_{ij}},y\zeta_{ij}\right)}{Y}\right)^{\left(yw_jYT_{i_j}\right)\Big/\sum_{i=1}^{n}\left(yw_jYT_{i_j}\right)}\right)^{\frac{1}{yx}}\right)\right)^{\frac{1}{C_n^{yx}}}\right)\right)
\end{array}\right\}
\tag{33}
$$

Step 5. Obtain the $SF\left(y\delta_i\right), AF\left(y\delta_i\right)$ in Eq. (34)- Eq. (35).

$$
SF\left(y\delta_i\right)=\frac{\left(2Y+\Delta^{-1}\left(ys_{t_i},y\xi_i\right)-\Delta^{-1}\left(ys_{i_i},y\psi_i\right)-\Delta^{-1}\left(ys_{f_i},y\zeta_i\right)\right)}{3Y}
\tag{34}
$$

$$
AF(y\delta_i)=\Delta^{-1}\left(ys_{t_i},y\xi_i\right)-\Delta^{-1}\left(ys_{f_i},y\zeta_i\right)
\tag{35}
$$

Step 6. Rank the choices $YA_i\left(i=1,2,\cdots,m\right)$ and derive the optimal one through employing the $SF\left(y\delta_i\right), AF\left(y\delta_i\right)$.

4. Numerical example and comparative analysis

4.1. Numerical example

In the era of informatization, computer information has become the core technology for global development. The demand for professional computer information talents in various industries is becoming increasingly strong, especially for vocational education with less output of undergraduate level talents, which cannot meet the needs of the people and industrial development for high-level technical and skilled talents. In the report of the 20th National Congress of the Communist Party of China, it was pointed out that "we will comprehensively promote the collaborative innovation of vocational education, higher education, and continuing education, promote the integration of vocational education, industry and education, and science and education, optimize the positioning of vocational education types." This once again clarifies the important position of vocational education and the important role of industry education integration as a vocational education model, further pointing out the direction for the development of vocational education. The integration of industry and education, as well as school enterprise cooperation, are the basic modes of vocational education and the key to running vocational education well. This promotes the optimization of the computer information talent training mode under the background of talent transformation. To achieve the integration of industry, academia, and research, it is necessary to reform the teaching system, improve the direct connection with industry and experience transmission, help society to transport professional talents, and improve the practical application system of computer information teaching in universities. Although there are still some problems in the development under the background of the changing demand for talent cultivation, the integration of industry, academia, and research has become an important teaching model for computer information majors in vocational colleges. From the perspective of curriculum analysis, "integration of industry, academia, and research" allows enterprises to participate in the design of professional courses, effectively connect with industry development, and reasonably set courses. Through the continuous development of courses, it can innovate the learning mode of theoretical knowledge for students, continuously promote and apply knowledge in classroom teaching, break traditional learning methods, stimulate the interest of course learning, enhance students' practical abilities, deepen their impression of computer information theory knowledge through practice, improve their professional skills and professional qualities, and cooperate with industry to enable students to understand timely evaluation of the industry, help them improve their technical deficiencies, and provide guidance for future employment. From the perspective of teacher team construction, the "industry university research integration" teaching model can promote the construction of the teacher team and improve the efficiency of talent resource utilization. Teachers can enter the industry for training, and students can enhance their ability to apply theoretical knowledge during the training. Employees in the industry can also create their own value through various ways of school teaching, achieving a win-win situation for multiple parties. The integrated teaching model of industry, academia, and research can not only help students integrate technical knowledge, but also help industry employees build their confidence in their own skills. The talent exchange between both parties can also provide scientific research guidance for universities, improve the overall level of teaching and research. The exchange of talents will undoubtedly promote the smooth development of scientific research work, and provide students with implementation space and development platforms for technological applications. Strong scientific research results can also provide guarantees for students' learning, enhance their comprehensive strength, and enable industries to have a certain understanding of student quality, which can help students and industries achieve two-way choices. The "integration of industry, academia, and research" teaching model can promote structural changes in the talent supply side, promote deep cooperation between schools and enterprises, start from professional settings and courses, provide impetus for the transformation of computer information teaching mode, optimize course teaching mode, break through traditional boring theoretical teaching, and achieve more efficient practical teaching through new teaching innovation. The new teaching model can effectively utilize relevant funds and equipment, improve the efficiency of resource utilization, provide convenience for students' computer information application, promote the improvement of curriculum system and innovation of teaching methods, help outstanding computer information talents promote teaching optimization, achieve quality education reform, and enhance students' employment competitiveness. In terms of industrial talent strategy, it can also be effectively implemented. "Integration of industry, academia, and research" can enhance the connection between universities and industries, allowing excellent computer information talents cultivated by universities to directly connect with the industry, reducing the human and material investment and resource waste generated by the industry in talent selection. Students can have sufficient opportunities for technical practice, understand the value they create and the loopholes that need to be improved in the practice process, Helping students develop into applied talents, the industry can also take this opportunity to enhance social image and expand the positive impact of industry reputation. Students can also quickly grasp the characteristics of their careers during the learning process, enhance their planning and goal setting for future careers, scientifically formulate learning goals, plan their careers, stimulate their own knowledge system construction and enthusiasm, gradually improve their skills, and give students a clearer motivation to learn, gradually improving their own value. In addition, the "integration of industry, academia, and research" teaching model can also help industries achieve transformation and development, facilitate economic reform, meet the demand for talent and technology, and provide lasting talent motivation for technological improvement and innovation within the industry. In this paper, we provide a numerical example for talent cultivation quality evaluation in practical aspects of computer information major through 2TLNPWDHM operator. There are five possible local engineering colleges and universities $YA_i\left(i=1,2,3,4,5\right)$ to be chosen in line with four attributes: ①YT_1 is the theoretical knowledge cultivation for computer information major; ②YT_2 is teaching costs computer information major; ③YT_3 is the team cooperation and coordination ability computer information major; ④YT_4 is the comprehensive literacy of college students computer information major. Evidently, YT_2 is the cost attributes.

