



## Cubic Spherical Neutrosophic Numbers for Communication Effectiveness Evaluation of Intangible Cultural Heritage Traditional Music

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**Abstract:** To protect cultural identity and encourage intergenerational continuity, it is essential to preserve and share intangible cultural heritage (ICH), especially traditional music. As digital media and communication technology have advanced, it is now crucial to assess how well different platforms communicate classical music. To evaluate traditional music's communication efficacy as a component of ICH, this study suggests an assessment approach. Reach of the audience, cultural authenticity, multimedia use, information transmission across generations, public awareness, and emotional resonance are important factors. Eight sample communication techniques are evaluated, ranging from instructional seminars and live performances to virtual reality and mobile applications. To determine which approaches best strike a compromise between cultural preservation and contemporary participation, the study uses a hybrid qualitative-quantitative methodology. This study uses Cubic Spherical Neutrosophic Numbers to evaluate the criteria and alternatives and overcome vague information. The results demonstrate how digital resources may be used to supplement traditional techniques, increasing traditional music's sustainability and exposure in modern culture.

**Keywords:** Cubic Spherical Neutrosophic Numbers; Intangible Cultural Heritage; Traditional Music; Evaluation Model.

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### 1. Introduction

In 1998, F. Smarandache expanded on Atanassov's theory of intuitionistic fuzzy sets by introducing and analyzing neutrosophic sets (NSs). Numerous NS generalizations have since surfaced, finding use in a wide range of domains[1], [2].

By transforming neutrosophic data into geometric spheres and creating a geometric representation with distinguishable centers and radii, Cubic Spherical Neutrosophic Sets (CSNs)

provide a revolutionary method[3]. A more thorough comprehension of uncertain information is made possible by this advanced representation, which expands the potential of conventional neutrophilic sets. Weighted additive and weighted geometric aggregation operations that are especially suited for CSNSs are defined and investigated in this paper. These operators are essential for negotiating the intricacies of ambiguous data and giving decision-makers strong instruments for well-informed choices[4], [5].

In the area of neutrosophic sets, the following contributions are made:

- This study proposes a neutrosophic set model for Communication Effectiveness Evaluation of Intangible Cultural Heritage Traditional Music.
- This study uses Cubic Spherical Neutrosophic Numbers to evaluate the criteria and alternatives.
- We use the Spherical Neutrosophic Numbers, then these numbers are converted to Cubic Spherical Neutrosophic Numbers.
- Six criteria and eight alternatives are used in this study.
- The CSNNs arithmetic operator and geometric operator are used in this study.

## 2. Related Work

Lack of inheritors and a limited audience present communication challenge for intangible cultural assets. As digital technologies have advanced, using digital communication techniques to close the communication gap has become essential. Consequently, the academic community is now focused on the process of enhancing the way traditional assets are presented to the public and altering the current conventional communication of intangible cultural heritage in conjunction with digital communication technology. The attention-interest-desire-memory-action audience reaction model and the technological acceptance model serve as the foundation for Xue et al.[6]'s definition of three layers of critical elements that affect the impacts of intangible cultural heritage on digital communication, along with their corresponding weights.

The Delphi approach is used to help conduct in-depth interviews with 50 seasoned specialists from six key areas linked to this research. The analytic hierarchy approach is used to build a theoretical evaluation model of the influence of intangible cultural assets on digital communication. The results of their study are expected to help with the communication and preservation of intangible cultural heritage by offering scholarly references and practical directions for the use of digital communication technologies in cultural communication.

There is a wealth of intangible cultural history along the Grand Canal of China, which is recognized as a UNESCO World history Site. Folk songs are a significant example of the intangible cultural heritage. To support the preservation and advancement of intangible cultural assets in pertinent regions as well as the establishment of the Grand Canal Cultural Belt, it is practically and socially significant to investigate its distribution features and influencing variables. Li [7] examined the distribution pattern of intangible cultural heritage items in the

Grand Canal basin from the perspectives of natural and social conditions, as well as from the dimensions of geographical and folk song genre, using the theories of musicology, geography, sociology, data statistical analysis, and spatial analysis.

Cao [8] examined the effects of digital marketing tactics for musical intangible cultural property on the TikTok short video platform. Using theories like Lasswell's Five Factors Communication Theory, Uses and Gratifications Theory, Digital Communication Theory, and Stimulus Organism Response Theory, a thorough theoretical framework for questionnaire analysis is developed. Participants' opinions on digital platforms, assessments of promotional strategies, and the function of digital communication in engagement and learning are then all covered in a questionnaire survey. This seeks to understand their views on digital communication as well as their understanding of musical intangible cultural property.

