AN ORDERED IDEAL INTUITIONISTIC FUZZY SOFTWARE QUALITY MODEL

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ABSTRACT

Software is one of the major factors in the development of computer-based systems and products. Measurement of the software quality is thus the key factor that has to be taken into account while developing a software system. Many software quality models with numerous quality parameters are under use to measure the performance of a software system, on the basis of which the software is valued. This study intends to make available a fuzzy multiple criteria decision making (FMCDM) approach to measure software quality and to propose new similarity measures between ordered ideal intuitionistic fuzzy sets (OIIFSs). The proposed model is applied to five live software projects so as to quantify the software quality of each project under fuzzy environment.

Keywords: Similarity measure, Software quality attributes, Fuzzy multi-criteria decision making, Intuitionistic fuzzy sets.

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1. INTRODUCTION

Life without the assistance of technology is unthinkable in this age. If you can read this, it is because of your know-how of technology. Human life is closely embedded with technology. Technology comes in the form of software and hardware which are in impossibly inseparable from among them and from among human life. Hardware is a visible reality whereas software is virtual. It is the spirit that guides a machine (hardware). Brilliant minds create efficient softwares that make things impossible possible.

Software engineering focuses on producing software. The software that has good quality which can keep up the constraints of budget and time is considered as an efficient software. Impossible though, there are mechanisms to measure the quality of softwares. International Organization for Standardization (ISO) defines characteristics and sub-characteristics that provide a consistent terminology for specifying, measuring and evaluating system and software product quality. In 1991, ISO/IEC9126 was issued to evaluate software quality. It was replaced by ISO/IEC 9126:2001 and on March 1, 2011, the new standard ISO/IEC 25010:2011 was released. This standard is reviewed and confirmed in 2017.[6]

Though software is virtual than real, it has three components viz., programs, documents and data that are real. All these three items emerged during the process of software engineering. There are software-induced hardwares and hardware-induced softwares.[27] Software engineering focuses on creating a basic conceptual structure for building the software that does not compromise on quality. At the same time, software quality management ensures that the software has met the basic requirements such as dependability, maintainability, and portability with an ignorable number of defects. The standard ISO/IEC 25010:2011 proposes two models viz., Quality-in-use Model and Product-Quality Model.[6] Both the models are applicable to the complete human-computer system, including both computer systems in use and software products in use.

Software standard becomes vital as they help to choose the best among all concerning quality. Thus, the process of quality control checks whether the software being developed fulfills well-established standards.[2,5] Software quality measurement is the method used to collect quantitative data about software and characteristics of software quality. The values of the software metrics which are collected may be used to make inferences about the quality of not only the product but also the process. There are no standardized and universally applicable software metrics.[24,26,27] Organizations have an opportunity to identify the metrics and analyze measurements based on local knowledge and circumstances.

A quality model must be able to support specification and evaluation of software and software-intensive computer systems from different perspectives by those associated with their acquisition, requirements, development, use, evaluation, support, maintenance, quality assurance and control, and audit.[17] A good model is universally applicable. All the stakeholders viz., the developers, the acquirers, the quality assurance, and control staff and the independent evaluators must get a reasonable amount of support in decision-making using the quality model.

According to the International Organization for Standardization, following are the various steps the product development. [6]

- Identifying software and system requirements
- Validating the comprehensiveness of a requirements definition
- Identifying software and system design objectives
- Identifying software and system testing objectives
- Identifying quality control criteria as part of quality assurance
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- Identifying acceptance criteria for a software product and/or software-intensive computer system
- Establishing measures of quality characteristics in support of these activities.

In this paper, we introduce a modified fuzzy multiple criteria decision-making approach to measure software quality. Multiple Attribute Decision Making (MADM) refers to making preference decisions over the available alternatives that are characterized by multiple, usually conflicting, attributes.[7, 21] In 1965, Zadeh [30] introduced the concept of fuzzy set theory. Unimaginably, various areas of research grew in leaps and bounds ever since. Wherever the conventional mathematical techniques proved less efficient, the fuzzy methods gave a boost.[31] The fuzzy set theory becomes relevant as the action is done not directly on the crisp real values like in the classic mathematical techniques. Instead, it is being done on the various membership functions (MF) assigned to the variables. This characteristic makes the fuzzy theory a better tool while handling inexact data or inefficient information. Thus, when the data is dynamic, noisy and incomparable, the fuzzy set theory becomes a more powerful tool to assess the underlying physical relationships are difficult to understand.[12, 14-16, 20, 21, 25, 29] The classical MADM methods, both deterministic and random processes, cannot effectively handle problems with such inaccurate and less precise information.[11, 13] Hence, the Fuzzy Multiple Attribute Decision Making (FMADM) has initiated great interest in Artificial Intelligence, Data Mining, Cloud Computing and High-Performance Computing.[3, 4, 7, 22, 23]

