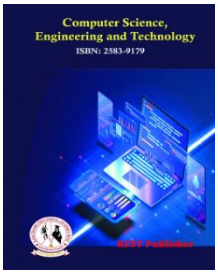
Computer Science, Engineering and Technology

Vol: 3(1), March 2025

REST Publisher; ISSN: 2583-9179 (Online)

Website: https://restpublisher.com/journals/cset/

DOI: https://doi.org/10.46632/cset/3/1/5



An Assessment on BIM for Smart Hospital Management Using the TOPSIS Method

***Jayaprakash B**

JAIN Deemed-to-be University, Bengaluru, Karnataka, India.

**Corresponding Author Email: b.jayaprakash@jainuniversity.ac.in*

Abstract: *BIM, or building information modelling, can be a useful technique for creating smart hospitals. Advanced technologies and data-driven systems are used by smart hospitals to improve operational effectiveness, improve patient care, and create a more connected healthcare environment. Building information modelling (BIM), which unifies multiple technologies, systems, and processes into a single digital platform, might be extremely important in the development of smart hospitals. By merging intelligent infrastructure, automation, and data-driven decision-making, BIM enables the efficient design, construction, and operation of smart hospitals. Many stakeholders in the building and architectural sectors place a high value on research in the field of building information modelling (BIM). Enhanced Project Design and Planning: BIM research enables the creation and improvement of project planning and design processes, tools, and best practises. Improvements in 3D modelling, conflict detection, visualisation, and simulation methods are included in this. Industry experts can increase their comprehension of how to use BIM successfully to optimise project planning, decrease errors, promote cooperation, and streamline the design process by doing research. By multiplying each of our goals by a weight provided by the user, we can scale our collection of goals into a single goal using the weighted sum approach. One of the most popular strategies is this one. Finding the appropriate weights to give each aim while using the weighted sum approach is a concern. Alternative Parameters taken as medical robots, portable sensors, and automated medical processes. network of things, cyber-physical system, artificial intelligence, management information system, and service technology innovation are some of the parameters used in evaluation. from the result we can see that automation of processes got 1st rank and portable sensors got last rank by using TOPSIS method we obtained that automation got 1st rank and portable sensors got last rank.*

Key Words: *BIM, Internet of things, Digital and physical systems, Artificial intelligence, Management information system, Service technology innovation, medical automation of processes, medical robotics, precision medicine, portable sensors.*

1. INTRODUCTION

Building Information Modelling (BIM) has become a competitive alternative to the traditional computer-aided design and drafting (CADD) method for many infrastructure design and development projects. In the context of Industry 4.0 trends, which include many functions of smart manufacturing and smart asset management, the accessibility of new information management technology has influenced not only the methods and techniques, such as digital twin, but also the who list governance and management processes and strategies. One of the main ways that BIM is used to manage physical assets is the asset information management system (AIMS), which contains geometric and non-geometric data derived from the information gathered throughout the project lifecycle prior to the completion and commissioning of the actual built asset.1[BIM allows the creator to analyse building performance and pipeline collisions. Because the complex pipeline components cannot be seen on a conventional two-dimensional CAD model, it is challenging to choose the best pipeline configuration during the advanced design stage. By completely eliminating the lack of information transmission in conventional two-dimensional design, BIM technology can raise the quality and effectiveness of design and construction. We will be able to entirely prevent cross-disciplinary interference during construction in the future, which will help pipeline maintenance and repair. For the quality of the indoor atmosphere and the structural performance, hospitals have stricter demands. Design units can conduct a range of performance evaluations of hospital construction projects using BIM and other specialised technologies, methodically optimising the comfort of the

