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# Multi-Valued Q-Neutrosophic Computation for Enhancing the Digital Media Content Creation and Editing with Computer Assistance

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**Abstract:** In the era of modern content production, evaluating digital creation tools across diverse hardware environments and user perspectives involves inherent vagueness, uncertainty, and subjectivity. This work Multi-valued Q-neutrosophic Computation (MV-QNC) approach for enhancing digital content creation by adapting to subjective artistic preferences. MV-QNC acts as a dependable tool to represent ambiguous, incomplete, unpredictable, and hesitant decision-making information and replicate the distribution features of all underlying assessment values. First, we introduce a definition of multi-valued Q-neutrosophic soft sets (MQNSS), along with extended combination operations, as well as necessity and possibility operations. Next, we present a methodological approach for multi-criteria group decision-making based on MV-QNC, that integrates a new multi-valued aggregation operator, as well as a balanced scoring function that accounts for the nature of different criteria. Finally, an explanatory example regarding Digital Content Creation is introduced to validate the proposed MV-QNC approach, and the results demonstrate their viability and legitimacy by comparison with other previous studies.

**Keywords:** Neutrosophic Logic (NL); Multi-Valued Neutrosophic Sets (MNS); Uncertainty Modeling; Digital Art; Digital Media Editing; Decision-Making.

## I. Introduction

In the digital age, computer-assisted digital content creation and editing have transformed industries such as graphic design [1], filmmaking [2], animation, virtual reality (VR), augmented reality (AR) [3], and multimedia production [4]. AI-driven tools, deep learning algorithms, and automation software have revolutionized content generation, enabling artists, designers, and editors to create sophisticated visual and audio media with increased efficiency. However, digital content creation and editing involve numerous uncertainties, including subjective aesthetic preferences, content variations, and ambiguous artistic choices [5], [6], [7]. Standards computing techniques like deterministic and probabilistic approaches have struggled to effectively capture and process such imprecise, indeterminate, and contradictory data in creative decision-making procedures. Consequently, there is a growing need for intelligent, uncertainty-aware computational methods that might adapt to the dynamic and multi-valued nature of digital media creation [8].

Despite the promise of advancements in computer-assisted digital content creation, there are several key challenges still come into sight. First, Digital media content is inherently subjective, making it difficult to define exact rules for enhancements, artistic styles, or content aesthetics. Images and videos often contain noise, missing information, or distortions that make automated editing challenging. Third, AI-based digital editing systems have to make decisions about colors, texture, filters, as well as style, often requiring user feedback [8]. Current models struggle to balance automation with user creativity. Fourth, the legacy soft computing approaches are constrained to handle only a limited degree of vagueness and may not capture higher-order uncertainties effectively [9].

Neutrosophic set (NS), first introduced by Florentin Smarandache, extends classical and fuzzy logic by introducing three fundamental components: Truth (T), Indeterminacy (I), Falsity (F) [10], [11]. NS provided a robust approach for handling imprecision, inconsistency, and incompleteness in various real-world applications. It allowed systems to count ambiguity, aesthetic uncertainty, and subjective artistic intent more successfully than out-of-date approaches [10], [11].

In response to the above-mentioned challenges, this research introduced and applied a neutrosophic computation approach that aims to achieve the following objectives:

- Exploration of the theoretical foundation of the new application of NSs for enhancing the computer-aided digital content creation as well as editing.
- Development of an assistive tool to enhance image and video processing algorithms through the incorporation of the NS method for adaptive filtering, enhancement, and noise reduction.
- Introduce novel application of NS model into real-world case studies in digital image enhancement, and video editing, evaluating its performance and effectiveness NS in improving the quality and expressiveness of digital content.

To achieve the aforementioned objectives, this work multi-valued Q-neutrosophic Computation (MV-QNC) approach for uncertainty-aware digital content creation that can adapt to subjective artistic preferences. Our MV-QNC extends traditional Q-neutrosophic sets [12], [13] to handle granular, uncertain, and context-sensitive evaluations, where each component is re-designated with a set of discrete values rather than single points. Our MV-QNC introduces A two-level aggregation-based decision algorithm that aggregates neutrosophic evaluations across multiple contexts, then computes a normalized score per parameter and ranks alternatives accordingly. We introduce a novel application of Our MV-QNC to evaluate digital content creation tools across multiple criteria and qualifiers, which imitate real-world subjectivity and context-variability in expert judgments. Finally, a proof-of-concept analysis is conducted and the quantitative and qualitative results demonstrate the efficiency and competitiveness of MV-QNC over the state-of-the-art (SOTA) methods.

To ease the navigation of this article, we provide the outline of the remaining part of this article as follows. Fundamental definitions are recapped in Sec. II. Sec III discusses the methodology of the proposed framework in the solution. In Sec IV, we discuss the application of our methods and discuss the results. Finally, we conclude our research in Sec V.

## II. Fundamentals

Herein, we provide a quick recap of fundamental concepts along with the subject matter of our work.

**Definition 1 (**[10], [11]**).** With the assumption of $\mathbb{U}$ as a universe of discourse, neutrosophic set $\aleph$ can be defined as:

$$\aleph = \{\langle \mathbb{u},(\mathbb{T}_{\aleph}(\mathbb{u}),\mathbb{I}_{\aleph}(\mathbb{u}),\mathbb{F}_{\aleph}(\mathbb{u}))\rangle : \mathbb{u} \in \mathbb{U}\},$$
$$\text{where}$$
$$\mathbb{T}_{\aleph}(\mathbb{u}), \mathbb{I}_{\aleph}(\mathbb{u}), \mathbb{F}_{\aleph}(\mathbb{u}) : \mathbb{U} \to ]^{-}0, 1^{+}[ \text{ and } {}^{-}0 \le \mathbb{T}_{\aleph}(\mathbb{u}) + \mathbb{I}_{\aleph}(\mathbb{u}) + \mathbb{F}_{\aleph}(\mathbb{u}) \le 3^{+} \quad (1)$$

**Definition 2 (**[14]**).** With the assumption of $\mathbb{U}$ as a universe of discourse and Q as a nonempty set, then the Q-neutrosophic set, $\aleph_Q$, is articulated follows:

$$\aleph_Q = \{\langle (\mathbb{u}, q), \mathbb{T}_{\aleph_Q}(\mathbb{u}, q), \mathbb{I}_{\aleph_Q}(\mathbb{u}, q), \mathbb{F}_{\aleph_Q}(\mathbb{u}, q)\rangle : \mathbb{u} \in \mathbb{U}, q \in Q\},$$
$$\text{where}$$
$$\mathbb{T}_{\aleph_Q}, \mathbb{I}_{\aleph_Q}, \mathbb{F}_{\aleph_Q} : \mathbb{U} \times Q \to ]^{-}0, 1^{+}[ \text{ and } {}^{-}0 \le \mathbb{T}_{\aleph_Q} + \mathbb{I}_{\aleph_Q} + \mathbb{F}_{\aleph_Q} \le 3^{+} \quad (2)$$

**Definition 3 (**[14]**).** With the assumption of $\mathbb{U}$ as a universe of discourse and Q as a nonempty set, l be any positive integer and I be a unit interval [0,1], then multi Q-neutrosophic set $\tilde{\aleph}_Q$ in $\mathbb{U}$ and Q is a set of ordered sequences

$$\tilde{\aleph}_Q = \{\langle (\mathbb{u}, q), \mathbb{T}_{\tilde{\aleph}_{Q_i}}(\mathbb{u}, q), \mathbb{I}_{\tilde{\aleph}_{Q_i}}(\mathbb{u}, q), \mathbb{F}_{\tilde{\aleph}_{Q_i}}(\mathbb{u}, q)\rangle : \mathbb{u} \in \mathbb{U}, q \in Q$$
$$\text{where}$$
$$\mathbb{T}_{\tilde{\aleph}_{Q_i}}, \mathbb{I}_{\tilde{\aleph}_{Q_i}}, \mathbb{F}_{\tilde{\aleph}_{Q_i}} : \mathbb{U} \times Q \to \mathbb{I}^l \ \forall\, i = 1,2, \dots, l \quad (3)$$
$$0 \le \mathbb{T}_{\tilde{\aleph}_{Q_i}} + \mathbb{I}_{\tilde{\aleph}_{Q_i}} + \mathbb{F}_{\tilde{\aleph}_{Q_i}} \le 3 \ \forall\ i = 1,2, \dots, l$$

