Neutrosophic Systems with Applications, Vol. 12, 2023
https://doi.org/10.61356/j.nswa.2023.99

Intelligent Healthcare: Evaluation Potential Implications of Metaverse in Healthcare Based on Mathematical Decision-Making Framework

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Abstract: The Metaverse has the ability to restructure and change the manner in which individuals connect with one another as well as the activities that they carry out on a daily basis. One definition of a Metaverse describes it as "a virtual, digital, and three-dimensional universe formed by the integration of various cutting-edge technologies and virtual places." In this piece, we will explore the potential applications of the Metaverse in the medical field. Our conversations on the notion of the Metaverse and the primary technologies that make it possible are both thought-provoking and in-depth. In this article, we study and analyze the possible uses of the Metaverse in the healthcare industry, including telemedicine and telehealth, medical education and training, medical marketing, healthcare supply chain, healthcare facilities, as well as fitness and wellness. The primary obstacles that prevent the broad implementation of the Metaverse in healthcare are discussed in this paper. Finally, evaluating implications of leveraging Metaverse in healthcare is discussed. Best Worst Method (BWM) is deployed with Triangular Neutrosophic Sets (TriNSs) to estimate criteria's weights where five criteria have been determined for alternatives of Metaverse. These alternatives are evaluated and ranked through weighted sum model (WSM) with help of TriNSs. The findings of this process demonstrated that Metaverse alternative 1 (MeT1) Health Surveillance is optimal according to global score. Antithesis Metaverse alternative 3 (MeT3) Virtual surgical is least one.

Keywords: Metaverse; Healthcare; Virtual reality; Blockchain; Artificial intelligence; Cutting-edge technologies; Neutrosophic.

1. Introduction

One of the most important factors that helps ensure the overall, physical, social, and mental well-being of the whole human population around the globe is access to quality healthcare [1]. Any healthcare system should have as its major goal to direct its resources towards actions that would promote, repair, maintain, and enhance healthcare services. Additionally, it makes a significant contribution toward the effective growth and industrialization of a nation's economy. Because of this, the sector has seen quick expansion and revolution as a result of being highly exposed to the progression of technology in the interest of enhancing the experience of contact between carers, patients, and associated stakeholder groups. The advent of digital healthcare has been a significant catalyst for transformation in the healthcare sector. The introduction of digital health services that make use of the internet and digital tools have had a significant effect on the contact that takes place between patients and medical professionals on a very broad scale. These changes were made visible as a result of the development of technologies such as blockchain, augmented reality (AR), and virtual reality (VR) [1]. Even though there has been a lot of progress made in the healthcare industry, there are still a lot of problems that need to be solved in this industry. Some of these problems include the overwhelming burden of long-term chronic diseases, rising expenses, an aging population, a lack of qualified healthcare workers, and limited resources that are available. Due to the prevalence of these problems, there is a growing need for medical treatments that may be delivered directly to the homes of patients. The most recent pandemic, COVID-19, has placed immense strain on the global healthcare system and the underlying labour, infrastructure, and supply chain management. COVID-19 has been the key cause for the acceleration of fast change across the healthcare ecosystem, and it has driven the players in this sector to seek adaption of the technologies that are utilized in this industry [2].

The period after the epidemic has been accompanied by significant changes in the fundamental underpinnings of the healthcare field. For instance, consumers of the current age have recently begun to take an active role in the decision-making process on matters pertaining to their healthcare, which has been followed by an enthusiastic adoption of virtual healthcare systems and other relevant digital advancements. Additionally, there has been an active drive for the utilization of inter-operable data and data analytics; unprecedented cooperation in the creation of treatments, which have forced governments, healthcare providers, and other stakeholders to adapt and innovate. However, there are still significant obstacles to overcome, and the way in which these obstacles are addressed will determine how far we go toward realizing the potential of the healthcare industry [3]. The patients and their experiences are the driving force behind innovations in this sector due to the fact that the consumers' ever-changing objectives and aspirations are what drive innovation. Their key preferences include the development of technologically enabled, on-demand, and seamless patient-clinician contact, with the goal of assuring the delivery of patient-centric services across geographical borders and socioeconomic groupings.