Copyright@REST Publisher

hospital's indoor environment. By evaluating a building's efficiency, we can determine its potential for energy savings, enabling the hospital to expand sustainably. [2] The emphasis is dramatically shifted from project-centric to seeing BIM from a business perspective by conceptualising it as a model of digital interaction for many sorts of properties across all stages, where everyone may first exchange and visualise utilising numerous digital interfaces. In this regard, a project called Life-Cycle BIM based on facility management was launched by St. Olavs Hospital and the Central Norway Regional Health Authority (HMN). Enterprise BIM (EBIM or business BIM) is a concept that focuses integration, information sharing, and transparency among different corporate organisations. Actually, the study places the most focus on this component of uniqueness and innovation. Each piece of information on the hospital structure, medical devices, and electro mechanics must be mapped to the proper BIM 3D building model for EM, which is based on BIM. By using such a link, management may instantly identify the issue. For instance, all of a valve's technical details might be displayed when we point to it in the hospital's 3D BIM building model. In the interim, it is also specified where the valves are located and how many there are. The link to the BIM model is made by of two parts Setting up external checkpoints is the first step. employing the BIM's coding tools, which are then recorded in the BIM system.[4] BIM technology modifies how information is obtained and transferred in traditional project management methodologies. According to a taxonomy created by the building SMART alliance in America, there are 25 different types of BIM applications in the fields of architecture and engineering. Through The conclusion drawn from looking at project management parties like the design enterprise, owner, building enterprise, estate management firm, and construction supervision institution is that the latter is best equipped to popularise BIM technology. Various plans are also put forth to establish a BIM technology service organisation, grow the BIM consultancy sector through supervisory institutions that combine the supervision business and the BIM consulting incorporation, popularise the supervision sector through the BIM consulting form.[5] Building information modelling (BIM) is a digital representation of a facility's structural and functional elements. When used as a trustworthy foundation for decisions made throughout a facility's lifecycle, which is defined as from initial conceptualization to destruction, a BIM is a shared knowledge resource. According to this point of view, the visual interface of BIM can assist decision-makers in locating issues and seeing potential hazards at crucial moments. Facility safety, interior localization, fire emergency simulation and analysis, emergency evacuation path design, and path discovery management are a few contemporary disaster management applications of BIM.A technology that provides two-way communication between the BIM and the users during a fire has been made available. In order to promote user understanding of the evacuation process. Geometric information collected from the BIM models of the structure was used to automatically estimate the best path for rescue efforts in the case of a tragedy. In this research area, BIM visualisation has gotten a lot of focus. The earthquake damage to non-structural building systems was calculated and displayed on the BIM model. Building owners received helpful information from the failure mode display.created a platform that combines geometry data from BIM models with data from Bluetooth sensors to aid decision-makers in locating fire spots and securing escape routes. This study provided an example of how BIM could be visualised in three dimensions. could help reduce the number of poor choices and the confusion that the crisis causes. In order to assess ground settling damage to buildings close to subterranean tunnel workshops, a decision-making tool was designed utilising BIM visualisation.[6] Building information modelling, or BIM, is a process that involves developing and maintaining digital representations of a building's or infrastructure's structural and functional elements. While the design and construction phases of a building project are where BIM is most frequently employed, its use can also be found in operational and management elements, such as in the context of smart hospital management. Utilising technology and data to improve the efficacy, efficiency, and security of healthcare operations is known as smart hospital management. The following are some ways that BIM can assist with smart hospital management: Creating and building: BIM can be used to optimise space utilisation, enhance workflows, and ensure optimal placement of infrastructure, utilities, and equipment during the design and building of a hospital. It helps interested parties to see the facility before to construction and spot any problems or conflicts, which improves planning and design choices. Asset and Facility Management: BIM models can act as a central database for data on the hospital's assets, such as its infrastructure, systems, and equipment. Maintenance staff may obtain real-time data about the assets, monitor their performance, plan maintenance actions, and even predict future needs by integrating BIM with facility management systems possible failures, enabling preventive maintenance. Energy Efficiency and Sustainability: By modelling energy performance and examining various scenarios, BIM can assist in optimising energy usage in hospitals. It can help with energy conservation options, HVAC system optimisation, and the incorporation of renewable energy sources. This may result in lower operating expenses and greater sustainability. Safety and Emergency Planning: BIM can help hospitals with emergency planning and response. Emergency responders can access crucial data during a disaster by including information about evacuation routes, safety gear, and utility shut-off points in the BIM model. For more effective emergency management, the BIM model can be coupled with real-time data regarding the whereabouts of patients, employees, and assets.Integration of data Interoperability: BIM can make it easier to integrate different hospital systems and technology, including patient management, building automation, security, and electronic health records. BIM may increase communication, expedite procedures, and improve decision-making across many departments and stakeholders by facilitating data interchange and interoperability between these systems.While BIM can be a valuable tool for smart hospital management, its effective use necessitates collaboration between architects, engineers, contractors, facilities managers, and other stakeholders over the course of the hospital's lifecycle.

2. MATERIALS & METHODS

Network of thing: The Network of Things (IoT) and Building Information Modelling (BIM), two distinct but related technologies, can be coupled to enhance the management and operation of building and infrastructure projects. Together, BIM and IoT offer a powerful ecosystem for collecting, analysing, and utilising real-time data to increase building efficiency and enable better decision-making.