**Definition 4 (**[13]**).** Given $\mathbb{U}$ as a universe of discourse, $Q$ as a nonempty set, and $E$ as set of parameters, and multi Q-neutrosophic sets, $\mu^l QNS(\mathbb{U})$, with dimension $l = 1$, then, a Q-neutrosophic soft set (Q-NSS) can be define as follows:

$$\aleph_Q: \mathbb{G} \to \mu^l QNS(\mathbb{U}) \text{ such that } \mathbb{G} \subseteq E \text{ and } \aleph_Q(e) = \phi \text{ if } e \notin \mathbb{G} \quad (4)$$

Q-NSS can be represented by the set of ordered pairs

$$(\aleph_Q, \mathbb{G}) = \{(e, \aleph_Q(e)): e \in \mathbb{G}, \aleph_Q \in \mu^l QNS(\mathbb{U})\}. \quad (5)$$

**Definition 5 ([14],[13]).** Given two subsets $(\aleph_Q, \mathbb{G}) = \left\{\left(\mathbb{T}_{\aleph_Q(e_j)}(\mathfrak{u}, q)_i, \mathbb{I}_{\aleph_Q(e_j)}(\mathfrak{u}, q)_i, \mathbb{F}_{\aleph_Q(e_j)}(\mathfrak{u}, q)_i\right): \forall e_j \in \mathbb{G}, (\mathfrak{u}, q)_i \in \mathbb{U} \times Q\right\} \in QNSS(\mathbb{U})$ and $(\Omega_Q, \mathbb{O}) = \left\{\left(\mathbb{T}_{\Omega_Q(e_j)}(\mathfrak{u}, q)_i, \mathbb{I}_{\Omega_Q(e_j)}(\mathfrak{u}, q)_i, \mathbb{F}_{\Omega_Q(e_j)}(\mathfrak{u}, q)_i\right): \forall e_j \in \mathbb{O}, (\mathfrak{u}, q)_i \in \mathbb{U} \times Q\right\} \in Q - NSS(\mathbb{U})$, then the $(\Omega_Q, \mathbb{O})$ can be declared as subset of $(\aleph_Q, \mathbb{G})$ if $\mathbb{O} \subseteq \mathbb{G}$ and $\Omega_Q(\mathfrak{u}) \subseteq \aleph_Q(\mathfrak{u})$ for all $\mathfrak{u} \in \mathbb{U}$.

$$\mathbb{G} \subseteq \mathbb{O} \;\&\; \Gamma_Q(e) \subseteq \Omega_Q(e) \forall e \in \mathbb{G}$$

where

$$\mathbb{T}_{\Gamma_Q(e)}(\mathfrak{u}, q) \leq \mathbb{T}_{\Omega_Q(e)}(\mathfrak{u}, q), \quad (6)$$
$$\mathbb{I}_{\Gamma_Q(e)}(\mathfrak{u}, q) \geq \mathbb{I}_{\Omega_Q(e)}(\mathfrak{u}, q), \mathbb{F}_{\Gamma_Q(e)}(\mathfrak{u}, q) \geq \mathbb{F}_{\Omega_Q(e)}(\mathfrak{u}, q), \forall (\mathfrak{u}, q) \in \mathbb{U} \times Q$$

**Definition 6 ([14],[13]).** Given two QNSSs $(\Gamma_Q, X) = \left\{\left(\mathrm{T}_{\Gamma_Q(e)}(\mathfrak{u}, q), \mathrm{I}_{\Gamma_Q(e)}(\mathfrak{u}, q), \mathrm{F}_{\Gamma_Q(e)}(\mathfrak{u}, q)\right): \forall e \in X, (\mathfrak{u}, q) \in \mathbb{U} \times Q\right\}$ and $(\Omega_Q, Y) = \left\{\left(\mathrm{T}_{\Omega_Q(e)}(\mathfrak{u}, q), \mathrm{I}_{\Omega_Q(e)}(\mathfrak{u}, q), \mathrm{F}_{\Omega_Q(e)}(\mathfrak{u}, q)\right): \forall e \in Y, (\mathfrak{u}, q) \in \mathbb{U} \times Q\right\}$, the union of these two sets can be symbolized as $(\cup_Q, C) = (\Gamma_Q, A) \cup (\Omega_Q, B)$, in which the membership functions are computed as follows:

$$\mathbb{T}_{\cup_Q(c)}(u, q) = \begin{cases} \mathbb{T}_{\Gamma_Q(c)}(u, q) & if c \in \mathbb{G} - \mathbb{O}, \\ \mathbb{T}_{\Omega_Q(c)}(u, q) & if c \in \mathbb{O} - \mathbb{G}, \\ max\{\mathbb{T}_{\Lambda_Q(c)}(u, q), \mathbb{T}_{\Omega_Q(c)}(u, q)\} & if c \in \mathbb{G} \cap \mathbb{O}, \end{cases}$$
$$\mathbb{I}_{\cup_Q(c)}(u, q) = \begin{cases} \mathbb{I}_{\Gamma_Q(c)}(u, q) & if c \in \mathbb{G} - \mathbb{O}, \\ \mathbb{I}_{\Omega_Q(c)}(u, q) & if c \in \mathbb{O} - \mathbb{G}, \\ \min\left\{\mathbb{I}_{\Gamma_Q(c)}(u, q), \mathbb{I}_{\Omega_Q(c)}(u, q)\right\} & if c \in \mathbb{G} \cap \mathbb{O}, \end{cases} \quad (7)$$
$$\mathbb{F}_{\cup_Q(c)}(u, q) = \begin{cases} \mathbb{F}_{\Gamma_Q(c)}(u, q) & if c \in \mathbb{G} - \mathbb{O}, \\ \mathbb{F}_{\Omega_Q(c)}(u, q) & if c \in \mathbb{O} - \mathbb{G}, \\ min\{\mathbb{F}_{\Gamma_Q(c)}(u, q), \mathbb{F}_{\Omega_Q(c)}(u, q)\} & if c \in \mathbb{G} \cap \mathbb{O}. \end{cases}$$

where $C = A \cup B$ and $c \in C, (\mathfrak{u}, q) \in U \times Q$.

**Definition 7 ([14],[13]).** Given two QNSSs $(\aleph_Q, \mathbb{G}) = \left\{\left(\mathbb{T}_{\aleph_Q(e)}(\mathfrak{u}, q), \mathbb{I}_{\aleph_Q(e)}(\mathfrak{u}, q), \mathbb{F}_{\aleph_Q(e)}(\mathfrak{u}, q)\right): \forall e \in \mathbb{G}, (\mathfrak{u}, q) \in \mathbb{U} \times Q\right\}$ and $(\Omega_Q, \mathbb{O}) = \left\{\left(\mathbb{T}_{\Omega_Q(e)}(\mathfrak{u}, q), \mathbb{I}_{\Omega_Q(e)}(\mathfrak{u}, q), \mathbb{F}_{\Omega_Q(e)}(\mathfrak{u}, q)\right): \forall e \in \mathbb{O}, (\mathfrak{u}, q) \in \mathbb{U} \times Q\right\}$, the intersection of these two sets can be symbolized as $\left(\cap_Q, C\right) = (\Gamma_Q, \mathbb{G}) \cap (\Omega_Q, \mathbb{O})$, in which the membership functions are computed as follows:

$$\begin{aligned} \mathbb{T}_{\cap_Q(c)}(\mathbb{u}, q) &= min\left\{\mathbb{T}_{\Gamma_Q(c)}(\mathbb{u}, q), \mathbb{T}_{\Omega_Q(c)}(\mathbb{u}, q)\right\}, \\ \mathbb{I}_{\cap_Q(c)}(\mathbb{u}, q) &= max\left\{\mathbb{I}_{\Gamma_Q(c)}(\mathbb{u}, q), \mathbb{I}_{\Omega_Q(c)}(\mathbb{u}, q)\right\}, \\ \mathbb{F}_{\cap_Q(c)}(\mathbb{u}, q) &= max\left\{\mathbb{F}_{\Gamma_Q(c)}(\mathbb{u}, q), \mathbb{F}_{\Omega_Q(c)}(\mathbb{u}, q)\right\}. \end{aligned} \tag{8}$$