The health journey of every single patient is distinct, and it is essential to recognize this fact in order to tailor the particular services and bring every encounter to the level of a personalized healthcare experience. It is now very necessary to use cutting-edge digital tools and services in order to maximize customer happiness. This will make it possible to keep better track of patient's health conditions and ensure that they take their drugs as prescribed. Customers in the healthcare industry are becoming more open to the idea of disclosing their private information [4]. As a result, there is a growing need for organizations to offer interoperability across different organizations and to maintain customers' confidence by displaying dependability, openness, and empathy in their business practices. The current plan calls for shifting the emphasis away from healthcare and towards health and well-being, which will hopefully motivate changes in the design of service offers and delivery methods. Therefore, organizations are pushing the adoption of virtual care, remote monitoring, digital diagnostics, decision support systems, at-home prescription delivery systems, and self-service apps for educational and social support purposes. Utilizing technologies such as artificial intelligence, cloud computing, augmented reality, and virtual reality, this digital revolution has had a tremendous influence on the healthcare ecosystem by enhancing its working capacity, access to services, and the experience that patients and clinicians have with one another.

The purpose of this essay is to provide a visionary framework for the Metaverse that addresses current difficulties in the healthcare industry by using a variety of sophisticated and upcoming technologies. We provide an overarching summary of the Metaverse, including information on its system architecture and the technologies that make it possible. We investigate the possible uses of the Metaverse in the medical field, which have the potential to revolutionize the industry and provide virtual healthcare services of a higher quality. We describe the many ways in which enabling technologies for the Metaverse may be incorporated expressly for applications in the healthcare industry. In addition, we show how the system architecture for such applications may be built and organized in a variety of different ways. In addition, we explore the possible associated difficulties that the Metaverse may provide for applications in the healthcare industry. In conclusion, we discuss potential avenues for further study.

2. Metaverse Overview

In Neal Stephenson's science fiction book titled "Snow Crash," which was published in 1992, the word "Metaverse" was first used. The story envisioned the creation of a virtual environment in which individuals might utilize digital avatars to explore and communicate with one another. The Metaverse is a new idea and a technology that is always developing, and its definition is subject to change depending on the people who are engaged and the application that it is designed to serve. A computer simulation that enables digital avatars of participants to interact with each other in a realistic, shared, and life-like environment is referred to as the Metaverse. In its most basic form, the Metaverse may be understood as a broad term. Although the idea of a Metaverse may be implemented in a variety of applications for a wide variety of reasons, the components of the system architecture are, for the most part, consistent. In general, it is made up of its physical world, its virtual world (the Metaverse), its interface and access, and the Metaverse enabling technologies. These four components make up its primary makeup.

- The real-world, physical environment is augmented with a computer-generated visual overlay in real-time via the use of augmented reality. It employs the use of lenses, glasses, or cellophanes. The purpose of the Metaverse is to supplement the knowledge that is already available in the natural world. Examples include the mobile game Pokémon Go and animated three-dimensional medical presentations.
- The inner word is expanded upon in another way via the practice of lifelogging. In contrast to augmented reality, the use of smart gadgets to capture ordinary lives and upload them to the internet is becoming more common. Instagram, Facebook, Twitter, and even apps that track your health are some examples.
- A simulation of our actual environment is what we mean when we talk about a "mirror world." The actual look, information, and structure are brought into a virtual area, which makes it possible to carry out tasks via the internet or mobile apps.
- The inner world is simulated using a technology known as virtual reality, which is an online simulation of a high-tech, three-dimensional reality complete with avatars and a tool for quick communication. The cultural, physical, and social qualities of the avatar are not reflective of reality, and the avatar may be customized to reflect the user's preferences. The avatar is able to carry in conversations with other entities and complete objectives. Online multiplayer video games, virtual hospitals and clinics, and online consultation spaces are a few examples.

3. Enabling Metaverse Technologies for Healthcare

Figure 1 provides a concise overview of the primary technologies that enable the Metaverse, and the following paragraphs provide a short summary of the roles played by these technologies.

3.1 Extended reality

In the realm of extended reality (XR), technologies such as AR, VR, holograms, and mixed reality (MR) are combined with artificial intelligence (AI), computer vision, and linked devices such as mobile phones, wearables, and head-mounted displays [5]. This innovative technology is revolutionizing the way services are provided and boosting their quality in a variety of industries. It does this by merging speech recognition, gesture recognition, motion tracking, vision, and haptics. People have always believed that VR will primarily be beneficial to the entertainment business. It was to be anticipated that participating in an immersive experience would in no way detract from a user's enjoyment of a movie or video game. Despite this, the use of XR has far exceeded these estimates. It is being used in an expanding range of sectors, ranging from the medical field to the industrial industry. XR will develop to its greatest potential and continue to advance as it is present in the Metaverse. Combining VR with AR technology enables users to experience a feeling of virtual presence inside the Metaverse. One example of such a technology is holographic communication, which provides users with an immersive experience in a setting that is relatively hassle-free. Holographic communications have the potential to materialize the three-dimensional digital representations that are used in the process. Integrating 3D capture, hologram synthesis, transport, and display, as well as other aspects of 3D technology makes this technology conceivable.