Cyber-physical system (CPS) are the combination of computer and physical elements that monitor and regulate physical processes. CPS can produce a potent framework for managing and optimising the operation of buildings and infrastructure projects when integrated with Building Information Modelling (BIM).
Synthetic intelligence: In order to enhance and optimise a variety of building lifecycle activities, from design and construction to operation and maintenance, building information modelling (BIM) and artificial intelligence (AI) can be used together. System of management information :An organization's managerial decision-making is supported by a Management Information System (MIS), which is a computerised system that gathers, processes, stores, and disseminates data and information. An MIS can improve the administration and use of information pertaining to construction projects and building operations when used in conjunction with building information modelling (BIM).

New service technologies innovation: In the construction and building management sectors, service technology innovation has been greatly aided by BIM (Building Information Modelling). It has made new methods and technologies possible that enhance the provision of services, raise operational effectiveness, and boost building performance.

Medical process automation Healthcare institutions may find it helpful to automate medical procedures using building information modelling (BIM). When data integration and automation are used in conjunction with BIM's digital representation of the building and its systems, processes can be streamlined, operational efficiency is increased, and patient care is improved.

Robots in machine The integration and use of medical robotics within healthcare facilities might be aided by Building Information Modelling (BIM). Planning, developing, and deploying medical robotic technology can be done on a platform made possible by BIM's digital depiction of the building and its systems.

Precision medicine Building information modelling (BIM) offers a digital framework for integrating and analysing various data sources, which can help with the adoption of precision medicine in healthcare facilities.
Hand held sensors sensors: Portable sensors can be included into and used with Building Information Modelling (BIM) to improve data collecting and analysis in a variety of applications. Portable sensors are tools that can be readily transported and set up in various areas to record and keep track of particular information. Portable sensors can deliver real-time information on ambient conditions, equipment performance, occupancy levels, and more when integrated with BIM.