**Definition 8 (**[14],[13]**)**. Given a *QNSSs* $\left(\aleph_Q, \mathbb{G}\right) = \left\{\left(\mathbb{T}_{\aleph_Q(e)}(\mathbb{u}, q), \mathbb{I}_{\aleph_Q(e)}(\mathbb{u}, q), \mathbb{F}_{\aleph_Q(e)}(\mathbb{u}, q)\right): \forall e \in \mathbb{G}, (\mathbb{u}, q) \in \mathbb{U} \times Q\right\}$, then, its complement is defined as $(\Gamma_Q, \mathbb{G})^c = (\Gamma_Q^c, \mathbb{G})$,

$$(\Gamma_Q, \mathbb{G})^c = \left\{\langle e, \mathbb{T}^c_{\Gamma_Q(e)}(\mathbb{u}, q), \mathbb{I}^c_{\Gamma_Q(e)}(\mathbb{u}, q), \mathbb{F}^c_{\Gamma_Q(e)}(\mathbb{u}, q)\rangle : e \in \mathbb{G}, (\mathbb{u}, q) \in U \times Q\right\}, \tag{9}$$

such that $\forall e \in \mathbb{G}, (\mathbb{u}, q) \in \mathbb{U} \times Q$

$$\begin{aligned} \mathbb{T}^c_{\Gamma_Q(e)}(\mathbb{u}, q) &= 1 - \mathbb{T}_{\Gamma_Q(e)}(\mathbb{u}, q), \\ \mathbb{I}^c_{\Gamma_Q(e)}(\mathbb{u}, q) &= 1 - \mathbb{I}_{\Gamma_Q(e)}(\mathbb{u}, q), \\ \mathbb{F}^c_{\Gamma_Q(e)}(\mathbb{u}, q) &= 1 - \mathbb{F}_{\Gamma_Q(e)}(\mathbb{u}, q). \end{aligned}$$

**Definition 9 (**[14],[13]**)**. Given $\left(\aleph_Q, \mathbb{G}\right) \in QNSS(\mathbb{U})$, $\aleph_Q(e) = \phi$ for all $e \in \mathbb{G}$, then $\left(\aleph_Q, \mathbb{G}\right)$ can be declared as a null $QNSS(\mathbb{U})$, and is referred to as $(\phi, \mathbb{G})$.

**Definition** 10 ([14],[13]). Given a QNSSs $\left(\aleph_Q, \mathbb{G}\right) = \left\{\left(\mathbb{T}_{\aleph_Q(e)}(\mathbb{u}, q), \mathbb{I}_{\aleph_Q(e)}(\mathbb{u}, q), \mathbb{F}_{\aleph_Q(e)}(\mathbb{u}, q)\right): \forall e \in \mathbb{G}, (\mathbb{u}, q) \in \mathbb{U} \times Q\right\}$, then, the necessity operation can be defined as:

$$\oplus (\Gamma_Q, \mathbb{G}) = \left\{\langle e, [(\mathbb{u}, q), \mathbb{T}_{\Gamma_Q}(\mathbb{u}, q), \mathbb{I}_{\Gamma_Q}(\mathbb{u}, q), 1 - \mathbb{T}_{\Gamma_Q}(\mathbb{u}, q)]\rangle : (\mathbb{u}, q) \in U \times Q\right\}. \tag{10}$$

**Definition 11 (**[14],[13]**)**.Given an QNSSs $\left(\aleph_Q, \mathbb{G}\right) = \left\{\left(\mathbb{T}_{\aleph_Q(e)}(\mathbb{u}, q), \mathbb{I}_{\aleph_Q(e)}(\mathbb{u}, q), \mathbb{F}_{\aleph_Q(e)}(\mathbb{u}, q)\right): \forall e \in \mathbb{G}, (\mathbb{u}, q) \in \mathbb{U} \times Q\right\}$, then, the possibility operation can be defined as:

$$\otimes (\Gamma_Q, \mathbb{G}) = \left\{\langle e, [(\mathbb{u}, q), 1 - \mathbb{F}_{\Gamma_Q}(\mathbb{u}, q), \mathbb{I}_{\Gamma_Q}(\mathbb{u}, q), \mathbb{F}_{\Gamma_Q}(\mathbb{u}, q)]\rangle : (\mathbb{u}, q) \in \mathbb{U} \times Q\right\}. \tag{11}$$

**Definition 12 (**[12]**)**. Given $\mathbb{U} = \{\mathbb{u}_1, \mathbb{u}_2, \ldots, \mathbb{u}_m\}$, $Q = \{q_1, q_2, \ldots, q_l\}$, and $\mathbb{G} = \{e_1, e_2, \ldots, e_n\}$, then, the hamming distance between two QNSSs $\left(\aleph_Q, \mathbb{G}\right)$, and $\left(\Omega_Q, \mathbb{O}\right)$ is defined as follows:

$$d_{QNSS}^{Hamm}\left((\aleph_Q,\mathbb{G}),(\Omega_Q,\mathbb{O})\right)=\sum_{j=1}^{n}\sum_{i=1}^{lm}\frac{\left|\mathbb{T}_{\aleph_Q\left(e_j^{\mathbb{G}}\right)}(\mathbb{u},q)_i-\mathbb{T}_{\Omega_Q\left(e_j^{\mathbb{O}}\right)}(\mathbb{u},q)_i\right|+\left|\mathbb{I}_{\aleph_Q\left(e_j^{\mathbb{G}}\right)}(\mathbb{u},q)_i-\mathbb{I}_{\Omega_Q\left(e_j^{\mathbb{O}}\right)}(\mathbb{u},q)_i\right|+\left|\mathbb{F}_{\aleph_Q\left(e_j^{\mathbb{G}}\right)}(\mathbb{u},q)_i-\mathbb{F}_{\Omega_Q\left(e_j^{\mathbb{O}}\right)}(\mathbb{u},q)_i\right|}{3}, \quad (12)$$

**Definition 13 (**[12]**)**. Given $\mathbb{U}=\{\mathbb{u}_1,\mathbb{u}_2,\ldots,\mathbb{u}_m\}$, $Q=\{q_1,q_2,\ldots,q_l\}$, and $\mathbb{G}=\{e_1,e_2,\ldots,e_n\}$, then, the excluding distance between two QNSSs $(\aleph_Q,\mathbb{G})$, and $(\Omega_Q,\mathbb{O})$ is defined as follows:

$$d_{QNSS}^{Eclud}\left((\aleph_Q,\mathbb{G}),(\Omega_Q,\mathbb{O})\right)=\sum_{j=1}^{n}\sum_{i=1}^{lm}\sqrt{\frac{\left(\mathbb{T}_{\aleph_Q\left(e_j^{\mathbb{G}}\right)}(\mathbb{u},q)_i-\mathbb{T}_{\Omega_Q\left(e_j^{\mathbb{O}}\right)}(\mathbb{u},q)_i\right)^2+\left(\mathbb{I}_{\aleph_Q\left(e_j^{\mathbb{G}}\right)}(\mathbb{u},q)_i-\mathbb{I}_{\Omega_Q\left(e_j^{\mathbb{O}}\right)}(\mathbb{u},q)_i\right)^2+\left(\mathbb{F}_{\aleph_Q\left(e_j^{\mathbb{G}}\right)}(\mathbb{u},q)_i-\mathbb{F}_{\Omega_Q\left(e_j^{\mathbb{O}}\right)}(\mathbb{u},q)_i\right)^2}{3}}, \quad (13)$$

# III. Methodology

In this section, we present an articulation of the main concept and theory of building the MV-QNC framework.