They specifically commend the usage of TikTok music and special effects as well as user involvement. Furthermore, most respondents said that they were "very familiar" or "relatively familiar" with musical intangible cultural heritage content on digital platforms, demonstrating a broad knowledge of this type of information. Digital communication has a major role in increasing attention, awareness, dissemination effects, audience demographic expansion, and engagement when it comes to promotional efficacy. He highlighted the critical role that digital communication plays in the transmission and promotion of intangible cultural heritage and offers empirical evidence in favor of promoting musical intangible cultural heritage on digital platforms.

### 3. Cubic Spherical Neutrosophic Numbers (CSNNs)

This part shows the definitions of CSNNs. The neutrosophic set is defined by three membership functions like truth, indeterminacy, falsity values[9]. Neutrosophic set is defined by:

$$N_e = \{(T_N(e), I_N(e), F_N(e)) | e \in E\}$$

The CSNNs can be defined as:

$$N_e = (csnT_N(e), csnI_N(e), csnF_N(e))$$

$$snT_N(e), csnI_N(e), csnF_N(e) \rightarrow [0,1]$$

These values present membership, non-membership, indeterminacy, and radius.

$$0 \leq csnT_N(e), csnI_N(e), csnF_N(e) \leq 3$$

$$CnT_N(e), csnI_N(e), csnF_N(e) = \left( \frac{\sum_{j=1}^{k_i} T_{i,j}}{k_i}, \frac{\sum_{j=1}^{k_i} I_{i,j}}{k_i}, \frac{\sum_{j=1}^{k_i} F_{i,j}}{k_i} \right)$$

The radius is defined as:

$$R_i = \min \left\{ \max_{1 \leq j \leq k_i} \sqrt{\begin{aligned} &\left( \text{cns} T_N(e) - T_{i,j}(e) \right)^2 + \\ &\left( \text{cns} I_N(e) - I_{i,j}(e) \right)^2 + \\ &\left( \text{cns} F_N(e) - F_{i,j}(e) \right)^2 \end{aligned}} \right\}$$

The cosine distance of CSNN is defined as:

$$\cos(e_1, e_2) = \left( 1 - \frac{\begin{aligned} &\text{cns } T_{e_1} \text{cns } T_{e_2} + \\ &\text{cns } I_{e_1} \text{cns } I_{e_2} + \\ &\text{cns } F_{e_1} \text{cns } F_{e_2} \end{aligned}}{\begin{aligned} &\| \text{cns } T_{e_1} \| \| \text{cns } T_{e_2} \| + \\ &\| \text{cns } I_{e_1} \| \| \text{cns } I_{e_2} \| + \\ &\| \text{cns } F_{e_1} \| \| \text{cns } F_{e_2} \| \end{aligned}} \times \frac{|R_{e_1} - R_{e_2}|}{\max(R_{e_1}, R_{e_2})} \right)$$

The operations of two CSNNs are defined as:

$$e_1 \oplus e_2 = \left( \begin{aligned} &\text{cns } T_{e_1} + \text{cns } T_{e_2} - \text{cns } T_{e_1} \text{cns } T_{e_2}, \\ &\text{cns } I_{e_1} \text{cns } I_{e_2}, \\ &\text{cns } F_{e_1} \text{cns } F_{e_2}; \\ &R_{e_1} + R_{e_2} - R_{e_1} R_{e_2} \end{aligned} \right)$$

$$e_1 \otimes e_2 = \left( \begin{aligned} &\text{cns } T_{e_1} \text{cns } T_{e_2}, \\ &\text{cns } I_{e_1} + \text{cns } I_{e_2} - \text{cns } I_{e_1} \text{cns } I_{e_2}, \\ &\text{cns } F_{e_1} + \text{cns } F_{e_2} - \text{cns } F_{e_1} \text{cns } F_{e_2}; \\ &R_{e_1} R_{e_2} \end{aligned} \right)$$

$$He_1 = \left( \begin{aligned} &1 - (1 - \text{cns } T_{e_1})^H, \\ &(\text{cns } I_{e_1})^H, \\ &(\text{cns } F_{e_1})^H, \\ &1 - (1 - R_{e_1})^H \end{aligned} \right)$$

$$e_1^H = \left( \begin{aligned} &(\text{cns } T_{e_1})^H, \\ &1 - (1 - \text{cns } I_{e_1})^H, \\ &1 - (1 - \text{cns } F_{e_1})^H, \\ &(R_{e_1})^H \end{aligned} \right)$$

#### 4. Aggregation Operations of CSNNs

The arithmetic operator of CSNNs is defined as:

$$CSNNWA_w(e_1, e_2, \dots, e_n) = \left( \begin{array}{c} 1 - \prod_{j=1}^n (1 - csn T_{e_j})^{w_j}, \\ \prod_{j=1}^n (csn I_{e_j})^{w_j}, \\ \prod_{j=1}^n (csn F_{e_j})^{w_j}, \\ 1 - \prod_{j=1}^n (1 - R_{e_j})^{w_j} \end{array} \right)$$