Intuitionistic fuzzy sets (IFS) by Atanassov [1] is an extension of fuzzy set theory in which not only a membership grade is given, but also a non-membership grade, which is more or less independent is supplied. There is no universal scale to measure the membership and non-membership grades. Thus, estimations like these will have a part which will remain indeterministic. If the indeterministic part is zero, the intuitionistic fuzzy set theory becomes more over the same as fuzzy set theory. In this paper, the ordered ideal intuitionistic fuzzy sets (OIIFSs) [13, 16] model is developed, some of the results on them are set forth and are used to develop an algorithm for software quality prediction in five different projects.

2. EXPERIMENTAL SETUP

There are several definitions for software quality given in the literature. One of the definitions of software quality goes as the conformation of all the mandatorily stated requirements for performance and functioning and meeting the explicitly documented development standards and implicit characteristics that are supposed to be maintained by all professionally developed software. Software quality comprises of various factors that depend on different applications and the requirements of the customer. There exist mainly two factors that affect the software quality. (1) factors that can be directly measured (e.g., defects per function-point) and (2) factors that can be measured only directly (e.g., usability or maintainability etc.). In each of these cases measurement is mandatory. McCall, Richards and Walters [17] came up with a useful categorization of factors that affect software quality. They are:

1. Correctness: The level to which the designed program satisfies the requirements of the customer’s mission.
2. Reliability: How good is the program while performing the intended function precisely?
3. Integrity: It checks the safety of the software by controlling unauthorized accessibility to data or software.
4. Efficiency: The amount of computing resources and code required by a program to perform its function.
5. Maintainability: How much effort is required to locate and correct an error in a program?
6. Testability: The work done in testing a program to ensure that it executes its intended function.
7. Usability: The work done to learn, operate, prepare input and interpret output of a program.
8. Flexibility: The work required to make changes in an operational program.
9. Portability: The work done in transferring the program from one hardware and/or software system environment to another.
10. Reusability: Extend to which a program [or part of the program] can be reused in other applications - related to the packaging and scope of the functions that the program performs.
11. Interoperability: Effort required to couple one system to another.

The above-mentioned quality factors described by McCall and his colleagues [17] represent one of a number of suggested “checklists” for software quality. The ISO 25010 has modified the ISO 9126 standard [6] with the following key quality identifiers.

- Functional Suitability
- Functional Correctness
- Functional Appropriateness
- Performance Efficiency
- Compatibility
- Usability
- Appropriateness Recognizability
- User Interface Aesthetics
- Reliability
- Security
- Maintainability
- Modifiability
- Portability

3. MODEL FORMULATION

We see some of the fundamental definitions first and then we propose a model.

**Definition: 1** [31] Let $H$ denote a universal set. Then, the function $\mu_C$ is defined as $\mu_C: H \rightarrow [0, 1]$. The function $\mu_C$ is called membership function and the set defined by it is called fuzzy set.

**Definition: 2** [1] An IFS in $H$ is defined as $C = \{(z, (\mu_C(z)), (\nu_C(z))) | z \in H\}$

Where $C$ is a subset of $H$. The functions $\mu_C: H \rightarrow [0, 1]$ and $\nu_C: H \rightarrow [0, 1]$ define the degree of membership and non-membership respectively of the element $z$ to the set $H$. The constraint $0 \leq (\mu_C(z)) + (\nu_C(z)) \leq 1$, $\pi_C(z) = 1(\mu_C(z)) - (\nu_C(z))$ is called the deterministic part for $x$. $0 \leq \pi_C(z) \leq 1$.