### 3.1. Theoretical framework

**Definition 15**. Let $U$ be a universe of discourse, $Q$ a non-empty set of qualifiers, and $E$ a set of decision parameters, $G\subseteq E$ is a subset of parameters for a specific decision context, $\mathcal{P}([0,1])$ is the power set of the real unit interval $[0,1]$, excluding the empty set, then, a Multi-Valued Q-Neutrosophic Soft Set (MQNSS) over $U$ is defined as a mapping:

$$\mathfrak{M}_Q: G\rightarrow \mu^{mv}QNS(U)$$

Such that for every $e\in G$ : (14)

$$\mathfrak{M}_Q(e)=\{[(x,q),\mathbb{T}_e(x,q),\mathbb{I}_e(x,q),\mathbb{F}_e(x,q)]\mid x\in U,q\in Q\}$$

Where $\mathbb{T}_e(x,q)\subseteq[0,1]$ , $\mathbb{I}_e(x,q)\subseteq[0,1]$ , $\mathbb{F}_e(x,q)\subseteq[0,1]$ is sets of memberships $\mathbb{T}_e(x,q),\mathbb{I}_e(x,q),\mathbb{F}_e(x,q)\in\mathcal{P}([0,1])$. For all, $\gamma\in\mathbb{T}_e(x,q),\eta\in\mathbb{I}_e(x,q)$, $\xi\in\mathbb{F}_e(x,q)$, the following conditions apply:

$$0\leq\gamma,\eta,\xi\leq 1, \quad (15)$$

Where the supremum of each component is defined as:

$$\gamma^+=\sup T_e(x,q),\ \eta^+=\sup I_e(x,q),\ \xi^+=\sup F_e(x,q), \quad (16)$$

Such that, the boundedness condition must apply:

$$0 \leq \gamma^{+} + \eta^{+} + \xi^{+} \leq 3, \tag{17}$$

In this regard, we can define the mapping for all $e \notin G$:

$$\mathfrak{M}_Q(e) \leftarrow \emptyset, \tag{18}$$

The MQNSS can be denoted by the pair. $(\mathfrak{M}_Q, G)$, and represented as a collection of ordered pairs:

$$(\mathfrak{M}_Q, G) \leftarrow \{(e, \mathfrak{M}_Q(e)) \mid e \in G\} \tag{19}$$

Each element $[(x,q), \mathbb{T}_e, \mathbb{I}_e, \mathbb{F}_e] \in \mathfrak{M}_Q(e)$ captures the multi-valued neutrosophic evaluation of object $x \in U$ under qualifier $q \in Q$, with respect to parameter $e \in G$.

**Example 1**. Given two digital images $U = \{x_1, x_2\}$ to be evaluated across multiple qualities $E = \{e_1 = aesthetic\ quality,\ e_2 = sharpness\}$ as *decision parameters*, under two viewing environments $Q = \{m{:}\ mobile, d{:}\ desktop\}$, G=E, *then* MQNSS could be given as:

$$(\mathfrak{M}_Q, G) \leftarrow \left\{ \begin{matrix} \left\langle \begin{matrix} e_1, [(x_1,m),\{0.8,0.9\},\{0.1\},\{0.2\}],[(x_1,d),\{0.6,0.7\},\{0.3\},\{0.2\}],[(x_2,m),\{0.9,0.8\},\{0.4,0.5\},\{0.1\}], \\ [(x_2,m),\{0.7,0.8\},\{0.2\},\{0.1\}] \end{matrix} \right\rangle, \\ \left\langle \begin{matrix} e_1, [(x_1,m),\{0.5,0.6\},\{0.3\},\{0.4\}],[(x_1,d),\{0.7,0.5\},\{0.1\},\{0.3\}],[(x_2,m),\{0.6\},\{0.1\},\{0.3,0.4\}], \\ [(x_2,m),\{0.9\},\{0.1\},\{0.0, 0.1\}] \end{matrix} \right\rangle \end{matrix} \right\}$$

**Definition 16**. Given $U$, $Q$, $E$ , $G \subseteq E$, $\mathcal{P}([0,1])$ as stated in Definition 15, then, a null MQNSS $(\tilde{\emptyset}_Q, G)$, is defined as a mapping:

$$\begin{gathered} \tilde{\emptyset}_Q : G \to \mu^{mv}QNS(U) \\ \text{such that} \\ \tilde{\emptyset}_Q(e) = \emptyset\ \forall e \in G \end{gathered} \tag{20}$$

**Definition 17**. Given two MQNSSs $(\mathfrak{M}_Q, G)$ and $(\mathfrak{N}_Q, O)$ on Universe $U$, qualifier set $Q$, and parameter sets $G \subseteq E, O \subseteq E$, respectively; then, the union of them, denoted by $(\mathfrak{L}_Q, C) = (\mathfrak{M}_Q, G) \cup (\mathfrak{N}_Q, O)$, is defined over the parameter set $C = G \cup O$, as follows:

$$\begin{gathered} \mathbb{T}_{\mathrm{L}_Q(c)}(x,q) = \begin{cases} \mathbb{T}_{\mathfrak{M}_Q(c)}(x,q) & \text{if } c \in G - O \\ \mathbb{T}_{\mathfrak{N}_Q(c)}(x,q) & \text{if } c \in O - G \\ \mathrm{Agg}_{\max}\left(\mathbb{T}_{\mathfrak{M}_Q(c)}(x,q) \cup \mathbb{T}_{\mathfrak{N}_Q(c)}(x,q)\right) & \text{if } c \in G \cap O \end{cases} \\ \mathbb{T}_{\mathrm{L}_Q(c)}(x,q) = \begin{cases} \mathbb{I}_{\mathfrak{M}_Q(c)}(x,q) & \text{if } c \in G - O \\ \mathbb{I}_{\mathfrak{N}_Q(c)}(x,q) & \text{if } c \in O - G \\ \mathrm{Agg}_{\min}\left(\mathbb{I}_{\mathfrak{M}_Q(c)}(x,q), \mathbb{I}_{\mathfrak{N}_Q(c)}(x,q)\right) & \text{if } c \in G \cap O \end{cases} \end{gathered} \tag{21}$$

$$\mathbb{F}_{\mathbb{L}_{Q(c)}}(x,q)=\begin{cases}\mathbb{F}_{\mathfrak{R}_{Q(c)}}(x,q) & \text{if } c\in G-O\\ \mathbb{F}_{\mathfrak{R}_{Q(c)}}(x,q) & \text{if } c\in O-G\\ \text{Agg}_{\min}\left(\mathbb{F}_{\mathfrak{M}_{Q(c)}}(x,q),\mathbb{F}_{\mathfrak{R}_{Q(c)}}(x,q)\right) & \text{if } c\in G\cap O\end{cases}$$

where $c \in C$, and $(x,q) \in U \times Q$, $c\ (A,B) = \{\, min(a,b) \mid a \in A, b \in B\,\}$, and $\text{Agg}_{\max}\ (A,B) = \{\, max(a,b) \mid a \in A, b \in B\,\}$.

**Definition 18**. Given two MQNSSs $(\mathfrak{M}_Q, G)$ and $(\mathfrak{N}_Q, O)$ on Universe $U$, qualifier set $Q$, and parameter sets $G \subseteq E, O \subseteq E$, respectively; then, the intersection between them, denoted by $(\mathfrak{L}_Q, C) = (\mathfrak{M}_Q, G) \cap (\mathfrak{N}_Q, O)$, is defined over the parameter set $C = G \cup O$, as follows:

$$\begin{gathered}\mathbb{T}_{\mathrm{L}_{Q(c)}}(x,q)=\text{Agg}_{\min}\left(\mathbb{T}_{\mathfrak{M}_{Q(c)}}(x,q)\cup\mathbb{T}_{\mathfrak{N}_{Q(c)}}(x,q)\right)\\ \mathbb{T}_{\mathrm{L}_{Q(c)}}(x,q)=\text{Agg}_{\max}\left(\mathbb{I}_{\mathfrak{M}_{Q(c)}}(x,q),\mathbb{I}_{\mathfrak{N}_{Q(c)}}(x,q)\right)\\ \mathbb{F}_{\mathbb{L}_{Q(c)}}(x,q)=\text{Agg}_{\max}\left(\mathbb{F}_{\mathfrak{M}_{Q(c)}}(x,q),\mathbb{F}_{\mathfrak{N}_{Q(c)}}(x,q)\right)\end{gathered} \tag{22}$$

Where $c \in C$, and $(x,q) \in U \times Q$.

