Interval Valued Neutrosophic Sets and Multi-Criteria Decision Making for Sustainable Mobile Healthcare Promotion

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Abstract

The use of health mobile websites or apps on smartphones like mobile-phones has made it possible for users to have quick, inexpensive access to the services of licensed medical professionals. As a result, mobile health care has the potential to lessen the burden on the healthcare system by lowering costs, decreasing wait times, and maximizing the effectiveness of available resources. In order to foster the long-term growth of healthcare infrastructure. This paper introduce the interval valued neutrosophic sets (IVNSs) to overcome the uncertainty. The IVNSs is combined with the MCDM methodology such as TOPSIS method. The TOPSIS technique is used to order the options. In addition to assisting with the selection of the best mobile health care option, this methodology may be used to close the performance gap between competing products and meet customer expectations. There were four distinct categories of mobile health care products investigated.

Keywords: Mobile Healthcare; MCDM; Interval Valued Neutrosophic Sets; TOPSIS;

1. Introduction

Using smart phones (such as mobile phones, tablets, and individual digital assistants) to offer medical products and health statistics to patients is a key component of electronic medicine. There are a lot of issues plaguing the healthcare system, such as the high cost of treatment and the limited availability of medical professionals. The use of health mobile apps or sites on smartphones like mobile-phones has made it possible for users to have quick, inexpensive access to the services of licenced medical professionals. As a result, mobile health care has the potential to lessen the burden on patients' wallets and their time while also making better use of the healthcare system's resources. Consequently, it has the potential to become a model for long-term growth in the healthcare sector. This is good news for regular customers, particularly those in precarious financial situations[1], [2]. People in China's rural regions and urban migrant populations have a hard time gaining access to adequate medical services and can't always afford pricey medical care. While the unequal distribution of healthcare resources is reflected by the redundancy of certain cities' medical facilities,. However, thanks to advances in mobile health care, patients may diagnose and treat common ailments like the flu and toothaches on their own, with guidance from board-certified

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physicians, thanks to the convenience of the internet. The elderly will be equipped with mobile medical equipment that will relay data to the enterprise's customer centre, where it will be examined by a physician and presented to the client. As a result, the quality, equality, and resilience of population health are all enhanced through mobile health[3], [4].
Many nations have reached the 4G age, thanks to the proliferation of mobile networks, and reap the benefits of ever-improving mobile networks and cutting-edge software and hardware. China Internet Backbone National Institute (CNNIC) reports that out of China's total internet population (772 million), 97.5 percent are now using mobile devices to access the internet. Premier Li Keqiang originally proposed the Net Plus implementation plan in March 2015, which called for the integration of the Internet with more conventional economic sectors. The goal of this strategy is to improve communication and cooperation between the medical field and the mobile internet sector by fusing the two[5].

There are clearly promising futures for the mobile health care business in terms of both mobile devices and consumer demand. Benefits to society and the economy may be substantial when hospital resources are distributed more effectively via mobile health care services.

Improve mobile healthcare promotion is a MCDM due to it contain the conflicting factors. The MCDM is integrated with the IVNSs to overcome the incomplete information. The IVNSs TOPSIS [6]–[9]method is used to rank the alternatives.

3. Interval Valued Neutrosophic Sets[10]–[16]

Definition 1:

Let E be a universe. A single valued neutrosophic sets A in E are characterized by a truth membership function TA, a indeterminacy membership function IA and a falsity − membership function FA. TA; IA and FA are real standard elements of [0,1]. *It can be written as*

$$A = \{< x, (T_A(x), I_A(x), F_A(x)) >: x \in E, T_A(x), I_A(x), F_A(x) \in [0,1]\}.$$

There is no restriction on the sum of $T_A\ (x);\ I_A\ (x)$ *and* $FA\ (x)$, *so*

$$0- \leq T_A(x) + I_A(x) + F_A(x) \leq 3 +.$$

Definition 2:

$X_j = \langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$ *is a collection of interval valued neutrosophic numbers where* $j = 1,2, \dots, n$ *and n is the number of decision makers.*

Definition 3:

Deneutrosophication: We propose a new deneutrosophication function of an interval valued neutrosophic number which is given below:

$$D(x) = \left(\frac{T_x^L + T_x^U}{2} + \left(1 - \frac{I_x^L + I_x^U}{2}\right) * (I_x^U) - \left(\frac{F_x^L + F_x^U}{2}\right) * (1 - F_x^U)\right)$$

where $x_j = \langle [T_x^L, T_x^U], [I_x^L, I_x^U], [F_x^L, F_x^U] \rangle$.

Definition 4:

$$T_N(x) = [T_N^L(x), T_N^U(x)] \subseteq [0,1],$$

$$I_N(x) = [I_N^L(x), I_N^U(x)] \subseteq [0,1], \text{and } F_N(x) = [F_N^L(x), F_N^U(x)] \subseteq [0,1].$$

They also meet the condition $0 \leq T_N^L(x) + I_N^L(x) + F_N^L(x) \leq 3$. *So,*

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$the\ interval\ valued\ neutrosophic\ set$

$N = \{\langle x, [T_N^L(x), T_N^U(x)], [I_N^L(x), I_N^U(x)], [F_N^L(x), F_N^U(x)]\rangle | x \in X\}.$

Definition 5:

$Let\ a = \langle [T_a^L, T_a^U], [I_a^L, I_a^U], [F_a^L, F_a^U]\rangle$

$and\ b = \langle [T_b^L, T_b^U], [I_b^L, I_b^U], [F_b^L, F_b^U]\rangle be\ two\ intervalvalued\ neutrosophic\ numbers.$

Their relations and arithmetic operations are given by

$a^c = \langle [F_a^L, F_a^U], [1 - I_a^U, 1 - I_a^L], [T_a^L, T_a^U]\rangle$

$a \subseteq I_a^L \geq b\ \ if\ and\ only\ if\ T_a^L \leq T_b^L;$

$T_a^U \leq T_b^U; I_b^L, I_a^U \geq I_b^U; F_a^L \geq F_b^L, F_a^U \geq F_b^U$

$a = b\ if\ and\ only\ if\ a \subseteq b\ and\ b\ \subseteq a.$

$a \oplus b = \langle [T_a^L + T_b^L - T_a^L T_b^L, T_a^U + T_b^U - T_a^U T\text{^}U\text{\_}b]$,×

$[I_a^L I_b^L, I_a^U I_b^U], [F_a^L F_b^L, F_a^U F_b^U]\rangle$

$a \oplus b = \langle [T_a^L T_b^L, T_a^U T_b^U]$

$[I_a^L + I_b^L - I_a^L I_b^L, I_a^U + I_b^U - I_a^U I_b^U]$,×

$[F_a^L + F_b^L - F_a^L F_b^L, F_a^U + F_b^U - F_a^U F_b^U]\rangle$

Definition 6:

$x \ominus y = \langle [T_x^L - F_y^U, T_x^U - F_y^L],$

$[Max(I_x^L, I_y^L), Max(I_x^U, I_y^U)]$,× $[F_x^L - T_y^U, F_x^U - T^L y]\rangle$

$where\ x = \langle [T_x^L, T_x^U], [I_x^L, I_x^U],$

$[F_x^L, F_x^U]\rangle\ and$
$y = \langle [T_y^L, T_y^U], [I_y^L, I_y^U], [F_y^L, F_y^U]\rangle.$