**Definition: 3** [7] An ordered intuitionistic fuzzy set (OIFS) in $H$ is defined as

$$C_{\mu,\nu} = \{(z, (\mu_A(z))^j, (\nu_A(z))^k) | z \in H\}$$
Where C is a subset of H, j, k ∈ N and are called weighted indices of the set C. The functions $\mu_C^z: H \to [0, 1]$ and $\nu_C^z: H \to [0, 1]$ define the degree of membership and non-membership respectively of the element z to the set H. 0 ≤ $(\mu_C(z))^j + (\nu_C(z))^k \leq 1$, $\pi_{c_{j,k}}(z) = 1 - (\mu_C(z))^j - (\nu_C(z))^k$ is called the ordered indeterministic part for z. 0 \leq \pi_{c_{j,k}}(z) \leq 1. If j = k = 1, the OIFS $C_{1,1}$ is called IFS.

**Definition 4:** The OIIFSs are defined as:

$M^i_{j,k} = \left\{ (\Gamma_r, \left(\mu^i_{M_{j,k}}(\Gamma_r), \nu^i_{M_{j,k}}(\Gamma_r)\right)) \mid \Gamma_r \in \Gamma \right\}$,

$M^+_{j,k} = \left\{ (\Gamma_r, \left(\mu^+_{M_{j,k}}(\Gamma_r), \nu^+_{M_{j,k}}(\Gamma_r)\right)) \mid \Gamma_r \in \Gamma \right\}$,

$M^-_{j,k} = \left\{ (\Gamma_r, \left(\mu^-_{M_{j,k}}(\Gamma_r), \nu^-_{M_{j,k}}(\Gamma_r)\right)) \mid \Gamma_r \in \Gamma \right\}$.

Where

$(\mu^+_{M_{j,k}}(\Gamma_r))^j = \max_i \left[ (\mu^i_{M_{j,k}}(\Gamma_r))^j \right]$, $(\nu^+_{M_{j,k}}(\Gamma_r))^k = \min_i \left[ (\nu^i_{M_{j,k}}(\Gamma_r))^k \right]$,

$(\mu^-_{M_{j,k}}(\Gamma_r))^j = \min_i \left[ (\mu^i_{M_{j,k}}(\Gamma_r))^j \right]$, $(\nu^-_{M_{j,k}}(\Gamma_r))^k = \max_i \left[ (\nu^i_{M_{j,k}}(\Gamma_r))^k \right]$.

$\pi^+_{M_{j,k}}(\Gamma_r) = 1 - (\mu^+_{M}(\Gamma_r))^j - (\nu^+_{M}(\Gamma_r))^k$, $\pi^-_{M_{j,k}}(\Gamma_r) = 1 - (\mu^-_{M}(\Gamma_r))^j - (\nu^-_{M}(\Gamma_r))^k$.

$(\mu^j_{M_{j,k}}(\Gamma_r))^j \in [0,1], (\nu^k_{M_{j,k}}(\Gamma_r))^k \in [0,1], (\mu^+_{M}(\Gamma_r))^j + (\nu^-_{M}(\Gamma_r))^k \leq 1$.

$\Gamma = \{\Gamma_1, \Gamma_2, \ldots, \Gamma_n\}$ be a set of attributes and $\{M^1, M^2, \ldots, M^m\}$ be a set of Projects. Let $M^+_{j,k}$ and $M^-_{j,k}$ be the ordered positive and negative ideals respectively. Let $\Psi(Z)$ be the set of all OIIFSs of Z. Let $T_{d_1}^{u,v}(M^+_{j,k}, M^-_{j,k})$ be the different similarity measures such that $(T_{d_1})^2 : (\Psi(Z))^2 \to [0, 1]$ for $s = 1, 2, \gamma = j + k + l + h$

**Definition 5:** The modified similarity measures between ordered intuitionistic fuzzy sets is defined as

$T_{d_1}^{j,k,l,h}(Q_{j,k}, R_{l,h}) = 1 - \sqrt{\frac{1}{3m} \sum_{i=1}^{m} \left[ |P^{(j,k,l,h)}(i)|^\frac{j}{2} + |M^{(j,l)}(i)|^\frac{k}{2} + |L^{(k,h)}(i)|^\frac{l}{2} \right]}$

Where, m is the number of parameters of the system.