**Definition 19**. Given MQNSSs $(\mathfrak{M}_Q, G)$ on Universe $U$, qualifier set $Q$, and parameter sets $G \subseteq E, O \subseteq E$, then, the complement of $(\mathfrak{M}_Q, G)$, denoted by $(\mathfrak{M}_Q^c, G)$, is defined as follows:

$$\begin{gathered}\mathfrak{M}_Q^c(e)=\{[(x,q),\mathbb{T}_e^c(x,q),\mathbb{I}_e^c(x,q),\mathbb{F}_e^c(x,q)]\mid(x,q)\in U\times Q\}\\ \text{such that}\\ T_e^c(x,q)=\{1-\xi\mid\xi\in F_e(x,q)\};\ I_e^c(x,q)=\{1-\eta\mid\eta\in I_e(x,q)\};\ F_e^c(x,q)=\\ \{1-\gamma\mid\gamma\in T_e(x,q)\}\end{gathered} \tag{23}$$

Where the supremum constraint is applied

$$0 \le \gamma^+ + \eta^+ + \xi^+ \le 3,$$

**Definition 20**. Given MQNSSs $(\mathfrak{M}_Q, G)$ on Universe $U$, qualifier set $Q$, and parameter sets $G \subseteq E, O \subseteq E$, then, the necessity operation, denoted by $\otimes\,(\mathfrak{M}_Q, G)$,, is defined as follows:

$$\begin{gathered}\otimes\left(\mathfrak{M}_Q,G\right)=\{[(x,q),\mathbb{T}_e(x,q),\mathbb{I}_e(x,q),\mathbb{F}'_e(x,q)]\mid(x,q)\in U\times Q\}\\ \text{such that}\\ F'_e(x,q)=\{1-\gamma\mid\gamma\in T_e(x,q)\}\end{gathered} \tag{24}$$

Where the supremum constraint is applied

$$0 \le \gamma^+ + \eta^+ + \xi^+ \le 3,$$

**Definition 21**. Given MQNSSs $(\mathfrak{M}_Q, G)$ on Universe $U$, qualifier set $Q$, and parameter sets $G \subseteq E, O \subseteq E$, then, the possibility operation, denoted by $\dagger\,(\mathfrak{M}_Q, G)$, is defined as follows:

$$\dagger\,(\mathfrak{M}_Q, G) = \{[(x,q), \mathbb{T}'_e(x,q), \mathbb{I}_e(x,q), \mathbb{F}_e(x,q)] \mid (x,q) \in U \times Q\}$$
$$\text{such that}$$
$$\mathbb{T}'_e(x,q) = \{1 - \xi \mid \xi \in \mathbb{F}_e(x,q)\} \tag{25}$$

Where the supremum constraint is applied

$$0 \le \gamma^+ + \eta^+ + \xi^+ \le 3,$$

**3.2. Algorithmic decision making**

In step 1, we aggregate all multi-valued membership values into single-valued counterparts.

**Definition 22**. Given MQNSSs $(\mathfrak{M}_Q, G)$ on Universe $U$, qualifier set $Q$, and parameter sets $G \subseteq E, O \subseteq E$, then, the aggregation operator, denoted by $(\mathfrak{M}_Q^{agg}, G)$, is defined as follows:

$$(\mathfrak{M}_Q^{agg}, G) = \{[(x,q), \mathbb{T}_e^{agg}(x,q), \mathbb{I}_e^{agg}(x,q), \mathbb{F}_e^{agg}(x,q)] \mid (x,q) \in U \times Q\}$$
$$\text{such that}$$
$$\begin{aligned} T_e^{\text{agg}}(x,q) &= \frac{1}{|\mathrm{Q}|}\sum_{\mathrm{q}\in\mathrm{Q}} \frac{1}{|\mathbb{T}_e(x_i,q)|}\sum_{\gamma\in\mathbb{T}_e(x_i,q)} \gamma \\ I_e^{\text{agg}}(x,q) &= \frac{1}{|\mathrm{Q}|}\sum_{\mathrm{q}\in\mathrm{Q}} \frac{1}{|\mathbb{I}_e(x_i,q)|}\sum_{\eta\in\mathbb{I}_e(x_i,q)} \eta \\ F_e^{\text{agg}}(x,q) &= \frac{1}{|\mathrm{Q}|}\sum_{\mathrm{q}\in\mathrm{Q}} \frac{1}{|\mathbb{F}_e(x_i,q)|}\sum_{\xi\in\mathbb{F}_e(x_i,q)} \xi \end{aligned} \tag{26}$$

where $\mathbb{T}^{\text{agg}}, \mathbb{I}^{\text{agg}}, \mathbb{F}^{\text{agg}} \in [0,1]$.

In step 2, we apply the score function to convert sets of $\mathbb{T}, \mathbb{I}, \mathbb{F}$ to a single numerical score

**Definition 22**. Given the aggregated MQNSS $(\mathfrak{M}_Q^{agg}, G) = \{[(x,q), \mathbb{T}_e^{agg}(x,q), \mathbb{I}_e^{agg}(x,q), \mathbb{F}_e^{agg}(x,q)] \mid (x,q) \in U \times Q\}$, the score function, $S_e(x_i, q_i) \in [0,1]$, is defined as:

$$S_e(x_i, q_i) = \tfrac{1}{2}\left(\mathbb{T}_e^{agg}(x,q) + \left(1 - \mathbb{F}_e^{agg}(x,q)\right)\right) \cdot \left(1 - \mathbb{I}_e^{agg}(x,q)\right) \tag{27}$$

In step 3, we normalize the score benefit criteria $e \in B$, as well as cost criteria, $e \in C$, as follows

$$S_e(x_i) = \begin{cases} S_e(x_i, q_i), & if\ e \in B \\ 1 - S_e(x_i, q_i), & if\ e \in C \end{cases} \tag{28}$$

In step 4, we give a final crisp score per alternative. $x_i$.

$$S(x_i) = \frac{1}{|E|}\sum_{e\in E} (x_i)$$

In step 5, we sort alternatives. $x_i$ in descending order of $S\,(x_i)$, where the highest value indicates the most preferable solution.

## IV. Application

In a modern content production company, creators rely on various digital tools for tasks like video editing, graphics, animation, and post-processing[15]. These tools vary in performance across multiple criteria and under different usage contexts. Due to subjective judgments and varying user environments, it is natural to evaluate them using our MQNSS framework to model uncertainty, vagueness, and context dependence. In our case study, assume there are different digital content creation tools/software platforms $U = \{x_1, x_2, \cdots, x_7\}$. These tools include $x_1$: Adobe Premiere Pro, $x_2$: Final Cut Pro, $x_3$: DaVinci Resolve, $x_4$: Camtasia Studio, $x_5$: HitFilm Express, $x_6$: Blender (video pipeline), $x_7$: OpenShot Video Editor. In this company, there are different hardware environments and practical usage conditions namely High-performance workstations ($q_1$), Mid-range laptop ($q_2$), and Mobile/Tablet editing ($q_3$). These can be regarded as qualifiers representing the usage contexts under which tools are evaluated. The evaluations of the aforementioned tools consider both performance & usability benefits and cost-efficiency penalties, which represent the decision parameters in our case. Multiple experts are involved in evaluating different attributes of the abovementioned media creation tools, including benefit parameters $e_1$ : Rendering Speed, $e_2$: Interface Usability, $e_3$: Editing Features & Tools $e_4$: Plugin/Asset Availability as shown in Table 1. These expert evaluations include cost parameters including $e_5$: System Resources consumption, $e_6$: License/Subscription Cost, and $e_7$: Learning curve Complexity, as shown in Table 2.