The geometric operator of CSNNs is defined as:

$$CSNNWG_w(e_1, e_2, \dots, e_n) = \left( \begin{array}{c} \prod_{j=1}^n (csn T_{e_j})^{w_j}, \\ 1 - \prod_{j=1}^n (1 - csn I_{e_j})^{w_j}, \\ 1 - \prod_{j=1}^n (1 - csn F_{e_j})^{w_j}, \\ \prod_{j=1}^n (R_{e_j})^{w_j} \end{array} \right)$$

## 5. Cubic Spherical Neutrosophic Number Model

This section shows the proposed approach to ranking the alternatives. This section uses the CSNN operator to combine the neutrosophic numbers. There are different decision makers who are experts who evaluate the criteria and alternatives, so, combining these values is an important role to obtain accurate results of ranking of alternatives. CSNN overcome the problems in the previous aggregation operations. This methodology is implemented for Communication Effectiveness Evaluation of Intangible Cultural Heritage Traditional Music.

Let a set of criteria  $CSNC = (CSNC_1, CSNC_2, \dots, CSNC_m)$  and set of alternatives such as  $CSNA = (CSNA_1, CSNA_2, \dots, CSNA_m)$ . The proposed approach is introduced as:

- Stage 1. Start.
- Stage 2. Input: set of criteria and set of alternatives.
- Stage 3. Evaluate criteria and alternatives using opinions of set of experts and decision makers.
- Stage 4. For every alternative, create the cubic spherical neutrosophic number using:

$$CnT_N(e), csnI_N(e), csnF_N(e) = \left( \frac{\sum_{j=1}^{k_i} T_{i,j}}{k_i}, \frac{\sum_{j=1}^{k_i} I_{i,j}}{k_i}, \frac{\sum_{j=1}^{k_i} F_{i,j}}{k_i} \right)$$

$$R_i = \min \left\{ \max_{1 \leq j \leq k_i} \left[ \frac{\left( \text{cns} T_N(e) - T_{i,j}(e) \right)^2 + \left( \text{cns} I_N(e) - I_{i,j}(e) \right)^2 + \left( \text{cns} F_N(e) - F_{i,j}(e) \right)^2}{3} \right] \right\}$$

Stage 5. Combine the values of criteria and alternatives using the CSN arithmetic operator:

$$CSNNWA_w(e_1, e_2, \dots, e_n) = \left( \begin{array}{c} 1 - \prod_{j=1}^n (1 - \text{cns} T_{e_j})^{w_j}, \\ \prod_{j=1}^n (\text{cns} I_{e_j})^{w_j}, \\ \prod_{j=1}^n (\text{cns} F_{e_j})^{w_j}, \\ 1 - \prod_{j=1}^n (1 - R_{e_j})^{w_j} \end{array} \right)$$

Stage 6. Compute the cosine distance.

Stage 7. Rank the alternatives.

The alternatives are ranked based on the smallest value in cosine distance.

Stage 8. Output. Greatest alternative

End.

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## 6. Results Analysis

This section shows the analysis of the results of the proposed approach to obtain the highest rank of alternatives. This study introduces the ranking of alternatives of Communication Effectiveness Evaluation of Intangible Cultural Heritage Traditional Music. We use six criteria and eight alternatives as shown in Table 1.

Table 1. Criteria for Communication Effectiveness Evaluation of Intangible Cultural Heritage Traditional Music.

Criteria	Alternatives
Audience Reach and Engagement	Live Performances and Festivals
Cultural Authenticity Preservation	Educational Workshops in Schools and Universities
Multimedia Communication Channels (e.g., audio, video, VR)	Radio Broadcasts and Traditional Media
Intergenerational Knowledge Transfer	YouTube Channels Featuring Traditional Music
Public Awareness and Recognition	Interactive Mobile Apps for Music Exploration
Emotional and Aesthetic Resonance	Virtual Reality (VR) or Augmented Reality (AR) Music Experiences
	Museum Exhibits with Audio Archives
	Podcasts and Storytelling Platforms Featuring Traditional Music

Three experts evaluate the criteria and alternatives using spherical neutrosophic number as shown in Table 2.

Table 2. SNNs.