TOPSIS Method: The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is one of the numerical methods used in multi-criteria decision making. It is a method with a broad range of applications and a simple mathematical foundation. It is also a very practical method that makes use of computers. Using the TOPSIS supplier rating method.The TOPSIS approach has the following primary benefits: 1. It is easy to operate. 2. It considers both subjective and objective factors of every kind. 3. It makes sense and is rational. 4. The computation techniques are simple. 5. The idea allows for the pursuit of the optimal choices as determined by a straightforward mathematical calculation. Yoon and Hwang originally presented the TOPSIS approach, which was evaluated by surveyors and various operators. A method for making decisions is TOPSIS. Finding the alternative that comes the closest to the optimal answer is done using a goal-based approach. This approach grades solutions according to how closely they resemble the ideal solution. An option receives a better score if it is more comparable to the ideal course of action. A solution that is ideal from any perspective but does not actually exist is one we attempt to approximate. In order to determine how closely a design (or alternative) resembles ideal and non-ideal levels, we primarily take into account the design's distance from ideal and non-ideal solutions. The best option from a list of possibilities is chosen using a multi-criteria decision-making (MCDM) approach termed TOPSIS (tactic for Order of Preference by Similarity to Ideal Solution). It comprises comparing alternatives to the best and worst possibilities and evaluating alternatives in relation to a set of standards. The TOPSIS method functions as follows: Criteria Identification Establish the relevant criteria that will be used to evaluate the alternatives. These standards ought to reflect the preferences of the decision-maker and be quantifiable and independent. For instance, while comparing several car models, factors may include cost, fuel economy, safety score, and interior room.To bring the criteria values to a single scale, normalise them. This phase makes sure that each criterion receives the same amount of weight when making a decision. Standardisation or min-max normalisation procedures are frequently used to convert the raw data into a unitless scale, such as a range between 0 and 1.The criteria should be given weights in order to indicate their respective relevance. The weights, which represent the decision-maker's preferences or priorities, are arbitrary. For instance, the safety rating criterion would be given more weight if it were thought to be more significant than price. The decision matrix should be built with the normalised values for each choice and criterion. The dimensions of the decision matrix will be m x n, where m represents the number of possibilities and n represents the number of criteria. the Best and Worst Solutions are Determined: Add up the normalised numbers for each criterion to determine the best solution and worst solution. For each criterion, the best performance is represented by the ideal solution, whilst the poorest performance is represented by the worst solution. This is accomplished by choosing, for each criterion, the maximum and minimum values.Using the performance of each alternative in comparison to the best and worst solutions, get the similarity scores for each one. A distance metric, such as the Manhattan distance or the Euclidean distance, is used to get the similarity score. Alternatives that are closer to the best option and farther from the worst option are deemed to be preferable.Prioritise the alternatives: Based on the similarity scores of the alternatives, order them. The option with the highest similarity rating is regarded as the best option.The TOPSIS method offers a methodical approach to decision-making by taking into account several variables at once. It aids decision-makers in objectively assessing alternatives and selecting the best choice in light of their preferences and the established criteria.Identifying the criteria that will be used to evaluate the alternatives is the first stage in the TOPSIS technique. These standards ought to be pertinent, quantifiable, and consistent with the choice issue. For instance, when choosing a supplier, factors may include cost, level of quality, timeliness of delivery, and level of customer service.The data must be normalised after the criteria have been developed in order to place all of the criteria on a common scale. This is carried out to guarantee that evaluation criteria with different measurement scales or units are appraised equally. Two examples of normalisation methods are min-max normalisation and linear normalisation.Weighting: Based on each criterion's relative importance or priority, decision-makers must assign weights to each one. The weights represent how significant each criterion was in the decision-making process. The weights can be determined using a variety of techniques, such as expert judgement, the analytical hierarchy process (AHP), or the preferences of other stakeholders. Putting together the Decision Matrix By arranging the normalised values of each criterion for each choice, the decision matrix is produced. Each column denotes a need, while each row denotes an option. The performance of the options in comparison to the criteria is numerically represented in the decision matrix.Making the Perfect Solution: The positive ideal solution (PIS) and the negative ideal solution (NIS) are two categories of ideal solutions that are taken into account by the TOPSIS approach.The PIS and NIS represent the best and worst possible results for each criterion, respectively. On the basis of either maximising or minimising each criterion, these ideal solutions are built.Making an estimate of the closeness coefficient The distance between each alternative and the ideal solutions is calculated using the closeness coefficient. The distances between each alternative and the PIS and NIS are compared to determine it. Different distance metrics, such as the Manhattan distance or the Euclidean distance, can be used to determine the distances.Putting the Alternatives in Order The final step is to rank the options according to their closeness coefficients. The option that is closest to the ideal solution, as measured by the closeness coefficient, is deemed to be the best option.When faced with several criteria and options, the TOPSIS approach is a helpful decision-making tool. It offers a methodical and organised methodology for assessing alternatives and ranking them according to how well they perform in comparison to the optimal solutions. Identification of Criteria: List the standards by which the alternatives will be judged. These standards ought to be pertinent, quantifiable, and directly tied to the decision-making issue.Give each criterion a weight to represent their relative relevance or order of importance. The decision-maker's subjective preferences are reflected in the weights, which can be established using a variety of techniques, including surveys, expert judgement, and analytical procedures.Normalisation: To counteract the impact of various measurement scales, normalise the assessment matrix. This is accomplished by standardising the raw data through transformation, usually When faced with several criteria and options, the TOPSIS approach is a helpful decision-making tool. It offers a methodical and organised Give each criterion a weight to represent their relative relevance or order of importance. The decision-maker's subjective preferences are reflected in the weights, which can be established using a variety of techniques, including surveys, expert judgement, and analytical procedures.

Normalisation: To counteract the impact of various measurement scales, normalise the assessment matrix. This is accomplished by standardising the raw data through transformation, usually.

Determine Ideal and Negative Ideal Solutions: Using the normalised values for each criterion, determine the ideal solution (maximum for benefit criteria and minimum for cost criteria) and the negative ideal solution (minimum for benefit criteria and maximum for cost criteria).

Calculate the Euclidean Distances: Determine how far apart the ideal and the negative ideal are from each choice. Each alternative's resemblance or proximity to the ideal and contra-ideal solutions is quantified by the Euclidean distance.Calculate the Relative Closeness: To determine how close each alternative is to the ideal and negative ideal solutions, divide the distance to the negative ideal solution by the sum of those distances.The choices should be ranked according to how near they are to each other. The best option is regarded as having the most relative proximity.The TOPSIS method enables decision-makers to evaluate choices in a methodical manner that takes both the advantages and disadvantages of each option into account. It can be used to enhance informed decision-making in a variety of areas, including project selection, supplier selection, investment decisions, and strategy planning.

3. RESULT AND DISCUSSION

TABLE 1. BIM for smart hospital management

	Network of things	Digital and physical systems	synthetic intelligence	System of management information	New service technologies
Automation of processes,	0.4297	0.7765	0.7533	0.8603	0.8484
Robots in medicine.	0.1901	0.7472	0.3851	0.1585	0.4881
Precise medical care,	0.2298	0.2600	0.6550	0.8859	0.7137
Handheld sensors.	0.1283	0.7913	0.8312	0.3991	0.8306

Table 1 shows the alternative: robots in medicine, precise medical care, handheld sensors and evaluation preference network of things Digital and physical systems, synthetic intelligence, system of management information and new service technologies. new service technologies.