Then, the 2TLNPWDHM technique is constructed for talent cultivation quality evaluation in practical aspects of computer information major.

Step 1. Construct the 2TLNN-matrix $YM=\left[y\delta_{ij}\right]_{5\times 4}$. The five local engineering colleges and universities $YA_i\left(i=1,2,3,4,5\right)$ are assessed through 2TLNNs with four attributes, which are implemented in Table 1.

Table 1. 2TLNNs information matrix

	YT_1	YT_2
YA_1	<(ys_2, -0.17), (ys_4,0.21) (ys_4,0.27)>	<(ys_2,0.32), (ys_2,0.16) (ys_4,0.24)>
YA_2	<(ys_2,0.43), (ys_3, -0.29) (ys_4,0.36)>	<(ys_3, -0.18), (ys_2,0.23) (ys_3,0.42)>
YA_3	<(ys_4,0.25), (ys_2,0.31) (ys_2,0.28)>	<(ys_5,0.16), (ys_2,0.08) (ys_2, -0.24)>
YA_4	<(ys_2,0.49), (ys_3,0.34) (ys_4,-0.19)>	<(ys_2,0.13), (ys_2,0.21) (ys_4,0.27)>
YA_5	<(ys_4,0.23), (ys_2,0.37) (ys_2,0.46)>	<(ys_5,0.12), (ys_2,0.32) (ys_2, -0.16)>

	YT_3	YT_4
YA_1	<(ys_3,0.26), (ys_2,0.29) (ys_4, -0.32)>	<(ys_4, -0.35), (ys_2,0.39) (ys_2,0.47)>
YA_2	<(ys_2,0.14), (ys_4,0.28) (ys_3,0.25)>	<(ys_2,0.42), (ys_4,0.43) (ys_4,0.49)>
YA_3	<(ys_3,0.26), (ys_2, -0.13) (ys_2,0.24)>	<(ys_2,0.16), (ys_2,0.27) (ys_4,0.36)>
YA_4	<(ys_2, -0.23), (ys_2,0.14) (ys_2,0.25)>	<(ys_4,0.14), (ys_2, -0.19) (ys_4,0.43)>
YA_5	<(ys_4,0.27), (ys_3,0.19) (ys_3, -0.17)>	<(ys_2, -0.28), (ys_3,0.37) (ys_2,0.26)>

Step 2. Normalize the $YM=\left[y\delta_{ij}\right]_{5\times4}$ to $NYM=\left[y\delta_{ij}\right]_{5\times4}$ (see Table 2).