	CSNC <sub>1</sub>	CSNC <sub>2</sub>	CSNC <sub>3</sub>	CSNC <sub>4</sub>	CSNC <sub>5</sub>	CSNC <sub>6</sub>
CSNA <sub>1</sub>	(0.9,0.1,0.1)	(0.8,0.2,0.3)	(0.6,0.5,0.4)	(0.4,0.5,0.6)	(0.3,0.6,0.7)	(0.2,0.7,0.8)
CSNA <sub>2</sub>	(0.9,0.1,0.1)	(0.1,0.8,0.9)	(0.2,0.7,0.8)	(0.3,0.6,0.7)	(0.4,0.5,0.6)	(0.6,0.5,0.4)
CSNA <sub>3</sub>	(0.8,0.2,0.3)	(0.6,0.5,0.4)	(0.4,0.5,0.6)	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.8,0.2,0.3)
CSNA <sub>4</sub>	(0.4,0.5,0.6)	(0.6,0.5,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.1)	(0.1,0.8,0.9)	(0.9,0.1,0.1)
CSNA <sub>5</sub>	(0.3,0.6,0.7)	(0.4,0.5,0.6)	(0.6,0.5,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.1)	(0.1,0.8,0.9)
CSNA <sub>6</sub>	(0.3,0.6,0.7)	(0.3,0.6,0.7)	(0.4,0.5,0.6)	(0.3,0.6,0.7)	(0.1,0.8,0.9)	(0.2,0.7,0.8)
CSNA <sub>7</sub>	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.1,0.8,0.9)	(0.3,0.6,0.7)	(0.4,0.5,0.6)
CSNA <sub>8</sub>	(0.1,0.8,0.9)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.4,0.5,0.6)	(0.6,0.5,0.4)
	CSNC <sub>1</sub>	CSNC <sub>2</sub>	CSNC <sub>3</sub>	CSNC <sub>4</sub>	CSNC <sub>5</sub>	CSNC <sub>6</sub>
CSNA <sub>1</sub>	(0.4,0.5,0.6)	(0.8,0.2,0.3)	(0.6,0.5,0.4)	(0.4,0.5,0.6)	(0.3,0.6,0.7)	(0.2,0.7,0.8)
CSNA <sub>2</sub>	(0.6,0.5,0.4)	(0.1,0.8,0.9)	(0.2,0.7,0.8)	(0.4,0.5,0.6)	(0.4,0.5,0.6)	(0.6,0.5,0.4)
CSNA <sub>3</sub>	(0.8,0.2,0.3)	(0.6,0.5,0.4)	(0.4,0.5,0.6)	(0.6,0.5,0.4)	(0.4,0.5,0.6)	(0.8,0.2,0.3)
CSNA <sub>4</sub>	(0.9,0.1,0.1)	(0.6,0.5,0.4)	(0.8,0.2,0.3)	(0.8,0.2,0.3)	(0.6,0.5,0.4)	(0.9,0.1,0.1)
CSNA <sub>5</sub>	(0.1,0.8,0.9)	(0.4,0.5,0.6)	(0.6,0.5,0.4)	(0.9,0.1,0.1)	(0.8,0.2,0.3)	(0.1,0.8,0.9)
CSNA <sub>6</sub>	(0.4,0.5,0.6)	(0.4,0.5,0.6)	(0.4,0.5,0.6)	(0.1,0.8,0.9)	(0.9,0.1,0.1)	(0.4,0.5,0.6)
CSNA <sub>7</sub>	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.6,0.5,0.4)	(0.8,0.2,0.3)
CSNA <sub>8</sub>	(0.8,0.2,0.3)	(0.8,0.2,0.3)	(0.8,0.2,0.3)	(0.3,0.6,0.7)	(0.6,0.5,0.4)	(0.8,0.2,0.3)
	CSNC <sub>1</sub>	CSNC <sub>2</sub>	CSNC <sub>3</sub>	CSNC <sub>4</sub>	CSNC <sub>5</sub>	CSNC <sub>6</sub>
CSNA <sub>1</sub>	(0.9,0.1,0.1)	(0.8,0.2,0.3)	(0.6,0.5,0.4)	(0.4,0.5,0.6)	(0.3,0.6,0.7)	(0.2,0.7,0.8)
CSNA <sub>2</sub>	(0.1,0.8,0.9)	(0.1,0.8,0.9)	(0.2,0.7,0.8)	(0.3,0.6,0.7)	(0.4,0.5,0.6)	(0.6,0.5,0.4)
CSNA <sub>3</sub>	(0.2,0.7,0.8)	(0.9,0.1,0.1)	(0.4,0.5,0.6)	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.8,0.2,0.3)
CSNA <sub>4</sub>	(0.3,0.6,0.7)	(0.1,0.8,0.9)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)
CSNA <sub>5</sub>	(0.4,0.5,0.6)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.9,0.1,0.1)	(0.1,0.8,0.9)	(0.9,0.1,0.1)
CSNA <sub>6</sub>	(0.6,0.5,0.4)	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.2,0.7,0.8)	(0.1,0.8,0.9)
CSNA <sub>7</sub>	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.8,0.2,0.3)	(0.9,0.1,0.1)
CSNA <sub>8</sub>	(0.1,0.8,0.9)	(0.1,0.8,0.9)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.9,0.1,0.1)	(0.1,0.8,0.9)

The spherical neutrosophic number is converted to cubic spherical neutrosophic number as shown in Figures 1-6.