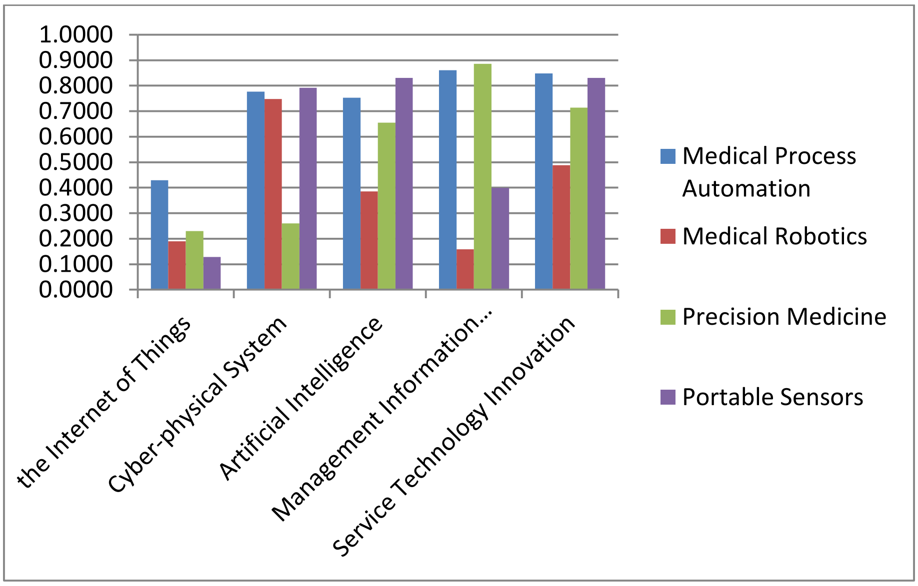


FIGURE 1.

Figure 1 shows the alternative: robots in medicine, precise medical care, handheld sensors and evaluation preference network of things Digital and physical systems, synthetic intelligence, system of management information and new service technologies. new service technologies.

TABLE 2. Square Root Matrix

	Network of things	Cyber-physical system	Synthetic intelligence	System of management information	New service technologies
Automation of processes	0.1846814	0.602883	0.567403	0.74009	0.719864
Robots in medicine.	0.0361404	0.558376	0.148322	0.02512	0.238226
Precise medical care	0.052801	0.067625	0.429019	0.78474	0.509397
Handheld sensors	0.0164696	0.62619	0.690878	0.159273	0.689889

Table 2 shows the square root of matrix value

TABLE 3. Normalized Data

	Network of things	Cyber-physical system	, synthetic intelligence	System of management information	New service technologies
Automation of processes	0.797891	0.57008	0.555974	0.658026	0.577647
Robots in medicine.	0.352962	0.548634	0.284257	0.12123	0.332301
Precise medical care	0.426631	0.190929	0.483445	0.677585	0.485921
Handheld sensors	0.238272	0.580995	0.613492	0.305261	0.565492

Table 3 shows the alternative: robots in medicine, precise medical care, handheld sensors and evaluation preference network of things Digital and physical systems, synthetic intelligence, system of management information and new service technologies. new service technologies. The normalized data is calculated from the data set value is divided by the sum of square root of the column value.