$|P^{(j,k,l,h)}(i)| = (\Phi_Q(z_i))^j - (\Phi_R(z_i))^l$,

$M^{(j,l)}(i) = (\mu_Q(z_i))^j - (\mu_R(z_i))^l$, $L^{(k,h)}(i) = (\nu_Q(z_i))^k - (\nu_R(z_i))^h$,

$(\Phi_Q(z_i))^j = \frac{\mu_Q(z_i)^j + 1 - (\nu_Q(z_i))^k}{2}$,

$(\Phi_R(z_i))^l = \frac{\mu_R(z_i)^l + 1 - (\nu_R(z_i))^h}{2}$

where $z_i \in G$. If $l = j$ and $h = k$, then

$T_{d_1}^{j,k}(Q_{j,k}, R_{j,k}) = 1 - \sqrt{\frac{1}{3m} \sum_{i=1}^{m} \left[ |P^{(j,k)}(i)|^\frac{j}{2} + |M^{(j,j)}(i)|^j + |L^{(k,k)}(i)|^k \right]}$.
Where, \( p^{(j,k)}(i) = \left( \Phi_Q(z_i) \right)^{j,k} - \left( \Phi_R(z_i) \right)^{j,k} \), \( M^{(j,j)}(i) = \left( \mu_Q(z_i) \right)^j - \left( \mu_R(z_i) \right)^j \), \( L^{(k,k)}(i) = \left( \nu_Q(z_i) \right)^k - \left( \nu_R(z_i) \right)^k \).

**Definition 6:** The degree of similarity of the ordered intuitionistic positive ideal \( M^+_{j,k} \) and alternative \( M^i_{j,k} \) based on \( T_{d_1}^{j,k} \) is defined as

\[
T_{d_1}^{j,k}(M^+_{j,k}, M^i_{j,k}) = 1 - \frac{1}{\sqrt{3m}} \sum_{i=1}^{m} \left[ \frac{p^{M^+_{j,k}}(i)^{(j+k)}}{2} + \frac{|M^+_{j,k}(i)|^j + |L^+_{j,k}(i)|^k}{2} \right]
\]

Where,

\[
p^{M^+_{j,k}}(i) = \left( \Phi_{M^+_{j,k}}(z_i) \right)^{j,k} - \left( \Phi_{M^i_{j,k}}(z_i) \right)^{j,k},
\]

\[
M^{M^+_{j,k}}(i) = \left( \mu_{M^+_{j,k}}(z_i) \right)^j - \left( \mu_{M^i_{j,k}}(z_i) \right)^j,
\]

\[
L^{M^+_{j,k}}(i) = \left( \nu_{M^+_{j,k}}(z_i) \right)^k - \left( \nu_{M^i_{j,k}}(z_i) \right)^k.
\]

**Definition 7:** The degree of similarity of the ordered intuitionistic negative ideal \( M^-_{j,k} \) and alternative \( M^i_{j,k} \) based on \( T_{d_1}^{j,k} \) is defined as

\[
T_{d_1}^{j,k}(M^-_{j,k}, M^i_{j,k}) = 1 - \frac{1}{\sqrt{3m}} \sum_{i=1}^{m} \left[ \frac{p^{M^-_{j,k}}(i)^{(j+k)}}{2} + \frac{|M^-_{j,k}(i)|^j + |L^-_{j,k}(i)|^k}{2} \right]
\]

Where,

\[
p^{M^-_{j,k}}(i) = \left( \Phi_{M^-_{j,k}}(z_i) \right)^{j,k} - \left( \Phi_{M^i_{j,k}}(z_i) \right)^{j,k},
\]

\[
M^{M^-_{j,k}}(i) = \left( \mu_{M^-_{j,k}}(z_i) \right)^j - \left( \mu_{M^i_{j,k}}(z_i) \right)^j,
\]

\[
L^{M^-_{j,k}}(i) = \left( \nu_{M^-_{j,k}}(z_i) \right)^k - \left( \nu_{M^i_{j,k}}(z_i) \right)^k.
\]

**Definition 8:** The similarity measures between ordered intuitionistic fuzzy sets is defined as

\[
T_{d_2}^{j,k,l,h}(Q_{j,k}, R_{l,h}) = 1 - \frac{1}{\frac{1}{2n}} \sum_{i=1}^{n} \left[ \frac{|H^{(j,l)}(i)^{(j+k)}}{2} + \frac{|N^{(j,h)}(i)^{(j+k)}}{2} + \frac{|I^{(j,k,l,h)}(i)^{(j+k)}}{2} \right]
\]