Table 1. Expert judgments for different media creation tools based on benefit parameters.

| $x_i$ | Q | $e_1$ | $e_2$ | $e_3$ | $e_4$ |
|---|---|---|---|---|---|
| $x_1$ | $q_1$ | [[0.67, 0.82], [0.14], [0.22, 0.04]] | [[0.66, 0.77, 0.82], [0.38, 0.15], [0.09, 0.01]] | [[0.66, 0.92], [0.29, 0.23], [0.18, 0.26]] | [[0.65, 0.96, 0.64], [0.14, 0.13], [0.11, 0.0]] |
| $x_1$ | $q_2$ | [[0.88, 0.89, 0.93], [0.26, 0.23], [0.25, 0.29]] | [[0.85, 0.69, 0.72], [0.37], [0.2]] | [[0.86, 0.99], [0.21], [0.11]] | [[0.94, 0.72], [0.27], [0.04]] |
| $x_1$ | $q_3$ | [[0.82, 0.61], [0.32], [0.25]] | [[0.66, 0.83], [0.22, 0.16], [0.06, 0.08]] | [[0.95, 0.82, 0.99], [0.15], [0.05, 0.18]] | [[0.7, 0.64], [0.18], [0.24, 0.24]] |
| $x_2$ | $q_1$ | [[0.82, 0.86], [0.13], [0.07]] | [[0.9, 0.96, 0.83], [0.21], [0.26, 0.14]] | [[0.74, 0.67], [0.25], [0.27]] | [[0.96, 0.87, 0.88], [0.39], [0.22, 0.06]] |
| $x_2$ | $q_2$ | [[0.91, 0.95], [0.13, 0.23], [0.05]] | [[0.61, 0.95], [0.17, 0.11], [0.18, 0.11]] | [[0.94, 0.64], [0.31], [0.09]] | [[0.93, 0.63], [0.27, 0.15], [0.11, 0.3]] |
| $x_2$ | $q_3$ | [[0.84, 0.97], [0.36], [0.01, 0.26]] | [[0.69, 0.61], [0.33, 0.27], [0.29]] | [[0.97, 0.69, 0.73], [0.27, 0.2], [0.05, 0.17]] | [[0.98, 0.73], [0.3], [0.11, 0.06]] |

| | | | | | |
|---|---|---|---|---|---|
| $x_3$ | $q_1$ | [[0.86, 0.92], [0.27], [0.14]] | [[0.83, 0.83], [0.11, 0.38], [0.05, 0.25]] | [[0.93, 0.84], [0.32], [0.13]] | [[0.61, 0.6], [0.34], [0.17]] |
| $x_3$ | $q_2$ | [[0.85, 0.81], [0.39, 0.2], [0.13]] | [[0.63, 0.62, 0.65], [0.17, 0.36], [0.26, 0.21]] | [[0.91, 0.99, 0.92], [0.13], [0.15]] | [[0.83, 0.94], [0.27, 0.23], [0.27, 0.02]] |
| $x_3$ | $q_3$ | [[0.9, 0.91, 0.9], [0.28], [0.08]] | [[0.77, 0.88], [0.23], [0.14, 0.06]] | [[0.74, 0.76], [0.2, 0.38], [0.05]] | [[0.63, 0.75], [0.25], [0.22, 0.02]] |
| $x_4$ | $q_1$ | [[0.96, 0.89, 0.6], [0.33], [0.09, 0.26]] | [[0.68, 0.77, 0.88], [0.26, 0.15], [0.23, 0.28]] | [[0.68, 0.76, 0.9], [0.27], [0.07, 0.13]] | [[0.63, 0.68], [0.12], [0.05, 0.2]] |
| $x_4$ | $q_2$ | [[0.93, 0.69, 0.66], [0.36], [0.15]] | [[0.77, 0.74], [0.13, 0.13], [0.22, 0.2]] | [[0.99, 0.78, 0.96], [0.17, 0.27], [0.29]] | [[0.79, 0.97, 0.86], [0.34, 0.12], [0.04]] |
| $x_4$ | $q_3$ | [[0.71, 0.76, 0.77], [0.18, 0.33], [0.16]] | [[0.69, 0.86, 0.86], [0.24, 0.28], [0.3]] | [[0.78, 0.63, 0.99], [0.13, 0.34], [0.01]] | [[0.6, 0.6], [0.13], [0.05]] |
| $x_5$ | $q_1$ | [[0.79, 0.88, 0.82], [0.32, 0.25], [0.09, 0.1]] | [[0.96, 0.7], [0.39], [0.06, 0.04]] | [[0.69, 0.61], [0.35, 0.16], [0.12, 0.03]] | [[0.93, 0.84], [0.32, 0.35], [0.1]] |
| $x_5$ | $q_2$ | [[0.81, 0.62, 0.96], [0.25], [0.15]] | [[0.71, 0.76], [0.4, 0.14], [0.04, 0.01]] | [[0.79, 0.79, 0.66], [0.22], [0.14]] | [[0.81, 0.84, 0.85], [0.25], [0.01, 0.06]] |
| $x_5$ | $q_3$ | [[0.72, 0.86], [0.11, 0.23], [0.08, 0.26]] | [[0.77, 0.87, 0.89], [0.26], [0.13, 0.25]] | [[0.72, 0.79, 0.77], [0.12, 0.24], [0.07]] | [[0.95, 0.9, 0.69], [0.39, 0.37], [0.24]] |
| $x_6$ | $q_1$ | [[0.99, 0.98, 0.97], [0.14], [0.07]] | [[0.95, 0.98], [0.32], [0.17, 0.13]] | [[0.83, 0.86, 0.86], [0.12], [0.02]] | [[0.83, 1.0, 0.8], [0.14, 0.12], [0.21, 0.26]] |
| $x_6$ | $q_2$ | [[0.75, 0.8, 0.69], [0.29, 0.2], [0.03]] | [[0.98, 0.9, 0.6], [0.33], [0.05, 0.0]] | [[0.68, 0.67], [0.35, 0.15], [0.19]] | [[0.97, 0.63], [0.32, 0.29], [0.1]] |
| $x_6$ | $q_3$ | [[1.0, 0.71], [0.36, 0.27], [0.17, 0.18]] | [[0.84, 0.63, 0.86], [0.29, 0.34], [0.13]] | [[0.91, 0.97, 0.73], [0.4, 0.13], [0.29]] | [[0.75, 0.83], [0.34], [0.26, 0.08]] |
| $x_7$ | $q_1$ | [[0.63, 0.64, 0.85], [0.15], [0.09]] | [[0.91, 0.63], [0.11, 0.39], [0.18, 0.17]] | [[0.74, 0.98], [0.24, 0.13], [0.06, 0.22]] | [[0.72, 0.71], [0.24], [0.05]] |
| $x_7$ | $q_2$ | [[0.71, 0.79], [0.14], [0.1, 0.01]] | [[0.71, 0.64, 0.73], [0.1, 0.18], [0.1]] | [[0.64, 0.77], [0.18], [0.11, 0.22]] | [[0.96, 0.63, 0.94], [0.38], [0.27, 0.25]] |
| $x_7$ | $q_3$ | [[0.98, 0.82, 0.92], [0.39], [0.02, 0.18]] | [[0.78, 0.87, 0.73], [0.36], [0.21, 0.28]] | [[0.81, 0.72], [0.19, 0.13], [0.21]] | [[0.8, 0.76], [0.33], [0.04]] |

Table 2. Expert judgments for different media creation tools based on cost parameters.