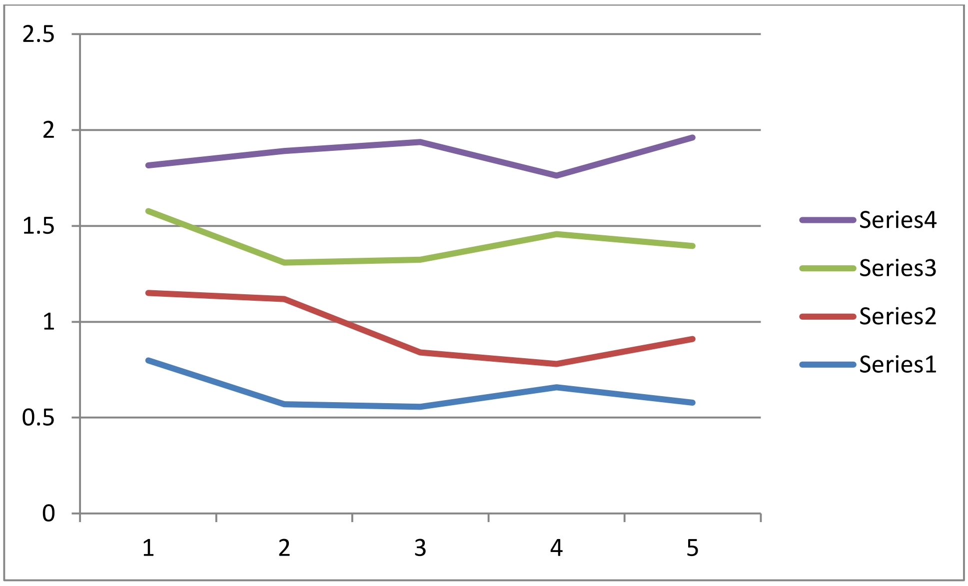


FIGURE 2. normalized data

Figure 2 shows the alternative: robots in medicine, precise medical care, handheld sensors and evaluation preference network of things Digital and physical systems, synthetic intelligence, system of management information and new service technologies. new service technologies. The normalized data is calculated from the data set value is divided by the sum of square root of the column value.

TABLE 4. weight

	Network of things	Cyber-physical system	, synthetic intelligence	System of management information	New service technologies
Automation of processes	0.20	0.20	0.20	0.20	0.20
Robots in medicine.	0.20	0.20	0.20	0.20	0.20
Precise medical care	0.20	0.20	0.20	0.20	0.20
Handheld sensors	0.20	0.20	0.20	0.20	0.20

Table 4 shows the information set of the weight all same value 0.20

TABLE 5. Weighted Normalized Decision Matrix

	network of things	Cyber-physical system	synthetic intelligence	system of management information	new service technologies
automation of processes	0.159578	0.114016	0.111195	0.131605	0.115529
robots in medicine.	0.070592	0.109727	0.056851	0.024246	0.06646
precise medical care	0.085326	0.038186	0.096689	0.135517	0.097184
handheld sensors	0.047654	0.116199	0.122698	0.061052	0.113098

Table 5 shows the informational set for the normalized data multiplication weight we use the formula.

TABLE 6. positive matrix values

	Network of things	Cyber-physical system	, synthetic intelligence	System of management information	New service technologies
Automation of processes	0.159578	0.116199	0.122698	0.135517	0.115529
Robots in medicine.	0.159578	0.116199	0.122698	0.135517	0.115529
Precise medical care	0.159578	0.116199	0.122698	0.135517	0.115529
Handheld sensors	0.159578	0.116199	0.122698	0.135517	0.115529

TABLE 7. negative matrix values

	network of things	Cyber-physical system	synthetic intelligence	system of management information	new service technologies
automation of processes	0.047654	0.038186	0.056851	0.024246	0.06646
robots in medicine.	0.047654	0.038186	0.056851	0.024246	0.06646
precise medical care	0.047654	0.038186	0.056851	0.024246	0.06646
handheld sensors	0.047654	0.038186	0.056851	0.024246	0.06646

TABLE 8. Si Plus**,** SI Negative**,** CI values, and Rank

	Si Plus	SI Negative		Rank
automation of processes	0.012345	0.187521	0.938233	1
robots in medicine.	0.164576	0.075128	0.313421	4
precise medical care	0.112305	0.127794	0.532256	2
handheld sensors	0.134454	0.118117	0.46766	3