Where,

\[
H^{(j,l)}(i) = \left( \mu_Q(z_i) \right)^j - \left( \mu_R(z_i) \right)^l, \quad N^{(j,h)}(i) = \left( \nu_Q(z_i) \right)^k - \left( \nu_R(z_i) \right)^h \]

\[
I^{(j,k,l,h)}(i) = \pi_Q(z_i) - \pi_R(z_i). \text{ If } l = j \text{ and } h = k, \text{ then}
\]

\[
T_{d_2}^{j,k}(Q_{j,k}, R_{j,k}) = 1 - \frac{1}{\frac{1}{2n}} \sum_{i=1}^{n} \left[ \frac{|H^{(j,l)}(i)^j + |N^{(j,h)}(i)^k + |I^{(j,k,l,h)}(i)^{(j+k)}}{2} \right]
\]

Where, \( H^{(j,l)}(i) = \left( \mu_Q(z_i) \right)^j - \left( \mu_R(z_i) \right)^l, \quad N^{(j,k)}(i) = \left( \nu_Q(z_i) \right)^k - \left( \nu_R(z_i) \right)^l \)
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Definition 8: The degree of similarity of the ordered intuitionistic positive ideal $M_{j,k}^+$ and alternative $M_{j,k}^i$ based on $T_{d_2}^{j,k}$ is defined as

$$T_{d_2}^{j,k}(M_{j,k}^+, M_{j,k}^i) = 1 - \frac{1}{2n} \sum_{i=1}^n \left[ |H_{M_{j,k}^+}(i)|^{(j,k)} + |N_{M_{j,k}^+}(i)|^{(j,k)} \right]$$

Where, $H_{M_{j,k}^+}(i) = (\mu_{M_{j,k}^+}(z_i))^j - (\mu_{M_{j,k}^i}(z_i))^j$, $N_{M_{j,k}^+}(i) = (\nu_{M_{j,k}^+}(z_i))^k - (\nu_{M_{j,k}^i}(z_i))^k$.

Definition 9: The degree of similarity of the ordered intuitionistic negative ideal $M_{j,k}^-$ and alternative $M_{j,k}^i$ based on $T_{d_2}^{j,k}$ is defined as

$$T_{d_2}^{j,k}(M_{j,k}^-, M_{j,k}^i) = 1 - \frac{1}{2n} \sum_{i=1}^n \left[ |H_{M_{j,k}^-}(i)|^{(j,k)} + |N_{M_{j,k}^-}(i)|^{(j,k)} \right]$$

Where, $H_{M_{j,k}^-}(i) = (\mu_{M_{j,k}^-}(z_i))^j - (\mu_{M_{j,k}^i}(z_i))^j$, $N_{M_{j,k}^-}(i) = (\nu_{M_{j,k}^-}(z_i))^k - (\nu_{M_{j,k}^i}(z_i))^k$.

Definition 10: The revised similarity measures between ordered intuitionistic fuzzy sets is defined as

$$T_{d_3}^{j,k,l,h}(Q_{j,k}, R_{l,h}) = 1 - \frac{1}{2} \sum_{i=1}^n \left[ |H_{Q_{j,k}}(i)|^{(j,k,l,h)} + |N_{Q_{j,k}}(i)|^{(j,k,l,h)} \right]$$

If $l = j$ and $h = k$, then

$$T_{d_3}^{j,k}(Q_{j,k}, R_{j,k}) = 1 - \frac{1}{2} \sqrt{\sum_{i=1}^n \left[ |H_{Q_{j,k}}(i)|^{(j,k)} + |N_{Q_{j,k}}(i)|^{(j,k)} \right]^{(j,k)}}$$

Definition 11: The degree of similarity of the ordered intuitionistic positive ideal $M_{j,k}^+$ and alternative $M_{j,k}^i$ based on $T_{d_3}^{j,k}$ is defined as

$$T_{d_3}^{j,k}(M_{j,k}^+, M_{j,k}^i) = 1 - \frac{1}{2} \sqrt{\sum_{i=1}^n \left[ |H_{M_{j,k}^+}(i)|^{(j,k)} + |N_{M_{j,k}^+}(i)|^{(j,k)} \right]^{(j,k)}}$$

Definition 12: The degree of similarity of the ordered intuitionistic negative ideal $M_{j,k}^-$ and alternative $M_{j,k}^i$ based on $T_{d_3}^{j,k}$ is defined as

$$T_{d_3}^{j,k}(M_{j,k}^-, M_{j,k}^i) = 1 - \frac{1}{2} \sqrt{\sum_{i=1}^n \left[ |H_{M_{j,k}^-}(i)|^{(j,k)} + |N_{M_{j,k}^-}(i)|^{(j,k)} \right]^{(j,k)}}$$