The CSNN is combined using the CSNN arithmetic operator. The cosine distance is used to obtain a final score. The ranks of alternative are shown in Figure 7.

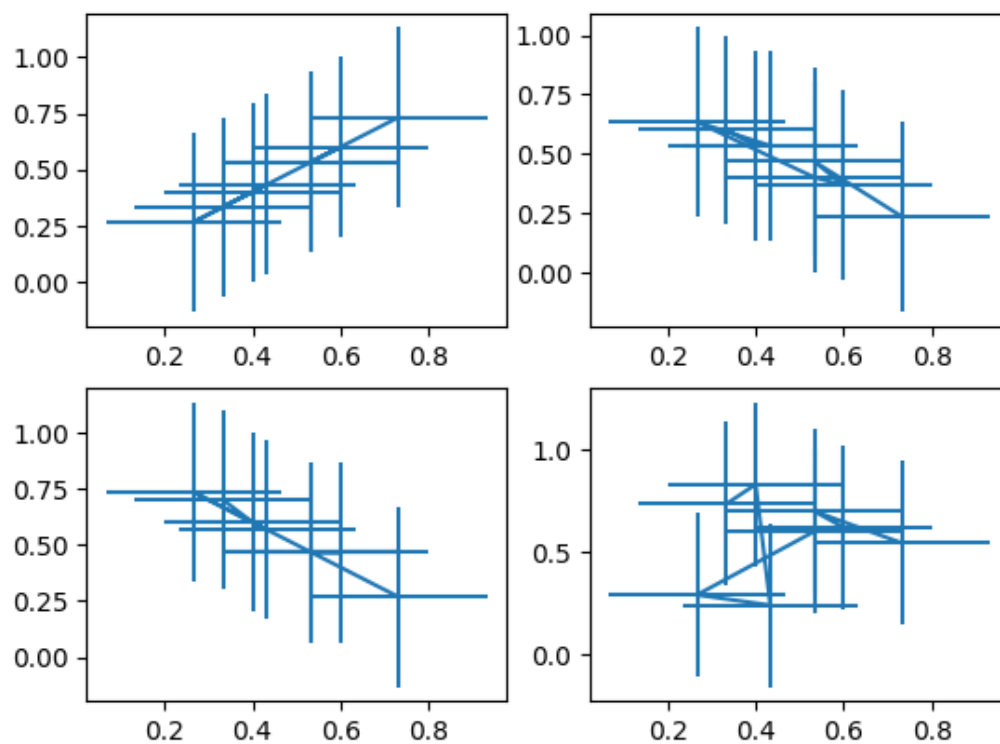


Figure 1. First cubic spherical neutrosophic number.