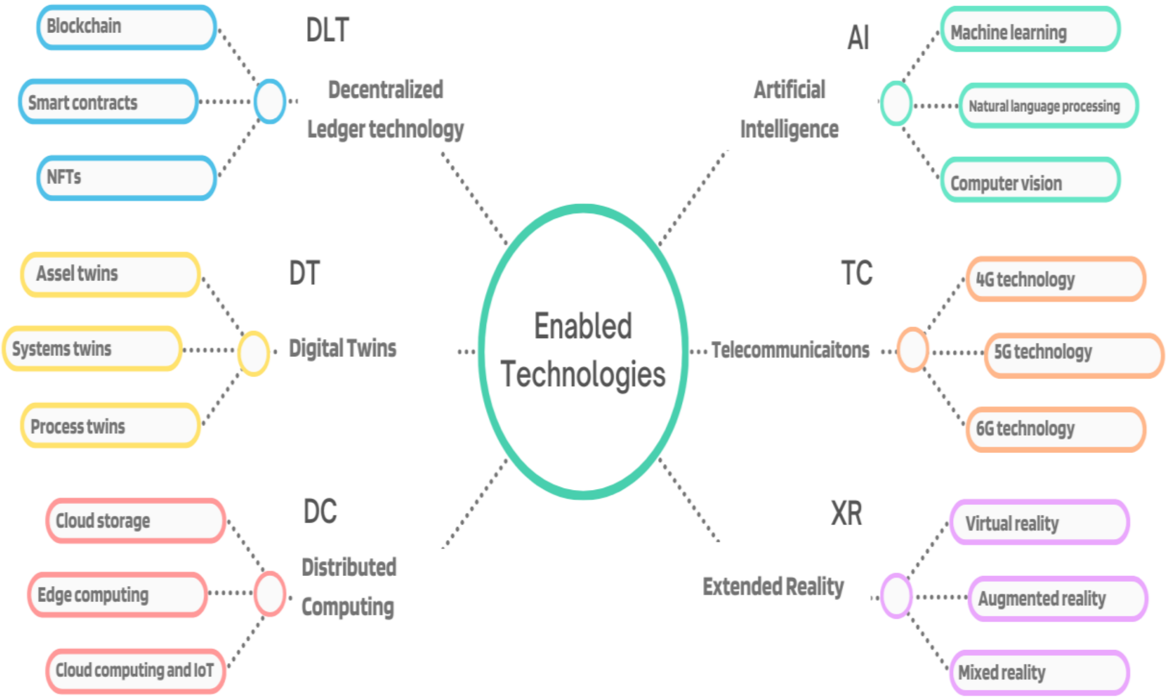

Figure 1: Metaverse technologies for healthcare.

3.2 *Artificial Intelligence*

The creation and administration of technology that can learn on its own to make judgments and carry out activities in place of people is the primary focus of AI, which is also referred to as machine intelligence [6]. Machine learning, computer vision, natural language understanding (NLU), and natural language processing are all examples of technologies that fall under the umbrella of AI. AI is a collection of technologies that encompasses any software or hardware component that enables these areas of study. The infrastructure of the Metaverse will be improved with the aid of AI, which will also improve the quality of the 3D immersive experience and the built-in services of virtual worlds. The use of AI technology will also contribute to the enhancement of the overall quality of the Metaverse environment.

3.3 *Distributed Computing*

Users in the Metaverse engage in real-time interaction with high-quality 3D representations as well as programs that are very sensitive to latency and demand a significant amount of bandwidth. In addition, Internet of Things devices and sensors that are installed in the real world are utilized to provide data to the Metaverse so that the status of digitized items may be kept up to date. As a result, in order to provide consumers with a seamless and immersive experience, it is necessary to handle an enormous quantity of data at very fast rates. In addition, developing and deploying a customized Metaverse is a process that is time-consuming, expensive, and difficult since it necessitates the use of innovative and cutting-edge technology to process and store the data that is created by the Metaverse.

The use of distributed computing enables a variety of approaches to problems involving the processing and storage of massive amounts of data. The first step in providing all of the necessary services for the Metaverse is to use cloud computing and cloud storage in combination with one another. The person responsible for deploying the Metaverse will first upload all of the required data to a cloud storage location, which will then make the data available to cloud computing services. After then, the Metaverse will be hosted by a specialized cloud computing service, which will also provide it with all of the necessary services to ensure that it continues to function normally. Second, because of the increase in demands for processing power, cloud computing will have difficulty consolidating and storing all of the resources that are involved. As a result, this kind of data will need distribution and relocation to be brought closer to the place where it will be consumed. Edge computing and Internet of Things devices may work together to guarantee that users get essential data in real-time without any delays. This can be accomplished by installing edge devices in distant regions at the edge of the network and closer to customers. Edge computing and IoT devices can also work together to ensure that users receive the required data in real-time.