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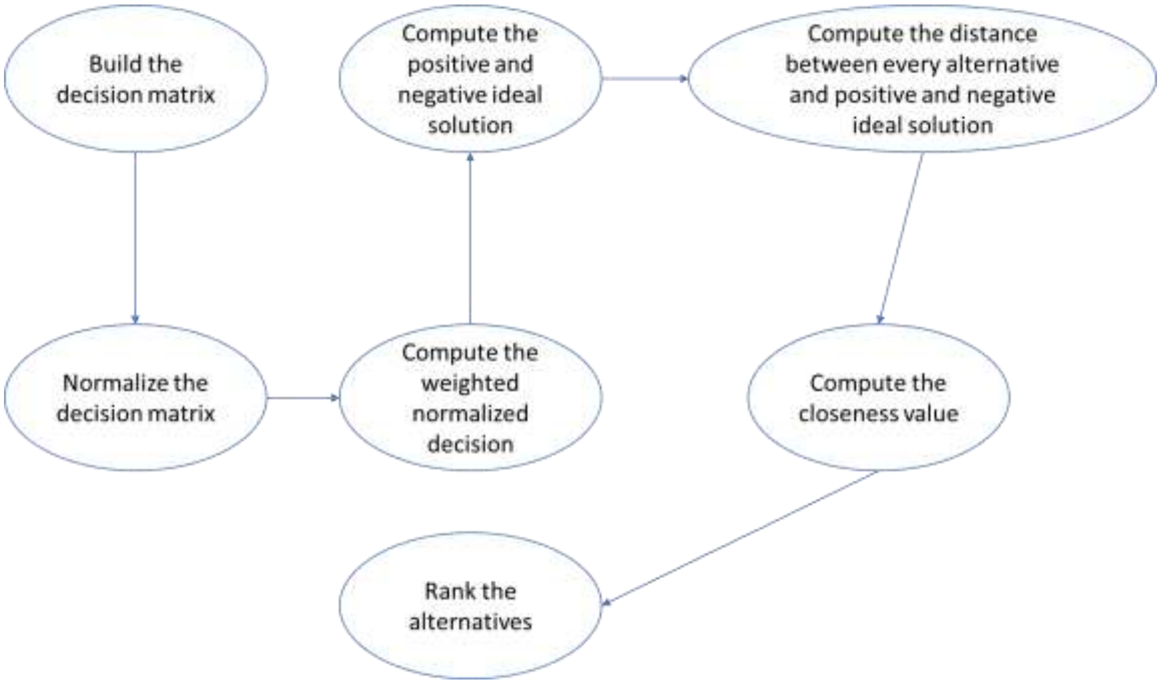

Figure 1: The IVNS TOPSIS method.

3. IVNSs TOPSIS method

TOPSIS, or the Technique for Ordering Preferences by Resemblance to the Ideal Solution, was developed by Yoon and Hwang. The theory holds that the optimal solution will be the one that is both the closest to the positive ideal and the furthest from the bad ideal[10], [17]. Each criteria has the greatest possible value in the ideal solution, however in the bad perfect result, this is not the case. It's a common outranking strategy used in many kinds of selection processes, including choosing amongst potential vendors. Figure 1 demonstrations the stages of the approach[18]–[21].

Step 1: Build the judgement background

The experts assessed the criteria and substitutions by the interval valued neutrosophic numbers. Then compute the weights of criteria.

Step 2: Normalize the judgement background

The decision matrix is normalized

Step 3: Compute the weighted normalized judgement background

Step 4: Calculate the optimistic and bad perfect result

For an IVN, the positive and negative ideal solution is defined as follows

$$y^{\cdot +}_{j} = ([max\ T^{L}_{ij}, \max T^{U}_{ij}], [minI^{L}_{ij}, minI^{U}_{ij}], [minF^{\cdot L}_{ij}, minF^{U}_{ij}])$$

$$y^{\cdot -}_{j} = ([min\ T^{L}_{ij}, \min T^{U}_{ij}], [maxI^{L}_{ij}, max\ I^{U}_{ij}], [max^{\cdot} F^{L}_{ij}, maxF^{U}_{ij}])$$

Step 5: Compute the distance among every substitute and optimistic and bad perfect result as:

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$$d_i^+ = \sum_{j=1}^{n} d(y_{\cdot ij}, y^{\cdot +}_j)$$

$$d_i^- = \sum_{j=1}^{n} d(y_{\cdot ij}, y^{\cdot -}_j)$$

Step 6: Compute the closeness value as

$$C = \frac{d_i^+}{d_i^+ + d_i^-}$$

Step 7: Rank the alternatives

4. Results

Step 1: Build the decision matrix

First let experts assess the factors and substitutions by using the numbers of interval valued neutrosophic sets. The collected criteria as: ease of use, trust, usefulness, economical, social, and compatibility. Then compute the weights of factors as shown in figure 2. The criterion 4 is the uppermost weight and criterion 3 is the lowest weight.