Table 2. The normalized 2TLNNs matrix

	YT_1	YT_2
YA_1	<(ys_2, -0.17), (ys_4,0.21) (ys_4,0.27)>	<(ys_4,-0.32), (ys_4,-0.16) (ys_2,-0.24)>
YA_2	<(ys_2,0.43), (ys_3, -0.29) (ys_4,0.36)>	<(ys_3, 0.18), (ys_4,-0.23) (ys_3,-0.42)>
YA_3	<(ys_4,0.25), (ys_2,0.31) (ys_2,0.28)>	<(ys_1,-0.16), (ys_4,-0.08) (ys_4, 0.24)>
YA_4	<(ys_2,0.49), (ys_3,0.34) (ys_4,-0.19)>	<(ys_4,-0.13), (ys_4,-0.21) (ys_2,-0.27)>
YA_5	<(ys_4,0.23), (ys_2,0.37) (ys_2,0.46)>	<(ys_1,-0.12), (ys_4,-0.32) (ys_4, 0.16)>

	YT_3	YT_4
YA_1	<(ys_3,0.26), (ys_2,0.29) (ys_4, -0.32)>	<(ys_4, -0.35), (ys_2,0.39) (ys_2,0.47)>

YA_2	$<(ys_2,0.14), (ys_4,0.28) (ys_3,0.25)>$	$<(ys_2,0.42), (ys_4,0.43) (ys_4,0.49)>$
YA_3	$<(ys_3,0.26), (ys_2, -0.13) (ys_2,0.24)>$	$<(ys_2,0.16), (ys_2,0.27) (ys_4,0.36)>$
YA_4	$<(ys_2, -0.23), (ys_2,0.14) (ys_2,0.25)>$	$<(ys_4,0.14), (ys_2, -0.19) (ys_4,0.43)>$
YA_5	$<(ys_4,0.27), (ys_3,0.19) (ys_3, -0.17)>$	$<(ys_2, -0.28), (ys_3,0.37) (ys_2,0.26)>$

Step 3. Implement the attributes weight.

$$yw_1 = 0.1760, yw_2 = 0.33781, yw_3 = 0.2751, yw_4 = 0.1708$$

Step 3. Utilize Eq. (24)- Eq. (25) to calculate the YT_{ij} $\left(i = 1, 2, 3, 4, 5; j = 1, 2, 3, 4\right)$ (see Table 3-4).

Table 3. The YT_{ij} $\left(i = 1, 2, 3, 4, 5; j = 1, 2, 3, 4\right)$

	YG_1	YG_2	YG_3	YG_4
YA_1	1.0000	0.4716	0.3537	0.2476
YA_2	1.0000	0.6118	0.4130	0.2478
YA_3	1.0000	0.4079	0.2397	0.1917
YA_4	1.0000	0.7138	0.5710	0.3640
YA_5	1.0000	0.7775	0.4665	0.3499

Table 4. The $yw_j YT_{ij}$ $\left(i = 1, 2, 3, 4, 5; j = 1, 2, 3, 4\right)$

	YG_1	YG_2	YG_3	YG_4
YA_1	0.1760	0.1783	0.0973	0.0423
YA_2	0.1760	0.2313	0.1136	0.0423
YA_3	0.1760	0.1542	0.0659	0.0327
YA_4	0.1760	0.2699	0.1571	0.0622

YA_5	0.1760	0.2940	0.1283	0.0598

Step 4. From table 2 and Table 4, the $y\delta_i \left(i=1,2,3,4,5\right)$ is derived through 2TLNPWDHM technique. Then, the final results are constructed in Table 5 ($yx=3$).

Table 5. The final results by 2TLNPWDHM technique

	2TLNPWDHM technique
YA_1	<(ys_2,0.4659), (ys_1, -0.2768), (ys_4,-0.3126) >
YA_2	<(ys_4,-0.2548), (ys_4,0.1217) , (ys_6,-0.3214) >
YA_3	<(ys_5, 0.2765), (ys_4, 0.4583) , (ys_6, -0.3315) >
YA_4	<(ys_3, -0.3257), (ys_4,-0.4347) , (ys_4,0.1658) >
YA_5	<(ys_2,-0.2436), (ys_4,0.2659) , (ys_6,-0.1432) >

Step 5. Through Table 5 and the score functions are constructed in Table 4.

Table 4. The score functions

	2TLNPWDHM
YA_1	0.6806
YA_2	0.5921
YA_3	0.4514
YA_4	0.5556
YA_5	0.6392

Step 6. From Table 4, the order is depicted in Table 5.

Table 5. The order for local applied higher education institutions

	Order
2TLNPWDHM technique	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$

4.2. Parameter influence

In order to fully depict the different parameters effects for 2TLNPWDHM technique, the results are fully implemented in Tables 6-7 and Figure 2-3.