3.4 Digital Twin

A virtual representation that functions in the same way as the digital equivalent of a physical thing or activity in real-time is referred to as a digital twin. The term "digital twin" was first used in David Gelernter's book "Mirror Worlds," which was published in the year 1991. Michael Grieves, writing in the year 2002, was another person to discuss the idea. The United States National Aeronautics and Space Administration (NASA) came up with the first operational definition of a digital twin in 2010. This was done with the intention of improving the physical-model simulation of spacecraft. The ever-increasing sophistication of product design and engineering practices has led to the development of digital twins. The term "digital twin" refers to a digital representation of an item, activity, or service that is physically existent in the world. A digital twin is a digital clone of a physical entity, such as a piece of equipment, a medical gadget, or even a bigger object, such as skyscrapers or even whole towns. Digital twins may also be created for larger things, such as entire cities. On the other side, the technology known as the Metaverse creates a virtual environment in which everything and everyone behaves in a manner that is analogous to how they behave in the real world. Because they generate a digital copy of every physical item in the Metaverse, digital twins are an essential component in the Metaverse's infrastructure.

Establishing a digital twin of the whole hospital in the Metaverse in order to analyze the needs enables one to investigate various operational strategies, staffing models, and care delivery formats. These virtual models in the Metaverse may be helpful in a variety of situations, including those involving a shortage of beds, the spread of infectious diseases, the scheduling of physicians, and the availability of operating rooms. By using a Metaverse that is equipped with digital twins, it is possible to enhance the treatment of patients, the costs, and the performance of the personnel. Because the healthcare industry is both very complex and highly sensitive, having this information is essential for making strategic choices. It is possible to create a completely risk-free environment by completely simulating a hospital inside the Metaverse utilizing digital twins. The creation of personalized artificial organs will likewise benefit from the Metaverse's use of digital twins. A digital twin enabled Metaverse may also assist in the performance of brain and heart operations by allowing doctors to practice their craft in virtual simulations of surgical procedures before carrying out difficult treatments in the real world.

3.5 Telecommunications

In order to offer users with an immersive experience that is both data-intensive and time-sensitive, the Metaverse needs continual synchronization in real time between the real and virtual goals. In addition, the Metaverse calls for the transmission of 3D virtual objects and services, which creates a major demand on the current infrastructure for 5G telecommunications. Advanced telecommunications technologies, such as 6G technology, are necessary to allow much faster data rates and capacity in order to minimize network breakdowns or delays. This is the case even though these technologies already exist.

4. Metaverse Applications in Healthcare

The "handicraft workshop model" of healthcare, in which a patient's diagnosis and course of treatment might vary depending on which physician treats them and which hospital they go to, is considerably improved by the use of the Metaverse to provide complete medical care. In the event of a complete healthcare scenario, judgments will be taken on the basis of the proposals given by the expert as well as the findings acquired from the many different technologies that are made possible by the Metaverse. In the field of medicine, the Metaverse may be used for a wide variety of purposes, including research, physical examination, diagnosis, and even insurance.

4.1 Medical Diagnosis

The process of assessing the medical status of a patient based on the symptoms presented by the patient is referred to as a medical diagnosis. With the assistance of a variety of cutting-edge technologies including augmented reality, virtual reality, extended digital twins, blockchain, 5G, and many others, the adoption of the Metaverse in the field of medicine substantially assists in the accurate diagnosis of a patient's numerous medical ailments [6]. An essay on the "expert consensus on the Metaverse in medicine" outlines how and why the Metaverse may be used in various verticals in healthcare for the purpose of giving excellent comprehensive healthcare for all individuals. The Metaverse may also be seen as an improvement on the current medical IoT, in that it overcomes the constraints of the medical IoT with regard to human-computer interaction, connectivity, and integration with and between real and virtual worlds.

4.2 Surveillance of the Patient

The combination of Telepresence, digital twinning, and blockchain will bring about remarkable advances in medical care, particularly in the area of patient monitoring. These advances will be made possible by the Metaverse. The provision of medical services using Telepresence in medicine, commonly known as telemedicine, may be done remotely. It is possible to employ test dummies of patients in emergency circumstances. This allows for the reactions of patients to procedures or medications to be understood far in advance of actually administering them to real patients. Because medical data is the most sensitive and significant of all data types, the use of blockchain technology may help ensure that it is safely stored and transferred. This ensures that the data will not be altered and that it will not be placed in jeopardy.