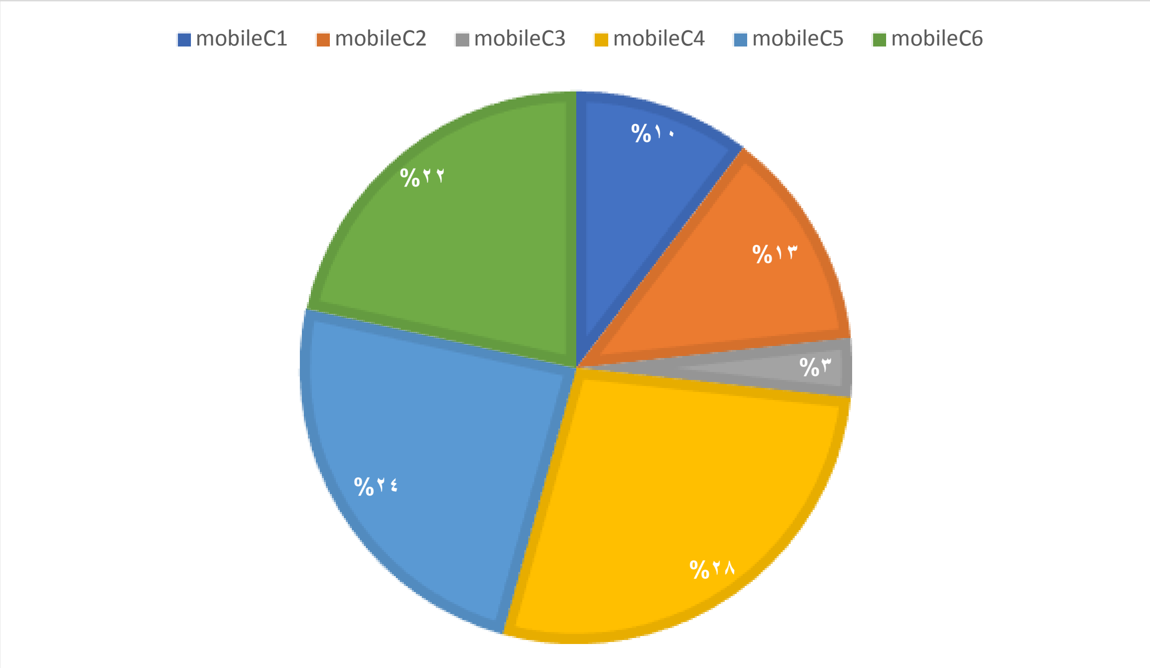

Figure 2: The weights of factors.

Step 2: Normalize the judgement background

Table 1 shows the normalization judgement background.

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Table 1: The normalization judgement background.

	MobileC1	MobileC2	MobileC3	MobileC4	MobileC5	MobileC6
MobileA1	0.438325	0.926227	0.800861	0.251134	0.302414	0.201763
MobileA2	0.222641	0.120812	0.327625	0.669691	0.462022	0.540436
MobileA3	0.619221	0.332233	0.482337	0.570759	0.546026	0.612494
MobileA4	0.612264	0.13088	0.13651	0.403336	0.63003	0.540436

Step 3: Compute the weighted normalized judgement background

The weights of criteria are multiplying by the normalization judgement background to obtain the weighted normalization judgement background as exposed in table 2.

Table 2: The weighted normalization judgement background.