Table 8 shows the information about the ranks obtained

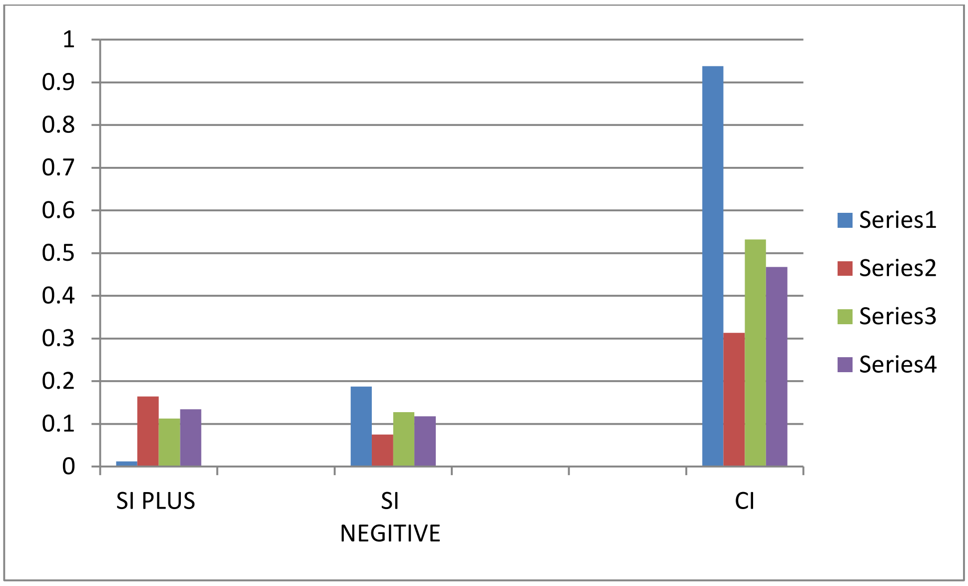


FIGURE 3. shows information about si positive si negative and ci

4. CONCLUSION

The management of smart hospitals relies heavily on building information modelling (BIM). It offers a digital platform that unifies numerous elements of hospital operations, including as facility planning and design, the incorporation of smart devices, real-time monitoring, and analytics. Smart hospitals can increase operational effectiveness, patient care, and resource utilisation by utilising BIM. BIM makes it easy for many stakeholders to collaborate, communicate, and exchange data, which promotes more informed decision-making and proactive management. With its capacity to integrate and manage intricate systems and data, BIM will continue to develop and enable smart hospital management as technology advances. To create sustainable, patient-centered, and technologically advanced healthcare facilities, BIM must be adopted in smart hospital management. IBM offers a range of goods and services that can significantly enhance hospital administration. IBM helps hospitals use data analytics, artificial intelligence, the Internet of Things, cloud computing, blockchain, and cybersecurity to streamline operations, enhance patient care, and increase overall productivity.These technologies enable hospitals to analyse vast amounts of data, make informed decisions, enhance patient outcomes, and implement preventive care strategies. IoT-based real-time monitoring of medical equipment and facilities increases operational effectiveness, lowers costs, and improves patient safety. Healthcare data may be processed and stored on a flexible and secure platform thanks to cloud computing. Blockchain guarantees safe patient record sharing and access, improving data integrity and interoperability. IBM's cybersecurity solutions preserve private health data and defend against online threats. Furthermore, IBM's Watson Health platform integrates AI, analytics, and healthcare knowledge to assist clinical decision-making, diagnosis, treatment recommendation, and medical research, enhancing medical precision and patient outcomes.In general, hospitals may become smart hospitals thanks to IBM's extensive range of technologies, which supports effective healthcare management while enhancing patient care and outcomes.

REFERENCES

[1]. Lin, Chih-Lung, James KC Chen, and Han-Hsi Ho. "BIM for smart hospital management during COVID-19 using MCDM." *Sustainability* 13, no. 11 (2021): 6181.
[2]. Wang, Qun, Jiangbo Zhang, Liping Fan, and Xiaoju Cao. "Research on the whole process engineering consulting mode of smart hospital based on BIM project management mode." In *Journal of Physics: Conference Series*, vol. 1744, no. 3, p. 032205. IOP Publishing, 2021.
[3]. Evjen, Tor Åsmund, Seyed Reza Hosseini Raviz, Sobah Abbas Petersen, and John Krogstie. "Smart facility management: Future healthcare organization through indoor positioning systems in the light of enterprise BIM." *Smart Cities* 3, no. 3 (2020): 793-805.
[4]. Zhou, Ying, Lingling Wang, Yayin Xu, Lieyun Ding, and Zhouping Tang. "Intelligent fangcang shelter hospital systems for major public health emergencies: the case of the optics valley fangcang shelter hospital." *Journal of Management in Engineering* 38, no. 1 (2022): 05021010.

[5]. Pavón, Rubén Muñoz, Marcos García Alberti, Antonio Alfonso Arcos Álvarez, and Isabel del Rosario Chiyón Carrasco. "Use of BIM-FM to transform large conventional public buildings into efficient and smart sustainable buildings." *Energies* 14, no. 11 (2021): 3127.Lv, Zhihan, Dongliang Chen, and Haibin Lv. "Smart city construction and management by digital twins and BIM big data in COVID-19 scenario." *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)* 18, no. 2s (2022): 1-21.

[6]. Yang, Xiaolin. "Application of BIM Technology in Whole Process Engineering Consultation of Emergency Hospital." *Journal of Information Technologyin Civil Engineering and Architecture* 15, no. 1 (2023): 83-88.

[7]. Guo, Yue, Yubin Zhang, Yihua Zhao, Qiong Jia, Qian Li, Zhe Jing, Yifei Ren, and Rong Li. "A BIM Integrated Hospital Emergency Management Framework." In *2018 IEEE 22nd International Conference on Computer Supported Cooperative Work in Design ((CSCWD))*, pp. 677-682. IEEE, 2018.