4.3 Medical Education

In the annals of the history of medical education, the Metaverse represents an extraordinary watershed moment. In the realm of medical education, the Internet of Things (IoT), blockchain, artificial intelligence, augmented reality, and virtual reality are the forerunners of the Metaverse. It was stated in that the unique identifying tag in blockchain helps identify data in blockchain-based Metaverse. This contribution of AI, blockchain, and the Metaverse to the field of medical care was discussed. The Metaverse is an artificial intelligence and blockchain-based platform that enables the creation of a digital virtual world that is unconstrained by the constraints of the physical world. Even when they are working in a hectic clinical setting, medical students are still able to concentrate on the session at hand, take part in the conversation, communicate with one another in more depth, and do so with a greater sense of fun.

4.4 Surgeries

The Metaverse is rapidly emerging as a significant technology in the field of medicine, particularly in the field of surgery. Surgeons are presently adopting a variety of instruments, such as VR headsets and haptic gloves, to simulate genuine surgical operations, which improves both their level of readiness and their level of productivity in the operating room. By removing barriers to data availability for surgeons, AR might make it easier for them to conduct surgery. Surgeons may have quick, convenient, and hands-free access to patient information using AR, which works by putting 3D virtual representations onto the body of the patient. Within the Metaverse, instructors and lecturers might demonstrate complex surgical procedures to students in a three-dimensional setting. Additionally, the Metaverse has the potential to be used in the delivery of counselling services to post-operative patients.

5. Motivations of Study

Even though the healthcare industry has advanced quickly, a number of problems still exist and discussed by prior studies as [7]. These problems are represented in the unwavering burden of chronic illnesses that last a lifetime, rising healthcare expenditures, an ageing population, a shortage of healthcare workers, and the scarcity of resources.

Also, [8] stated that the COVID-19 pandemic has put a great deal of strain on the labour, infrastructure, and supply chain management associated with the global healthcare industry. Hence, other scholars expressed their opinion about solutions for these problems. For instance, [9] where suggested that it is now essential to implement cutting-edge digital tools and services to maximize customer happiness, allowing for better tracking, health status monitoring, and medication adherence.in same vein [10] expressed that the organizations are pushing for the use of digital diagnostics, virtual care, at-home prescription delivery systems, remote monitoring, decision support systems, and self-service applications for social assistance and education. Lately, the Metaverse offers a plethora of opportunities for application in clinical treatment. In the surgeon's field of vision, real-time advice may be given through immersive experiences that are re-created from surgical procedures. AR will make information within the operating room's sterile environment accessible, improving the flexibility and precision of surgery. In addition to collaborative medical operations, the Metaverse will provide simultaneous planning, teaching, and training.

Based on the suggestion of previous researchers, the importance of applying Metaverse in the medical sector was demonstrated. Hence, this study suggested a mathematical decision-making framework (MDMF) to evaluate alternatives of Metaverse entities which contribute to reconstruction as well as medical administration also, its implications on human health and clinical practice.

Toward evaluation process, MCDM techniques have been leveraged to evaluate alternatives based on set of criteria.in this study, judgments and evaluations exposed to uncertainty situations in ambiguity environment. Hence, neutrosophic theory has been exploited for supporting MCDM techniques toward accurate evaluations and judgments.

6. Methodology: Mathematical Decision-Making Framework

This section demonstrates the followed methodology through employing BWM techniques in cooperation with TriNSs as branch of neutrosophic theory. The methodology of evaluation has been implemented according to several stages.

Stage 1: Determination of main factors

First factor: Estimating Set of several alternatives of Metaverse entities are determined as MeTs = {MeT_1, MeT_2,…etc.}.Herein, we estimated these alternatives as:

i. **MeT_1: Health Surveillance:** Patients according to [11] will be able to keep an eye on their health without physically visiting a hospital or scheduling doctor's appointments thanks to AI-based services in the Metaverse.
ii. **MeT_2: Leveraging a virtual environment for consultation:** people may be able to have virtual consultations with physicians or other healthcare providers [12].
iii. **MeT_3: Virtual surgical:** With the development of Metaverse technology, medical professionals may now operate virtually with great accuracy and little mistake from humans [12].

iv. **MeT4: Healthcare Education:** The patient in the virtual mode is carried to a batch of medical students. Otherwise, conventional methods [5]**.**