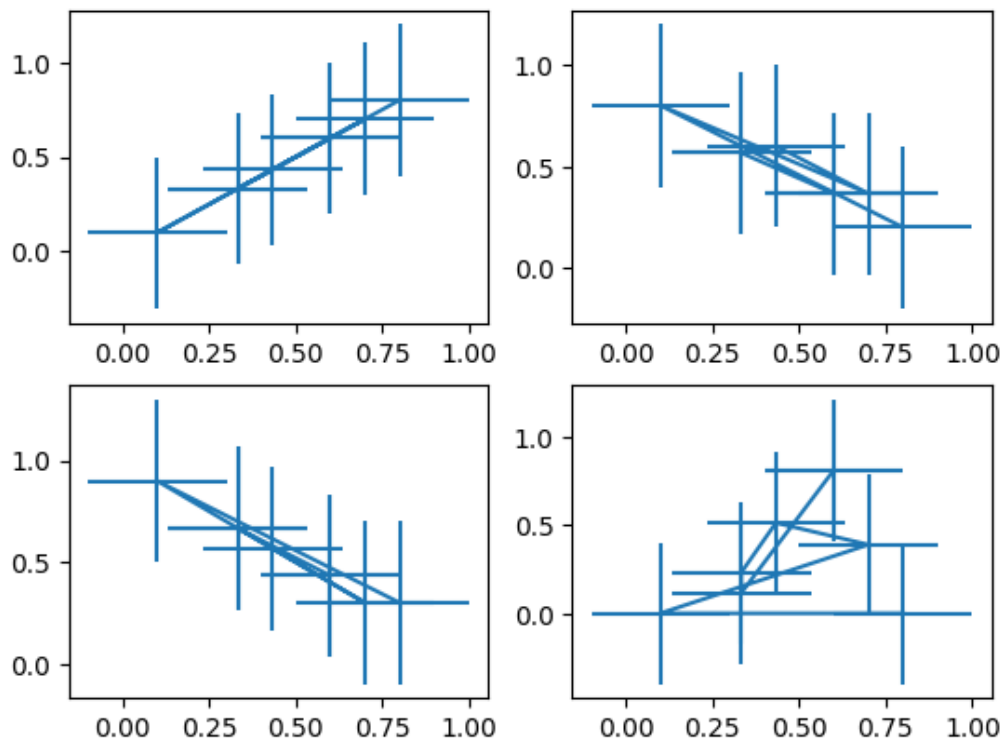


Figure 2. Second cubic spherical neutrosophic number.

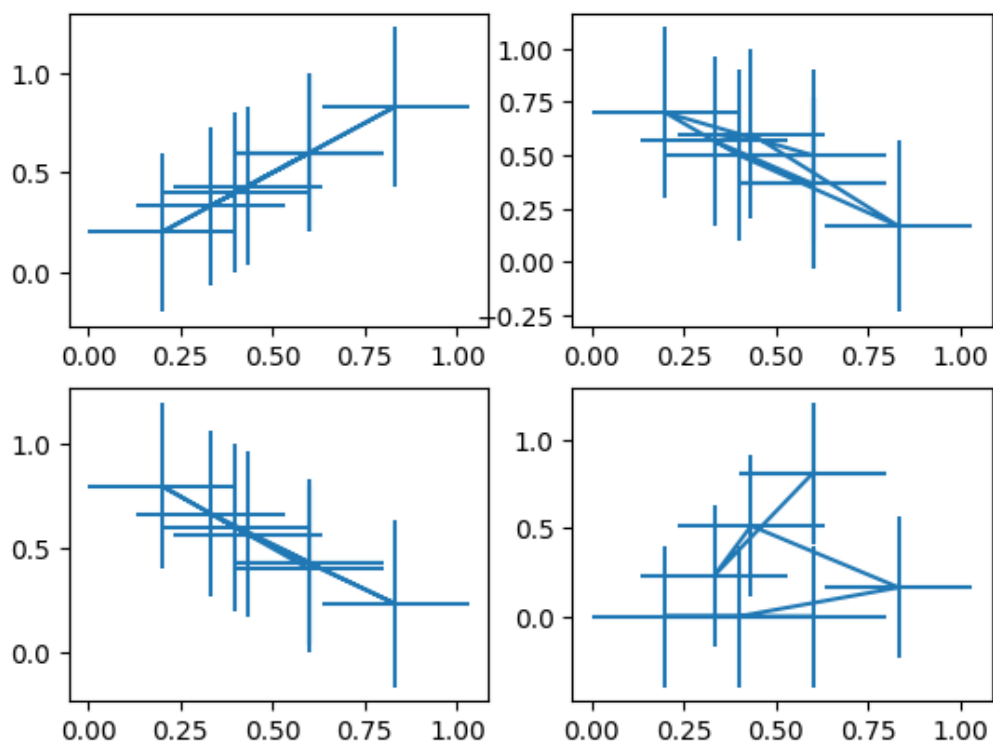


Figure 3. Third cubic spherical neutrosophic number.