Table 6. Scores for different parameters of 2TLNPWDHM technique

yx	$SF(YA_1)$	$SF(YA_2)$	$SF(YA_3)$	$SF(YA_4)$	$SF(YA_5)$
1	0.5881	0.5117	0.3901	0.4802	0.5524
2	0.6327	0.5504	0.4196	0.5165	0.5942
3	0.6806	0.5921	0.4514	0.5556	0.6392
4	0.7633	0.6641	0.5063	0.6232	0.7170

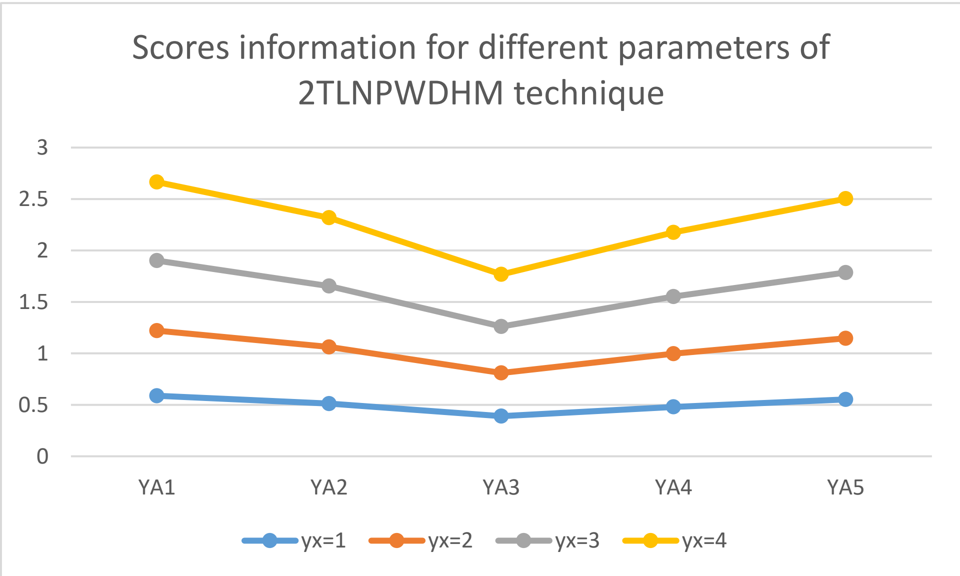

Figure 2. Scores for different parameters of 2TLNPWDHM technique

Table 7. Order for different parameters of 2TLNPDHM technique

yx	Order
1	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
2	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
3	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
4	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$

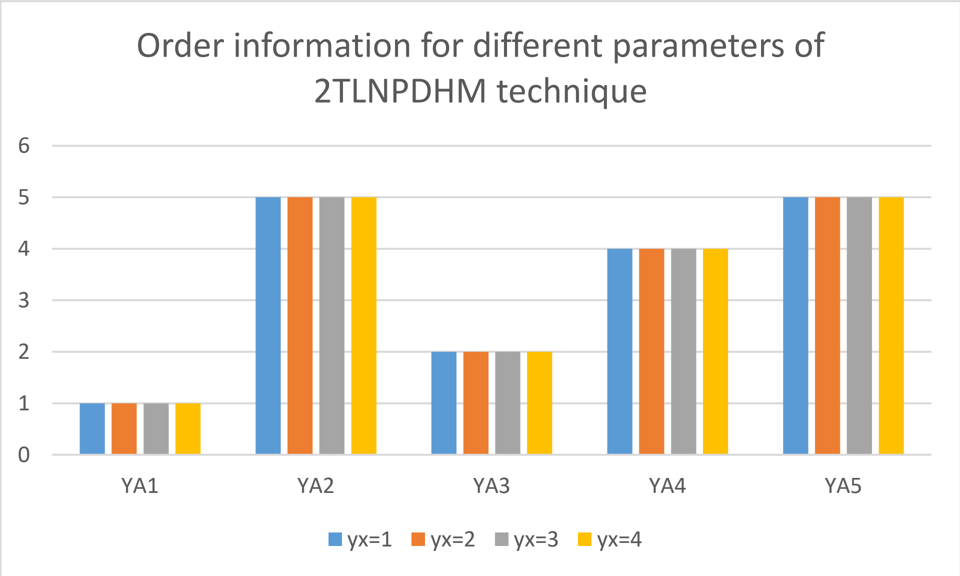

Figure 3. Scores information for different parameters of 2TLNPWDHM technique

4.3. Comparative analysis

Then, the 2TLNPWDHM is compared with 2TLNNWA technique [34], 2TLNNWG technique [34], 2TLNWHM technique [40] , 2TLNWDHM technique[40], 2TLNN-CODAS technique [39], 2TLNN-EDAS technique [44] and 2TLNN-TODIM technique [45]. The comparative studies are fully portrayed in Table 8.