| $x_i$ | Q | $e_5$ | $e_6$ | $e_7$ |
|---|---|---|---|---|
| $x_1$ | $q_1$ | [[0.83, 0.75], [0.39, 0.33], [0.07]] | [[0.86, 0.63, 0.7], [0.28], [0.1, 0.02]] | [[0.76, 0.76, 0.87], [0.33, 0.34], [0.07, 0.12]] |
| $x_1$ | $q_2$ | [[0.71, 0.94, 0.69], [0.11, 0.37], [0.28, 0.02]] | [[0.63, 0.73], [0.27], [0.0, 0.07]] | [[0.8, 0.71, 0.84], [0.13, 0.13], [0.06]] |
| $x_1$ | $q_3$ | [[0.93, 0.64, 0.96], [0.22, 0.29], [0.17, 0.07]] | [[0.64, 0.98], [0.3], [0.21]] | [[0.87, 0.7], [0.35], [0.28]] |
| $x_2$ | $q_1$ | [[0.87, 0.67, 0.84], [0.27], [0.26]] | [[0.77, 0.85, 0.77], [0.28], [0.01]] | [[0.96, 0.8, 0.77], [0.28, 0.29], [0.28, 0.05]] |
| $x_2$ | $q_2$ | [[0.94, 0.69], [0.21, 0.28], [0.23]] | [[0.91, 0.97, 0.68], [0.12, 0.1], [0.07]] | [[0.62, 0.91, 0.99], [0.33], [0.13]] |
| $x_2$ | $q_3$ | [[0.62, 0.65], [0.34, 0.36], [0.12, 0.26]] | [[0.92, 0.95, 0.6], [0.3, 0.15], [0.21]] | [[0.7, 0.87], [0.38], [0.26]] |
| $x_3$ | $q_1$ | [[0.94, 0.88], [0.2, 0.2], [0.01]] | [[0.67, 0.81], [0.34], [0.28]] | [[0.89, 0.72, 0.85], [0.23, 0.32], [0.01]] |
| $x_3$ | $q_2$ | [[0.79, 0.88, 0.63], [0.17, 0.11], [0.01]] | [[0.65, 0.92], [0.32], [0.16]] | [[0.9, 0.76, 0.94], [0.33], [0.07]] |
| $x_3$ | $q_3$ | [[0.75, 0.8], [0.26], [0.25]] | [[0.9, 0.65], [0.21], [0.25]] | [[0.61, 0.97, 0.8], [0.18, 0.36], [0.03, 0.03]] |
| $x_4$ | $q_1$ | [[0.78, 0.63], [0.21], [0.09, 0.18]] | [[1.0, 0.81, 0.84], [0.25, 0.14], [0.22, 0.28]] | [[0.81, 0.86], [0.29, 0.18], [0.25, 0.23]] |
| $x_4$ | $q_2$ | [[0.81, 0.7], [0.39, 0.19], [0.09]] | [[0.64, 0.67], [0.29], [0.03, 0.18]] | [[0.84, 0.92], [0.21], [0.1]] |
| $x_4$ | $q_3$ | [[0.86, 0.88], [0.36, 0.21], [0.01]] | [[0.83, 0.66, 0.63], [0.2], [0.08, 0.14]] | [[0.7, 0.88], [0.19, 0.17], [0.03]] |
| $x_5$ | $q_1$ | [[0.88, 0.71], [0.13, 0.13], [0.3, 0.28]] | [[0.81, 0.79], [0.36, 0.33], [0.16, 0.06]] | [[0.61, 0.66, 0.97], [0.12], [0.03]] |
| $x_5$ | $q_2$ | [[0.83, 0.71], [0.26, 0.38], [0.07, 0.09]] | [[0.79, 0.62], [0.21], [0.09, 0.13]] | [[0.72, 0.63], [0.38], [0.28]] |
| $x_5$ | $q_3$ | [[0.75, 0.75, 0.83], [0.22], [0.19, 0.26]] | [[0.72, 0.62, 0.62], [0.34, 0.32], [0.17, 0.08]] | [[0.61, 0.9], [0.2], [0.25, 0.14]] |
| $x_6$ | $q_1$ | [[0.69, 0.95, 0.81], [0.31], [0.09]] | [[0.72, 0.92], [0.25], [0.2]] | [[0.92, 0.62, 0.82], [0.19, 0.27], [0.14, 0.23]] |

| | | | | |
|---|---|---|---|---|
| $x_6$ | $q_2$ | [[0.87, 0.74, 0.63], [0.14, 0.37], [0.2, 0.17]] | [[0.92, 0.73], [0.4], [0.2]] | [[0.67, 0.77, 0.82], [0.26], [0.08]] |
| $x_6$ | $q_3$ | [[0.71, 0.82, 0.99], [0.17, 0.18], [0.11, 0.29]] | [[0.62, 0.92, 0.95], [0.33], [0.22]] | [[0.95, 0.88, 0.99], [0.3], [0.23]] |
| $x_7$ | $q_1$ | [[0.99, 0.74, 0.95], [0.31], [0.11, 0.15]] | [[0.92, 0.83], [0.33], [0.28]] | [[0.84, 0.79], [0.37], [0.17, 0.18]] |
| $x_7$ | $q_2$ | [[0.8, 0.7], [0.35, 0.25], [0.23]] | [[0.96, 0.71], [0.23], [0.12, 0.04]] | [[0.74, 0.85], [0.29, 0.12], [0.01]] |
| $x_7$ | $q_3$ | [[0.97, 0.81, 0.95], [0.15, 0.26], [0.28, 0.21]] | [[0.73, 0.82], [0.38, 0.27], [0.25, 0.08]] | [[0.77, 0.73], [0.31, 0.37], [0.08, 0.03]] |

In Table 3, we present the aggregated multi-valued Q-neutrosophic decision matrix for all tools across benefit and cost parameters, including evaluations from different usage.

Table 3. Multi-Valued Q-Neutrosophic decision matrix showing aggregated evaluations across all qualifiers (contexts) for each alternative

| Tool | $e_1$ | $e_2$ | $e_3$ | $e_4$ | $e_5$ | $e_6$ | $e_7$ |
|---|---|---|---|---|---|---|---|
| $x_1$ | [0.728, 0.22, 0.154] | [0.795, 0.312, 0.203] | [0.827, 0.3, 0.198] | [0.75, 0.16, 0.207] | [0.76, 0.33, 0.193] | [0.848, 0.185, 0.112] | [0.82, 0.208, 0.096] |
| $x_2$ | [0.829, 0.137, 0.117] | [0.8, 0.323, 0.13] | [0.771, 0.237, 0.125] | [0.748, 0.235, 0.118] | [0.78, 0.208, 0.148] | [0.859, 0.266, 0.18] | [0.749, 0.29, 0.098] |
| $x_3$ | [0.793, 0.177, 0.105] | [0.78, 0.244, 0.155] | [0.735, 0.275, 0.143] | [0.854, 0.268, 0.127] | [0.789, 0.2, 0.143] | [0.771, 0.237, 0.197] | [0.77, 0.257, 0.115] |
| $x_4$ | [0.812, 0.267, 0.183] | [0.786, 0.275, 0.058] | [0.833, 0.248, 0.106] | [0.861, 0.158, 0.16] | [0.836, 0.24, 0.124] | [0.804, 0.24, 0.207] | [0.769, 0.198, 0.21] |
| $x_5$ | [0.797, 0.347, 0.11] | [0.847, 0.278, 0.148] | [0.834, 0.29, 0.11] | [0.762, 0.322, 0.18] | [0.806, 0.31, 0.136] | [0.77, 0.297, 0.138] | [0.84, 0.323, 0.185] |
| $x_6$ | [0.84, 0.286, 0.143] | [0.837, 0.24, 0.207] | [0.846, 0.313, 0.165] | [0.853, 0.28, 0.135] | [0.816, 0.245, 0.21] | [0.781, 0.238, 0.147] | [0.822, 0.28, 0.083] |
| $x_7$ | [0.886, 0.282, 0.194] | [0.795, 0.278, 0.134] | [0.782, 0.277, 0.155] | [0.823, 0.205, 0.21] | [0.778, 0.294, 0.114] | [0.856, 0.28, 0.138] | [0.799, 0.263, 0.142] |

In Table 4, we provided normalized scores of each tool for all decision parameters after computing after performing two-level aggregation.