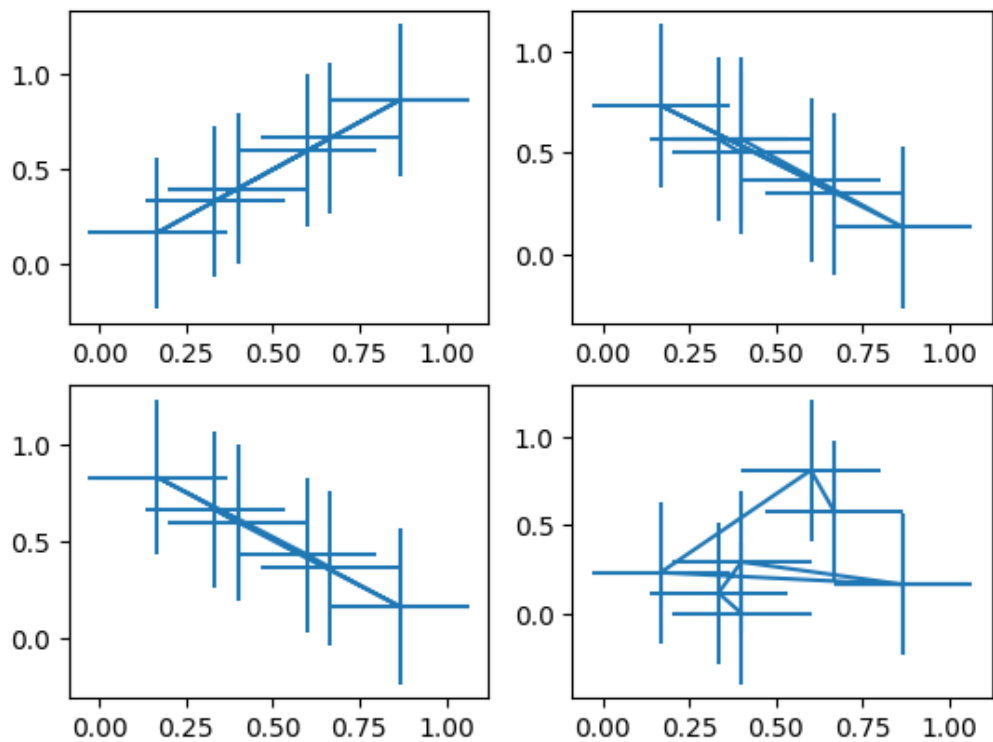


Figure 4. Fourth cubic spherical neutrosophic number.

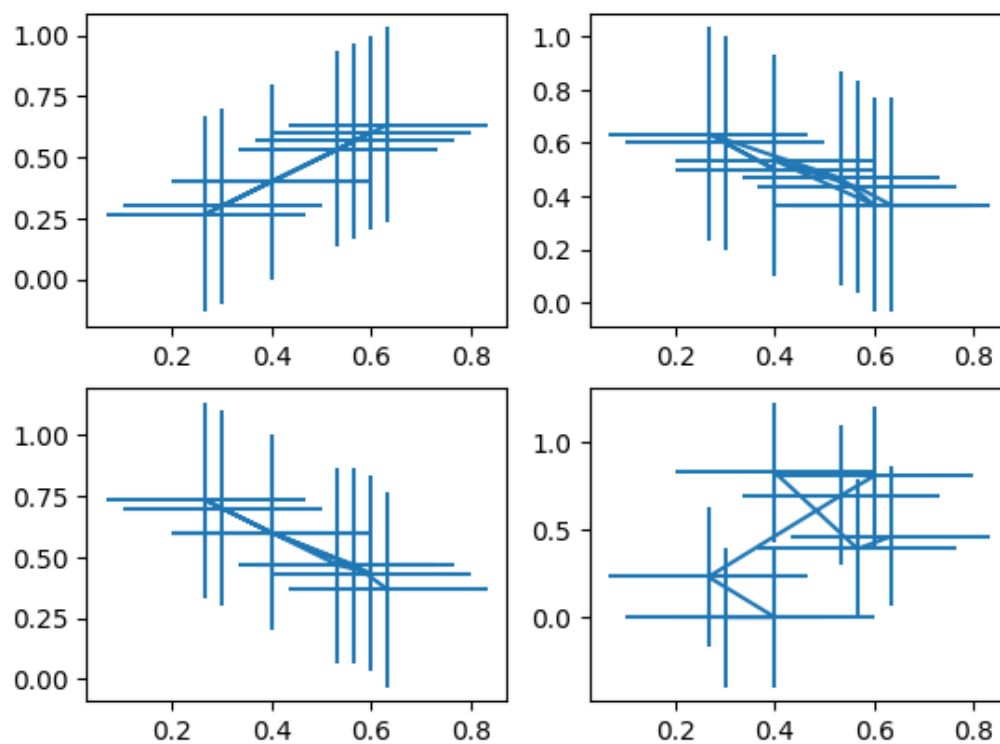


Figure 5. Fifth cubic spherical neutrosophic number.