[8]. Jørstad, Finn Kristian. "Smart Hospital: Indoor positioning with BIM." *Dept. of Computer Science, Specialisation Project. Norwegian University of Science and Technology, Trondheim, Norway* (2016).

[9]. van der Zwart, Johan. "Smart hospital conceptualisations by experts in teams." In *ARCH19 June 12–13, 2019–Trondheim, Norway. Proceedings from the 4th Conference on Architecture Research Care & Health*. SINTEF Academic Press, 2021.

[10]. Jørstad, Finn Kristian. "Smart Hospital."

[11]. Cheng, Weibin, Wanmin Lian, and Junzhang Tian. "Building the hospital intelligent twins for all-scenario intelligence health care." *Digital Health* 8 (2022): 20552076221107894.

[12]. Tao, Xingyu, Moumita Das, Chengliang Zheng, Yuhan Liu, Peter Kok-Yiu Wong, Yuqing Xu, Hao Liu, Xingbo Gong, and Jack CP Cheng. "Enhancing BIM security in emergency construction projects using lightweight blockchain-as-a-service." *Automation in Construction* 150 (2023): 104846.

[13]. Zhan, Zhaoxi, Wenna Xu, Lin Xu, Xinyue Qi, Wenjie Song, Chen Wang, and Ziye Huang. "BIM-based Green Hospital building performance pre-evaluation: a case study." *Sustainability* 14, no. 4 (2022): 2066.

[14]. Ren, Lifeng, Yanqiong Zhang, Yiren Wang, and Zhenqiu Sun. "Comparative analysis of a novel M-TOPSIS method and TOPSIS." *Applied Mathematics Research eXpress* 2007 (2007).

[15]. Pavić, Zlatko, and Vedran Novoselac. "Notes on TOPSIS method." *International Journal of Research in Engineering and Science* 1, no. 2 (2013): 5-12.

[16]. Zavadskas, Edmundas Kazimieras, Abbas Mardani, Zenonas Turskis, Ahmad Jusoh, and Khalil MD Nor. "Development of TOPSIS method to solve complicated decision-making problems—An overview on developments from 2000 to 2015." *International Journal of Information Technology & Decision Making* 15, no. 03 (2016): 645-682.

[17]. Jahanshahloo, Gholam Reza, F. Hosseinzadeh Lotfi, and Mohammad Izadikhah. "Extension of the TOPSIS method for decision-making problems with fuzzy data." *Applied mathematics and computation* 181, no. 2 (2006): 1544-1551.

[18]. Dymova, Ludmila, Pavel Sevastjanov, and Anna Tikhonenko. "A direct interval extension of TOPSIS method." *Expert Systems with Applications* 40, no. 12 (2013): 4841-4847.

[19]. Chen, Pengyu. "Effects of normalization on the entropy-based TOPSIS method." *Expert Systems with Applications* 136 (2019): 33-41.

[20]. Karim, Rubayet, and C. L. Karmaker. "Machine selection by AHP and TOPSIS methods." *American Journal of Industrial Engineering* 4, no. 1 (2016): 7-13.

[21]. Sun, Chia-Chi, and Grace TR Lin. "Using fuzzy TOPSIS method for evaluating the competitive advantages of shopping websites." *Expert Systems with Applications* 36, no. 9 (2009): 11764-11771.

[22]. İç, Yusuf Tansel. "An experimental design approach using TOPSIS method for the selection of computer-integrated manufacturing technologies." *Robotics and Computer-Integrated Manufacturing* 28, no. 2 (2012): 245-256.

[23]. Assari, Ali, T. Mahesh, and Erfan Assari. "Role of public participation in sustainability of historical city: usage of TOPSIS method." *Indian Journal of Science and Technology* 5, no. 3 (2012): 2289-2294.

[24]. Sarkar, Asis. "A TOPSIS method to evaluate the technologies." *International Journal of Quality & Reliability Management* 31, no. 1 (2013): 2-13.

[25]. Wątróbski, Jarosław, Aleksandra Bączkiewicz, Ewa Ziemba, and Wojciech Sałabun. "Sustainable cities and communities assessment using the DARIA-TOPSIS method." *Sustainable Cities and Society* 83 (2022): 103926.

[26]. Ashtiani, Behzad, Farzad Haghighirad, Ahmad Makui, and Golam ali Montazer. "Extension of fuzzy TOPSIS method based on interval-valued fuzzy sets." *Applied Soft Computing* 9, no. 2 (2009): 457-461.

Copyright@REST Publisher