Definition 13: Let $L_r(M_{j,k}^i)$ be the relative similarity measure. It is defined as

$$L_r(M_{j,k}^i) = \frac{T_{d_r}^{j,k}(M_{j,k}^+, M_{j,k}^i)}{T_{d_r}^{j,k}(M_{j,k}^+, M_{j,k}^i) + T_{d_r}^{j,k}(M_{j,k}^-, M_{j,k}^i)}$$
for \( r = 1,2 \) and \( j,k \in N \).

**Definition 11:** If \( L_r(M^i_{j,k}) \) is the relative similarity corresponding to the alternative \( M^i \), then the software quality index of the project is denoted by \( SQI_i \) and is defined as \( SQI_i = [L_r(M^i_{j,k}) \times 100] \% \), where \( 0 \leq L_r(M^i_{j,k}) \leq 1 \) and \( 0 \leq SQI_i \leq 100 \). This index of the project \( SQI_i \) is called the crisp output of the software quality. For details of various intuitionistic fuzzy models, readers may refer [3,4,8-11].

### 3.1 Similarity Measure Algorithm

The similarity measure algorithm computes the fuzzified value of software quality in the following seven steps.

1. Identify the relevant software quality attributes \( (P_j) \).
2. Identify different Projects \( (M^i) \).
3. Construct OIFSSs \( M^i_{j,k} \).
4. Construct OIFSSs \( M^i_{j,k}^+ \), \( M^i_{j,k}^- \).
5. Calculate \( T^i_{dr}(M^i_{j,k}^+ \), \( M^i_{j,k}^- \) and \( T^i_{dr}(M^i_{j,k}^+ \), \( M^i_{j,k}^- \) for all \( i, r \).
6. Calculate \( L_r \) corresponding to \( M^i \).
7. Obtain the software quality index.

### 4. EXPERIMENT AND RESULT

The proposed model intends to predict the software quality of five software projects under fuzzy environment. The five projects are denoted by \( P_1 \), \( P_2 \), \( P_3 \), \( P_4 \), \( P_5 \) and \( P_6 \). The software quality attributes are correctness, maintainability, verifiability, efficiency, integrity, reliability, usability, testability, expandability, flexibility, portability, reusability and interoperability. The proposed model involves five software projects and 13 software quality attributes. The attribute set \( E = \{ \Gamma_1, \Gamma_2, \Gamma_3, \Gamma_4, \Gamma_5, \Gamma_6, \Gamma_7, \Gamma_8, \Gamma_9, \Gamma_{10}, \Gamma_{11}, \Gamma_{12}, \Gamma_{13} \} \) denotes correctness, maintainability, verifiability, efficiency, integrity, reliability, usability, testability, expandability, flexibility, portability, reusability and interoperability, in that order.

The OIFSSs are computed as:

\[
\{ \{ \Gamma_1 \}, \{ \Gamma_2 \}, \{ \Gamma_3 \}, \{ \Gamma_4 \}, \{ \Gamma_5 \}, \{ \Gamma_6 \}, \{ \Gamma_7 \}, \{ \Gamma_8 \}, \{ \Gamma_9 \}, \{ \Gamma_{10} \}, \{ \Gamma_{11} \}, \{ \Gamma_{12} \}, \{ \Gamma_{13} \} \}, \text{ Where } \\
\{ \Gamma_1 \} = \{ M^1/((7,2), (1,1)), M^2/((6,1), (2,2)), M^3/((6,2), (2,2)), M^4/((9,2), (0.5,1)), M^5/((5,2), (2.5,1)) \}, \\
\{ \Gamma_2 \} = \{ M^1/((7,1), (1,1)), M^2/((8,1), (1,3)), M^3/((9,3), (0.5,2)), M^4/((6,1), (3.3,2)), M^5/((9,2), (0.5,1)) \}, \\
\{ \Gamma_3 \} = \{ M^1/((8,1), (1,1)), M^2/((8,1), (1,3)), M^3/((1,1), (0,1)), M^4/((7,2), (1.9,1)), M^5/((8,2), (1,1)) \}, \\
\{ \Gamma_4 \} = \{ M^1/((9,2), (0.5,1)), M^2/((9,1), (0,1)), M^3/((1,1), (0,1)), M^4/((8,1), (1,2)), M^5/((9,2), (0.5,1)) \}, \\
\{ \Gamma_5 \} = \{ M^1/((1,1), (0,1)), M^2/((5,2), (1,1)), M^3/((1,1), (0,1)), M^4/((5,2), (3,1)), M^5/((5,2), (3,1)) \}, \\
\]
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\[ \{ \Gamma_6 \} = \{ M^1/((.5)^2, (.4)^1), M^2/((1)^1, (0)^1), M^3/((1)^1, (0)^1), M^4/((.5)^2, (.4)^2), M^5/((.5)^2, (.4)^1) \}, \]