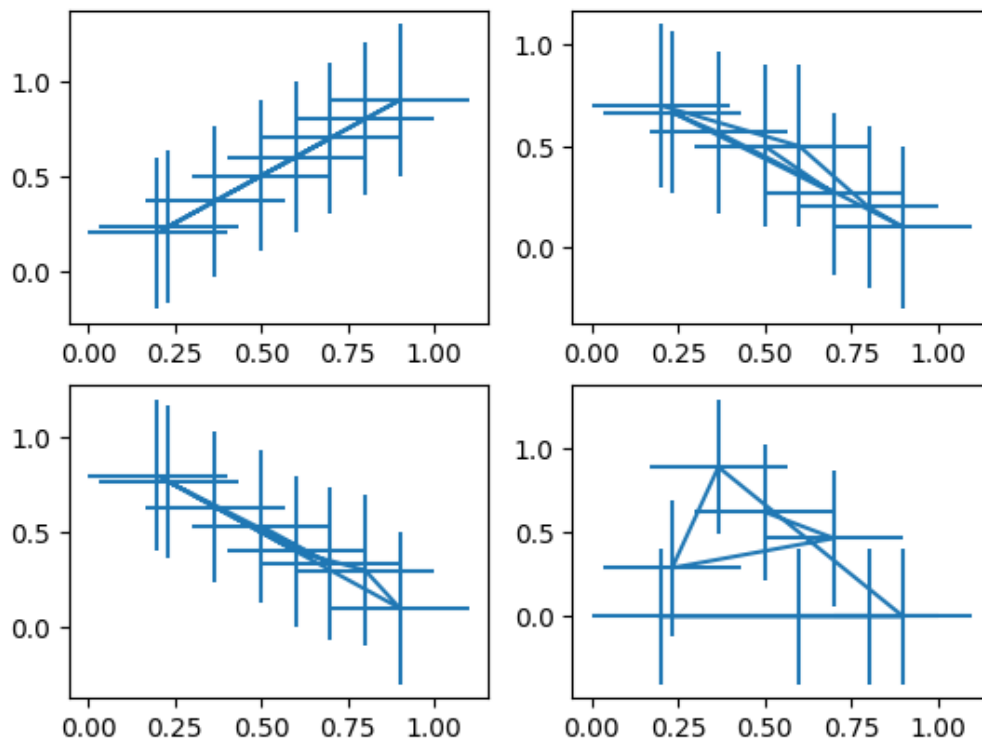


Figure 6. Sixth cubic spherical neutrosophic number.

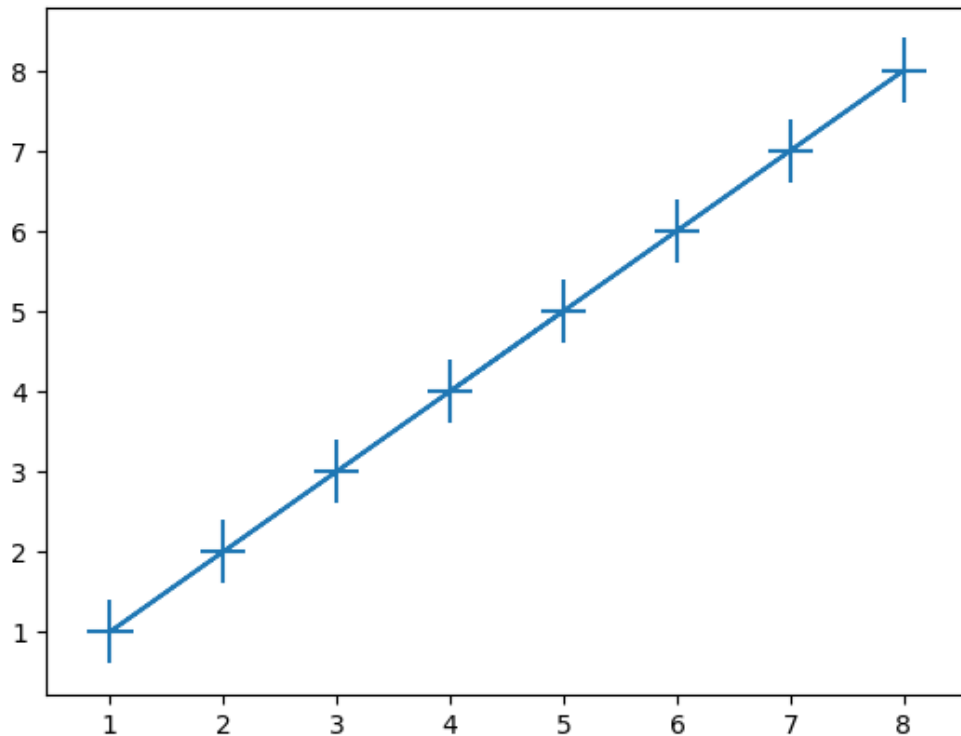


Figure 7. Rank of alternatives.

## 7. Conclusions

According to this assessment, the incorporation of digital platforms—such as smartphone applications, and virtual reality—offers promise pathways for wider and more participatory distribution, even while conventional communication modalities like live performances and educational programs remain essential. While digital approaches excelled in reach and accessibility, face-to-face or experience settings were determined to have the best emotional resonance and cultural authenticity. For the successful dissemination of ICH traditional music, a hybrid communication strategy that blends conventional and contemporary methods is advised. In addition to guaranteeing increased audience involvement, this hybrid approach promotes a better understanding of culture, ensuring intangible heritage's ongoing relevance and vitality in the digital age. Experts used the Spherical Neutrosophic Numbers to evaluate the criteria and alternatives. These numbers are converted to Cubic Spherical Neutrosophic Numbers (CSNNs). The CSNN operator is used to combine these numbers. The alternatives are ranked based on the cosine distance.

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