Table 8. Order for different techniques

	Order
2TLNNWA technique [34]	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
2TLNNWG technique [34]	$YA_1 > YA_5 > YA_4 > YA_2 > YA_3$
2TLNWHM technique [40]	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
2TLNWDHM technique[40]	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
2TLNN-CODAS technique [39]	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
2TLNN-EDAS technique [44]	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$
2TLNN-TODIM method [45]	$YA_1 > YA_2 > YA_5 > YA_4 > YA_3$
The proposed 2TLNPWDHM technique	$YA_1 > YA_5 > YA_2 > YA_4 > YA_3$

On the basis of the WS coefficients [46, 47], the WS coefficient between 2TLNNWA technique [34], 2TLNNWG technique [34], 2TLNWHM technique [40] , 2TLNWDHM technique[40], 2TLNN-CODAS technique [39], 2TLNN-EDAS technique [44], 2TLNN-TODIM technique [45] and the proposed 2TLNPWDHM technique is 1.0000, 0.7917, 1.0000, 1.0000, 1.0000, 1.0000, 0.7266, respectively. The WS coefficient shows the order of the proposed 2TLNPWDHM technique are same to the order of the 2TLNNWA technique [34], 2TLNWHM technique [40], 2TLNWDHM technique[40], 2TLNN-CODAS technique [39] and 2TLNN-EDAS technique [44]; the WS coefficient shows the order of the proposed 2TLNPWDHM technique are slightly different to the ranking results of the 2TLNNWG technique [34] and 2TLNN-TODIM technique [45]. This validates the effectiveness of the 2TLNPWDHM technique. The main advantages of 2TLNPWDHM technique are summarized: (1) The 2TLNPWDHM technique could consider the prioritization among the attributes. (2) The 2TLNPWDHM could take into account the interrelationship between any arguments and could eliminate the influence of unfairly information on the final outcome.

5. Conclusion

The computer information industry is a strategic, fundamental, and pioneering industry of the national economy. The cultivation of high-level and compound talents plays an important role in promoting the vigorous development of the computer information industry, driving economic growth, adjusting industrial structure, and transforming development methods. New engineering has put forward new requirements for the construction of computer information majors in comprehensive universities, promoting the integration of computer information majors with emerging industries, accelerating the transformation and upgrading of traditional majors, especially in exploring and innovating high-level engineering talent training programs and models. The professional characteristics of the Computer Information Science and Technology major are not obvious, the curriculum is too focused on basics, and is not closely integrated with the national strategic emerging computer information industry and market demand. The proportion of theoretical courses is too high, and the proportion of practical courses is low. Computer information majors are highly practical majors, and this curriculum that emphasizes theory over practice is increasingly detrimental to the cultivation of students' innovative awareness and ability. The number of elective courses is too few, and the speed of product updates and upgrades in the field of computer information is fast. New knowledge and technologies are constantly emerging, and a single course setting can no longer meet the diverse needs of the industry. Practical activities related to innovation and entrepreneurship mainly involve student participation in competitions, with limited corresponding curriculum and insufficient integration of industry, academia, and research. The talent cultivation quality evaluation in practical aspects of computer information major is looked as the MADM issue. In this paper, the WDHM and PA operator are combined with 2TLNNs to construct the 2TLNPWDHM operator. Finally, a real-life example for talent cultivation quality evaluation in practical aspects of computer information major is employed to depict the built methods. The main study contributions of current study are constructed: (1) the 2TLNPWDHM operator is built; (2) the 2TLNPWDHM operator is designed to cope with the MADM with 2TLNNs; (3) an empirical real-life example for talent cultivation quality evaluation in practical aspects of computer information major is constructed to verify the 2TLNPWDHM operator; (4) some comparative decision studies are constructed to verify the rationality of the 2TLNPWDHM operator.

This study may have some limitations that could be implemented for talent cultivation quality evaluation in practical aspects of computer information major in future studies:(1) The MADM technique proposed doesn't investigate the consensus issues of DMs and applying consensus theory to talent cultivation quality evaluation in practical aspects of computer information major with 2TLNS is a worthwhile research topic; (2) In subsequent decision studies for talent cultivation quality evaluation in practical aspects of computer information major, the MADM techniques of 2TLNS need to be studied in any other uncertain environment.

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