\[ \{ \Gamma_7 \} = \{ M^1/((.5)^2, (.4)^1), M^2/((.6)^1, (.2)^2), M^3/((1)^1, (0)^1), M^4/((.4)^2, (.42)^2), M^5/((.9)^2, (.05)^1) \}, \]

\[ \{ \Gamma_8 \} = \{ M^1/((.8)^1, (.1)^1), M^2/((.8)^1, (.1)^3), M^3/((1)^1, (0)^1), M^4/((.7)^2, (.19)^1), M^5/((.8)^2, (.1)^1) \}, \]

\[ \{ \Gamma_9 \} = \{ M^1/((1)^1, (0)^1), M^2/((.5)^2, (.1)^1), M^3/((1)^1, (0)^1), M^4/((.5)^2, (.3)^1), M^5/((.5)^2, (.3)^1) \}, \]

\[ \{ \Gamma_{10} \} = \{ M^1/((.5)^2, (.4)^1), M^2/((.6)^1, (.2)^2), M^3/((1)^1, (0)^1), M^4/((.4)^2, (.42)^2), M^5/((.9)^2, (.05)^1) \}, \]

\[ \{ \Gamma_{11} \} = \{ M^1/((.7)^2, (.1)^1), M^2/((.6)^1, (.2)^2), M^3/((.6)^2, (.2)^2), M^4/((.9)^2, (.05)^1), M^5/((.5)^2, (.25)^1) \}, \]

\[ \{ \Gamma_{12} \} = \{ M^1/((.5)^2, (.4)^1), M^2/((1)^1, (0)^1), M^3/((1)^1, (0)^1), M^4/((.5)^2, (.4)^2), M^5/((.5)^2, (.4)^1) \}, \]

\[ \{ \Gamma_{13} \} = \{ M^1/((.5)^2, (.4)^1), M^2/((1)^1, (0)^1), M^3/((1)^1, (0)^1), M^4/((.5)^2, (.4)^2), M^5/((.5)^2, (.4)^1) \}. \]

### Table 1 \( T^{l/k}_{d_1}(M^i_{j,k}, M^i_{j,k}), T^{l/k}_{d_1}(M^-_{j,k}, M^i_{j,k}), L_1(M^i_{j,k}) \)

<table>
<thead>
<tr>
<th>( M^i_{j,k} )</th>
<th>( T^{l/k}<em>{d_1}(M^i</em>{j,k}, M^i_{j,k}) )</th>
<th>( T^{l/k}<em>{d_1}(M^-</em>{j,k}, M^i_{j,k}) )</th>
<th>( L_1(M^i_{j,k}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.6283</td>
<td>0.5831</td>
<td>0.5173</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.7879</td>
<td>0.5437</td>
<td>0.5917</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.8913</td>
<td>0.2834</td>
<td>0.7587</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.6697</td>
<td>0.7903</td>
<td>0.4586</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.6864</td>
<td>0.7332</td>
<td>0.4835</td>
</tr>
</tbody>
</table>

### Table 2 \( T^{l/k}_{d_2}(M^i_{j,k}, M^i_{j,k}), T^{l/k}_{d_2}(M^-_{j,k}, M^i_{j,k}), L_2(M^i_{j,k}) \)

<table>
<thead>
<tr>
<th>( M^i_{j,k} )</th>
<th>( T^{l/k}<em>{d_2}(M^i</em>{j,k}, M^i_{j,k}) )</th>
<th>( T^{l/k}<em>{d_2}(M^-</em>{j,k}, M^i_{j,k}) )</th>
<th>( L_2(M^i_{j,k}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.7823</td>
<td>0.7503</td>
<td>0.5104</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.8361</td>
<td>0.7437</td>
<td>0.5292</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.9693</td>
<td>0.2739</td>
<td>0.7797</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.7076</td>
<td>0.9049</td>
<td>0.4388</td>
</tr>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.7499</td>
<td>0.8389</td>
<td>0.5282</td>
</tr>
</tbody>
</table>