	MobileC1	MobileC2	MobileC3	MobileC4	MobileC5	MobileC6
MobileA1	0.045344	0.119771	0.027616	0.069278	0.072997	0.043483
MobileA2	0.023032	0.015622	0.011297	0.184742	0.111522	0.116473
MobileA3	0.064057	0.042961	0.016632	0.157451	0.131799	0.132003
MobileA4	0.063338	0.016924	0.004707	0.111265	0.152076	0.116473

Step 4: Compute the optimistic and bad perfect result

Step 5: Compute the distance among every alternative and optimistic and bad perfect result

Step 6: Compute the closeness value

Step 7: Order the substitutions as exposed in figure 3. The substitute 3 is the finest substitute and substitute 1 is the worst substitute.

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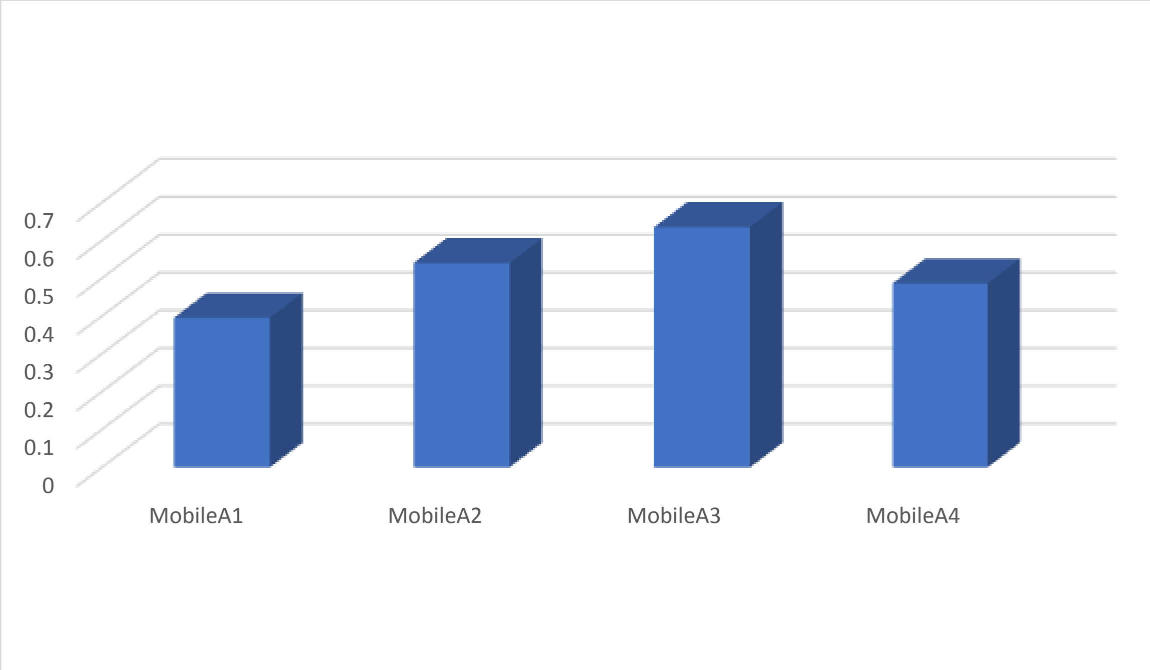

Figure 3: The order of substitutions.

5. Conclusion

Mobile health care that delivers efficient answers is not only more accessible and cost-effective, but also has the potential to foster the efficient use of healthcare resources over time. Still, there is a lot of room for growth when it comes to the use of mobile health care. An MCDM methodology was developed to analyse the elements that affected consumer interest in mobile health services. The product improvement performance gaps were determined using a revised version of the TOPSIS approach.

IVNSs are a new subfield of NSs that may be used to solve issues in the actual world of science and engineering that are complicated by the presence of vague, ambiguous, incomplete, or contradictory data. In this research, we present a method to MCDM problem solution utilizing INSs, and we construct certain aggregation operations.

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