Table 4. Parameter-level scoring of each alternative based on neutrosophic aggregation across usage contexts.

| | $e_1$ | $e_2$ | $e_3$ | $e_4$ | $e_5$ | $e_6$ | $e_7$ |
|---|---|---|---|---|---|---|---|
| $x_1$ | 0.7390 | 0.5657 | 0.6276 | 0.6233 | 0.3533 | 0.3839 | 0.4138 |
| $x_2$ | 0.5973 | 0.6265 | 0.6493 | 0.7162 | 0.3493 | 0.3931 | 0.3746 |
| $x_3$ | 0.6941 | 0.6142 | 0.5773 | 0.6320 | 0.3418 | 0.3990 | 0.3849 |
| $x_4$ | 0.6071 | 0.6000 | 0.5886 | 0.6410 | 0.4128 | 0.3814 | 0.3898 |
| $x_5$ | 0.5511 | 0.6138 | 0.6119 | 0.5362 | 0.4239 | 0.4266 | 0.4394 |
| $x_6$ | 0.6057 | 0.6196 | 0.5772 | 0.6184 | 0.3938 | 0.3775 | 0.3742 |
| $x_7$ | 0.6137 | 0.5481 | 0.5700 | 0.6482 | 0.4749 | 0.2928 | 0.3176 |

In Figure 1, we visualize the final ranking of alternatives according to their aggregated scores, which reflects the overall performance of each tool when evaluated across all criteria, accounting for both types of criteria under uncertain, context-dependent conditions.

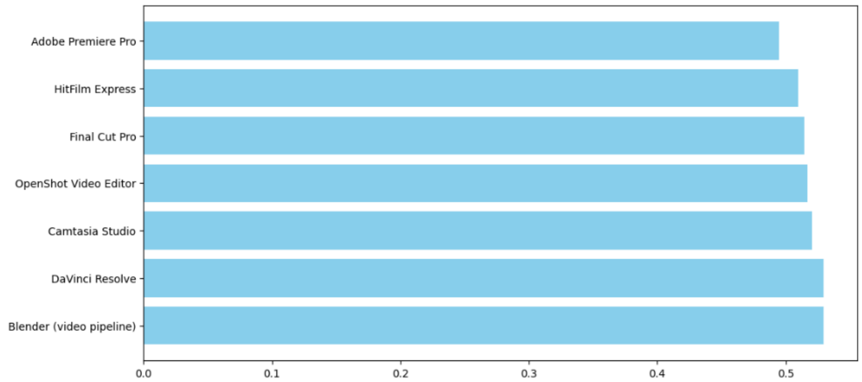


Figure 1. Final ranking of digital content creation tools based on aggregated multi-valued Q-neutrosophic scores.

To validate the robustness of our method, a comparative analysis is conducted using three widely recognized techniques: EDAS, TOPSIS, and MAIRCA. Each method is applied to the same decision matrix derived from the scoring of multi-valued neutrosophic evaluations. While all methods produced consistent rankings for the top-performing alternatives, minor variations in ranking positions were observed across middle-tier tools due to differences in how each algorithm handles trade-offs between different criteria. The results, summarized in Table 4, approve the relative stability and alignment of the MQNSS-Rank output with established MCDM frameworks, which demonstrate its effectiveness and compatibility in uncertain, context-rich decision environments.

Table 4. Comparative rankings of digital content creation tools based on MQNSS-derived scores using multiple MCDM methods

| | **Ours** | **EDAS** | **TOPSIS** | **MAIRCA** |
|---|---|---|---|---|
| $x_1$ | 1 | 2 | 1 | 3 |
| $x_2$ | 2 | 1 | 2 | 1 |
| $x_3$ | 3 | 3 | 3 | 2 |
| $x_4$ | 4 | 6 | 6 | 5 |
| $x_5$ | 5 | 7 | 7 | 7 |
| $x_6$ | 6 | 5 | 5 | 4 |
| $x_7$ | 7 | 4 | 4 | 6 |

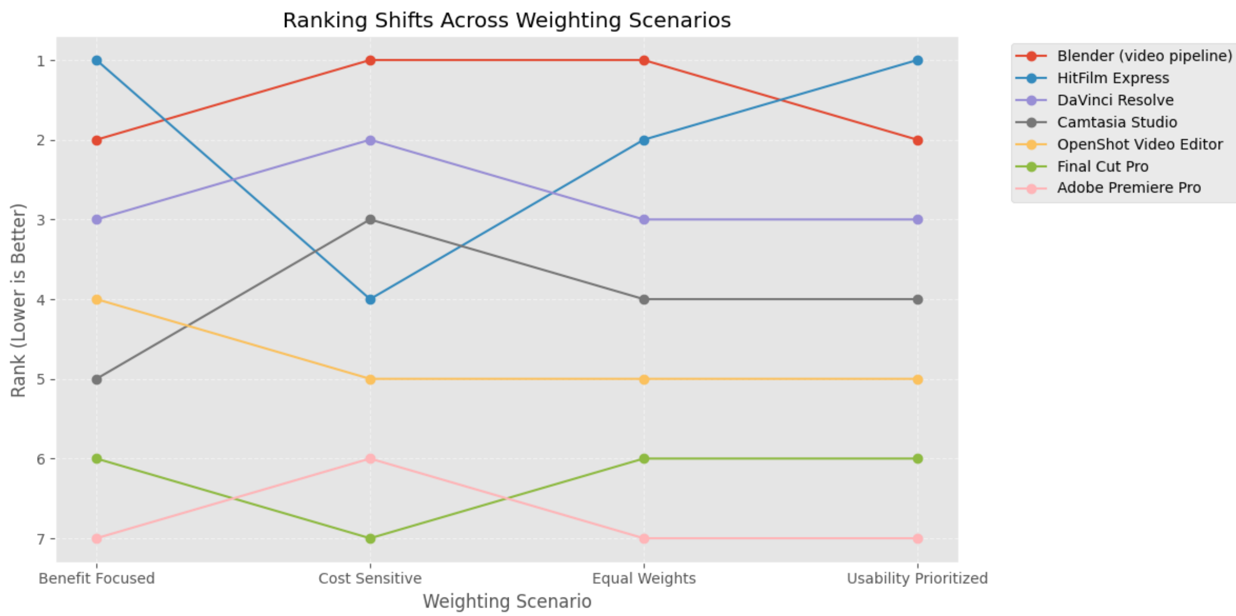


Figure 2. Sensitivity analysis of tool rankings under varying decision parameter weighting scenarios.

To assess the robustness of the proposed framework, a sensitivity analysis is performed by applying four distinct weighting schemes to the decision parameters, as shown in Figure 2. As shown, we include equal weighting (baseline), benefit-focused prioritization, cost-sensitive emphasis, and usability-centered preferences. The results revealed noticeable shifts in tool rankings depending on the evaluation priorities. This can be evident from Blender (video pipeline) and Final Cut Pro exhibiting stronger performance in cost-sensitive and usability-prioritized scenarios. On the opposite side, tools like Adobe Premiere Pro maintained relatively stable rankings across the most weighting models, which indicated a balanced performance profile. This analysis validates the importance of incorporating flexible weighting strategies in uncertain and multi-criteria evaluation environments such as digital media tool selection.

## V. Conclusion

This study introduced a novel MV-QNC framework to model and analyze uncertainty, subjectivity, and context dependence in the evaluation of digital content creation tools. With the incorporation of multi-valued truth, indeterminacy, and falsity degrees, the proposed approach provides a granular and expressive representation of expert decisions across changeable environments. A two-level aggregation-based ranking algorithm has been formulated, which enables robust decision-making with the integration of both benefit and cost parameters. The applications of this framework in a real-world case study demonstrated its effectiveness in ranking software tools based on complex, qualitative assessments. The results reveal that tools such as Final Cut Pro and Adobe Premiere Pro exhibit strong balanced performance, while cost-effective alternatives also perform competitively under certain contexts. This approach not only improves the evaluation process in multimedia environments but also sets a groundwork for future applications in other uncertain and multi-context decision-making domains.

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