### Table 3 \( T^{l/k}_{d_3}(M^i_{j,k}, M^i_{j,k}), T^{l/k}_{d_3}(M^-_{j,k}, M^i_{j,k}), L_3(M^i_{j,k}) \)

<table>
<thead>
<tr>
<th>( M^i_{j,k} )</th>
<th>( T^{l/k}<em>{d_3}(M^i</em>{j,k}, M^i_{j,k}) )</th>
<th>( T^{l/k}<em>{d_3}(M^-</em>{j,k}, M^i_{j,k}) )</th>
<th>( L_3(M^i_{j,k}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M^i_{j,k} )</td>
<td>0.5770</td>
<td>0.5417</td>
<td>0.5157</td>
</tr>
</tbody>
</table>

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4. ANALYSIS

In this work, we developed an OIIFS model to measure software quality. The relative similarity measure \( L_r \) is analyzed on the basis of its dependability. Identical outputs are generated by the application of either of the proposed relative similarity measures. The choice of parameters plays a critical role in the prediction of software quality. Values of \( j \) and \( k \) vary according to the differences in situations. \( L_r(M_{j,k}^i) \) leads to the conclusion that for higher values of \( u \), the membership value is decreasing. At the same time the non-membership value is increasing for the smaller values of \( u \).

The analyses reveal that the relative similarity measure satisfies the condition

\[
0 \leq L_r(M_{j,k}^i) \leq 1.
\]

Clearly, \( 0 \leq T_{d_r}^{j,k}(M_{j,k}^i, M_{j,k}^i), T_{d_r}^{j,k}(M_{j,k}^i, M_{j,k}^i) \leq 1 \). If the similarity measure of ordered positive ideal is increasing then the ordered negative ideal is decreasing and vice versa. If \( L_r(M_{j,k}^i) = 1 \), the cumulative impact of software quality attributes are highly affects the output. Therefore, \( T_{d_r}^{j,k}(M_{j,k}^i, M_{j,k}^i) = 0 \). In that case the software quality index belongs to the class 'very high'. If \( 0.70 \leq L_r(M_{j,k}^i) \leq 1 \), the software quality index is belongs to the class 'very high'. If \( 0.5 \leq L_r(M_{j,k}^i) < 0.70 \), it belongs to the class 'high'. If \( 0.25 \leq L_r(M_{j,k}^i) < 0.5 \), it belongs to the class medium. The value is less than 0.25, it belongs to the class low. The quality of software product is important for the smooth running of the business.

5. CONCLUSION

The output shows that the Project \( M_{j,k}^3 \) has maximum software quality index and hence it is the most suitable one. The study is intended to enable researchers the world over to do more substantial studies in similar fields. The future holds great possibilities taking in to consideration the huge potential the model has diverse avenues open up in the field of further researches in this area.

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Table 4 $SOI_i$

<table>
<thead>
<tr>
<th>( M_{j,k}^i )</th>
<th>Mean(( T_{d_1}^{j,k}(M_{j,k}^i, M_{j,k}^i), T_{d_2}^{j,k}(M_{j,k}^i, M_{j,k}^i) ))</th>
<th>$SOI_i$</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M_{j,k}^1 )</td>
<td>0.5144</td>
<td>51.44</td>
<td>High</td>
</tr>
<tr>
<td>( M_{j,k}^2 )</td>
<td>0.5588</td>
<td>55.88</td>
<td>High</td>
</tr>
<tr>
<td>( M_{j,k}^3 )</td>
<td>0.7690</td>
<td>76.90</td>
<td>Very High</td>
</tr>
<tr>
<td>( M_{j,k}^4 )</td>
<td>0.4453</td>
<td>44.53</td>
<td>Medium</td>
</tr>
<tr>
<td>( M_{j,k}^5 )</td>
<td>0.4862</td>
<td>48.62</td>
<td>Medium</td>
</tr>
</tbody>
</table>

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An Ordered Ideal Intuitionistic Fuzzy Software Quality Model

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REFERENCES