Second Factor: Estimate various criteria related to employ Metaverse in healthcare sector as set of C= {C1, C2…etc.}.in this study the criteria included:

i. **C1: Confidentiality and privacy:** It is vital to the healthcare industry. Certain medical data that is obtained within the Metaverse has to be safeguarded by current and upcoming privacy laws [2].
ii. **C2: Real-time guidance:** allow access to the information easily.
iii. **C3: patient care management:** To provide doctors a better view of the patient's interior anatomy, augmented reality (AR) can enable doctors to display medical pictures, such as CT (Computed Tomography) scans, directly onto patients and in line with their bodies even when the patients move.
iv. **C4: Need for skilled users:** Technology professions require knowledge and experience [13].
v. **C5: Bolster clinician judgement and guarantee more accurate treatments:** Combining other technologies as AI for enhance planning, instruction, and training concurrently using a cooperative platform for cooperative medical treatments and education [2].

Third Factor: Forming expert panel which consists of four members who related to study's scope.

Stage 2: Determination of criteria's weights

BWM based on TriNSs is applied to determine best and worst criterion based on its values of weights. The following steps are clarifying process of obtaining criteria's weights.

Step 1: the relationships between best and worst criterion with other are clarified where these relations are exhibited in the same vein of [14].

Expert panel is rating the best criterion_{Best} over other ceriteria_{j} as $\widetilde{\text{criterion}}_{\text{Best}} = (\widetilde{\text{criterion}}_{\text{Best }1}, \ldots, \widetilde{\text{criterion}}_{\text{Best }4})$ based on scale listed in Table 1.

Also [14] identify the relation between other criteria to criterion_{Worst} . Consequently, expert panel rating criteria_{j} over least desired/important criterion_{Worst} as $\widetilde{\text{criterion}}_{\text{Worst}} = (\widetilde{\text{criterion}}_{1\ \text{Worst}}, \ldots, \widetilde{\text{criterion}}_{6\ \text{Worst}})$ according to Table 1.

Step 2: Utilizing Eq. (1) to convert expert panel's evaluation from TriNSs scale into crisp values. Following that, Eq. (2) where crisp matrices are aggregate into an aggregated matrix.

$$s(x_{ij}) = \frac{(l_{ij}+m_{ij}+u_{ij})}{9} * (2 + \theta - \lambda - \gamma) \quad (1)$$

where $\boldsymbol{s}(x_{ij})$refers to score function. $\theta,\ \lambda,\ \gamma$ refers to truth, false, and indeterminacy respectively.

$$\text{Agg}_{ij} = \frac{(\sum_{j=1}^{S} x_{ij})}{M} \quad (2)$$

where x_{ij} refers to value of criterion in matrix, M refers to number of panel.

Table 1. Linguistic triangular neutrosophic scale

Crisp Scale	Explanation	TriNSs Scale
1	Equally Essential	<<1,1,1>;0.5,0.5,0.5>>
2	Slightly Moderately	<<1,2,3>;0.4,0.6,0.65>>
3	slightly Essential	<<2,3,4>;0.3,0.75,0.7>>
4	Minor To Strong	<<3,4,5>;0.35,0.6,0.4>>
5	Mighty Essential	<<4,5,6>;0.8,0.15,0.2>>
6	Slightly Strong Essential	<<5,6,7>;0.7,0.25,0.3>>
7	High Strong Essential	<<6,7,8>;0.9,0.1,0.1>>
8	Very High Strong Essential	<<7,8,9>;0.85,0.1,0.15>>
9	Absolutely High Essential	<<9,9,9>;0.1,0.0,0.0>>

Step 3: Find the optimal weights for determining criteria according to following Eqs:

$$\text{minmax}_j = \left\{\left|\frac{w_B}{w_j} - \text{criteria}_{\text{Best}j}\right|, \left|\frac{w_j}{w_w} - \text{criteria}_{j\text{worst}}\right|\right\}$$

$$\text{s.t}$$

$$\sum w_j = 1 \tag{3}$$

$$w_j \geq 0 \text{ for all j}$$

minmax_j is converted to a linear model as:

$$\min \varepsilon^L$$

$$\text{s.t}$$

$$\left|w_B - \text{criteria}_{\text{Best}j} w_j\right| \leq \varepsilon^L, \text{for all j}$$

$$\left|w_j - \text{criteria}_{j\text{worst}} w_{\text{worst}}\right| \leq \varepsilon^L, \text{for all j} \tag{4}$$

$$\sum w_j = 1$$

$$w_j \geq 0 \text{ for all j}$$

Where w_{Best} is the weight of best criterion. w_{worst} is the weight of the worst indicator.

Stage 3: Finding optimal alternative.

Herein WSM based on TriNSs for ranking the estimated alternatives and obtain optimal one according to following steps.

Step 4: Each member in panel rate alternatives based on set of criteria and decision matrix is constructed for each member based on scale are listed in Table 1.

Step 5: we are exploiting Eq. (1) to deneutrosophic the matrices after that Eq. (2) aggregated these matrices into one decision matrix.

Step 6: The new developed decision matrix in pervious step normalize based on Eqs. (5-7).

$$\text{Nor}_{\text{Agg}} = \frac{Y_{ij}}{\text{sum}(Y_{ij})} \quad , For\ Benficial\ criteria \tag{5}$$

$$N = \frac{1}{Y_{Ij}} \tag{6}$$

$$\text{Nor}_{\text{Agg}j} = \frac{N}{\text{sum}(N)} \quad , For\ Non-Benficial\ criteria \tag{7}$$

Where Y_{ij} indicates to each element in the aggregated matrix.

Step 7: The obtained criteria' weights of BWM are applied in the following Eq. (8) to generate weighted decision matrix.

$$\text{Dec\_mat}_{ij} = \text{weight}_i * \text{Nor}_{\text{Agg}} \tag{8}$$

Where Dec_mat_{ij} is weighted decision matrix.

Step 8: Utilizing Eq. (9) contributes to calculate global score. Based on values of $V(\text{Dec\_mat}_{ij})$, ranking process for set of En (n) perform and obtain optimal and worst alternative.

$$V(\text{Dec\_mat}_{ij}) = \sum_{j=1}^{n} \text{Dec\_mat}_{ij} \tag{9}$$

Where $V(\text{Dec\_mat}_{ij})$ is global score values.

7. Empirical Case Study

Our constructed MDMF is applied on real healthcare organization which embrace our study's notion. The purpose of this step is to validate our MDMF. We communicated to four experts to contribute to evaluation process.

7.1 Scoring alternatives and criteria

- Each member in constructed panel is forming his/her decision matrix based on determined the best and worst criterion where C_2 is best criterion and C_3 is worst criterion based on scale in Table 1.
- The constructed TriN decision matrices are converted to crisp decision matrices through Eq. (1).
- Eq. (2) played vital role toward aggregating crisp matrices into one decision matrix.

7.2 Estimation criteria's weights

- Eqs. (3-4) are applied to obtain the final criteria' weight.
- Figure 2 showcases the final criteria's weights where C_2 is optimal with highest weight value. Otherwise, C_3 is worst where weight value is least.

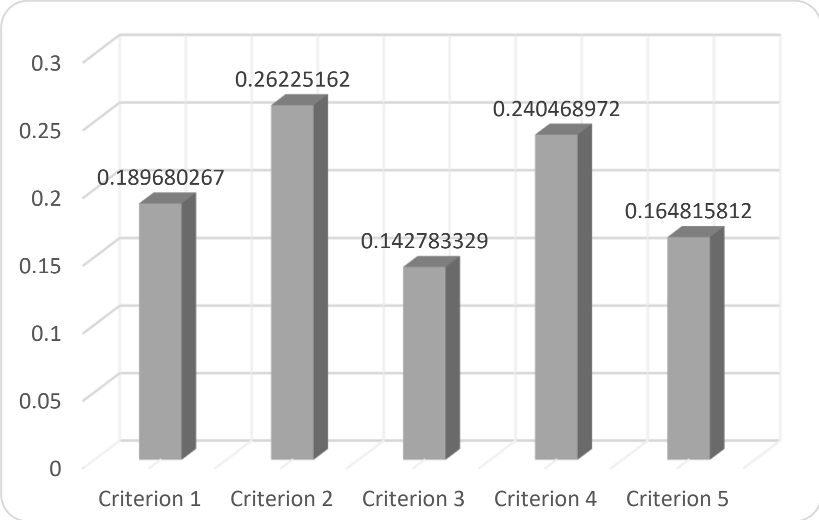

Figure 2. Final criteria weights based on BWM-TriNSs

7.3 Finding optimal alternative

- Four experts are rating alternatives based on criteria through Table 1. Hence, four TriNS decision matrices are constructed.
- Eq. (1) is converting TriNS decision matrices to crisp matrices and these matrices are aggregated as in Table 2 through Eq. (2).
- We normalized the aggregated matrix by employing Eq. (5) where all criteria in this study are beneficial criteria. Table 3 represents normalized matrix.
- The normalized decision matrix is multiply by weights obtained from BWM-TriNSs as in Eq. (8) to generate weighted decision matrix as listed in Table 4.
- Finally, Figure 3 illustrates the ranking of MeT alternatives based on value of global score. These values recommended that MeT_1 is optimal otherwise MeT_3 is the worst one.

Table 2. An aggregated decision matrix.

	C_1	C_2	C_3	C_4	C_5
MeT_1	2.4875	0.85	1.8	1.395833333	2.941666667
MeT_2	1.325	0.588888889	0.4	0.333333333	0.761111111
MeT_3	0.5	0.5	0.4	0.488888889	0.366666667
MeT_4	3.275	0.427777778	0.394444444	0.522222222	0.872222222

Table 3. Normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5
MeT_1	0.327841845	0.35915493	0.601113173	0.509376584	0.595278246
MeT_2	0.174629325	0.248826291	0.133580705	0.121642169	0.154019112
MeT_3	0.065897858	0.211267606	0.133580705	0.178408515	0.074198988
MeT_4	0.431630972	0.180751174	0.131725417	0.190572732	0.176503654

Table 4. Weighted normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5
MeT_1	0.062185129	0.094188962	0.08582894	0.122489264	0.098111268
MeT_2	0.033123737	0.065255098	0.019073098	0.029251167	0.025384785
MeT_3	0.012499523	0.055405272	0.019073098	0.042901712	0.012229167
MeT_4	0.081871878	0.047402288	0.018808194	0.045826829	0.029090593

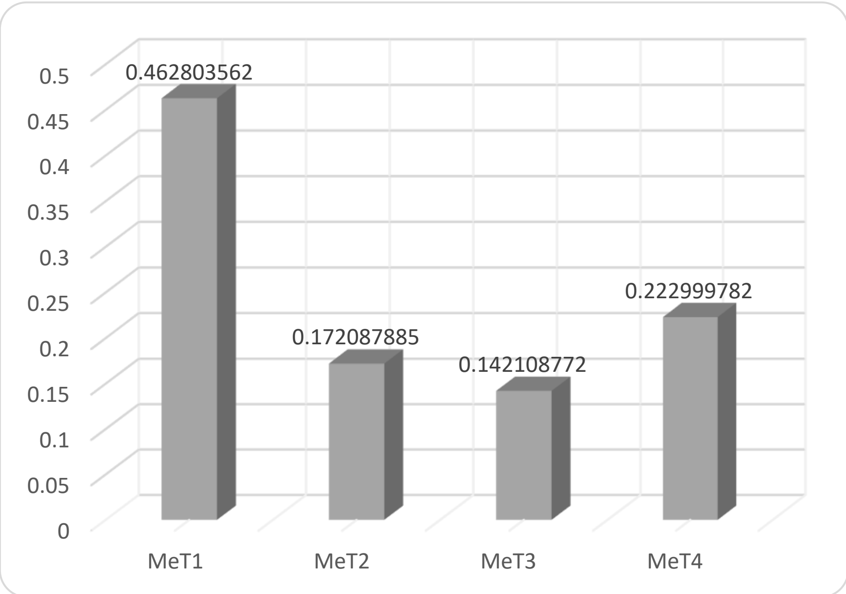

Figure 3. Final ranking for alternatives based on WSM-TriNSs.

8. Conclusions

In this paper, we provided an overview of the potential uses of the Metaverse in the medical field. We spoke about the Metaverse and its most important characteristics. We also introduced the primary technologies that make the Metaverse possible and outlined the roles those technologies play. We investigated the many ways in which the Metaverse may revolutionize medical practice. For the effective incorporation of the Metaverse into healthcare, we have outlined the essential components and prerequisites that must be addressed. We spoke about a few of the key problems that need to be overcome in order to make sure that the Metaverse can be successfully implemented in the healthcare industry. The following is a list of many potential future research directions.

- The technologies that make the Metaverse possible will have a significant impact on the direction in which it will develop in the future. It is exceedingly difficult to handle the related expenses of integrating the Metaverse with current systems and giving equitable access to all users if the creators of these technologies do not properly align themselves with one another.

- It is anticipated that the incorporation of the Metaverse into healthcare would result in the emergence of new societal problems, particularly for those who participate in the Metaverse to an unhealthy degree. As a result, there has to be an established strategy on how to strike a healthy balance between online and offline activities.
- The Metaverse has to have well-established norms, standards, and codes of ethics before it can be utilized by a significant number of people.

Acknowledgments
The author is grateful to the editorial and reviewers, as well as the correspondent author, who offered assistance in the form of advice, assessment, and checking during the study period.

Data availability
The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflict of interest
The authors declare that there is no conflict of interest in the research.

Ethical approval
This article does not contain any studies with human participants or animals performed by any of the authors.

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Received: 07 Jul 2023, **Revised:** 15 Oct 2023,
Accepted: 25 Oct 2023, **Available online:** 23 Nov 2023.