Indonesian Journal of Electrical Engineering and Computer Science
Vol. 36, No. 1, October 2024, pp. 338~346
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v36.i1.pp338-346

Enhancing clinical decision-making with cloud-enabled integration of image-driven insights

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Article Info

Article history:

Received Dec 14, 2023
Revised May 23, 2024
Accepted Jun 5, 2024

Keywords:

Bayesian networks
Clinical decision support
Clinical decision-making
Cloud-enabled integration
Image-driven insights
System

ABSTRACT

Using the complementary strengths of Bayesian networks, decision trees, artificial neural networks (ANNs), and Markov models, this endeavor intends to completely revamp clinical decision-making. In order to provide instantaneous access to image-driven insights and clinical decision support systems (CDSS), want to create a revolutionary framework that merges these cutting-edge methods with cloud-enabled technologies. The proposed framework gives a comprehensive perspective of patient data by merging the probabilistic reasoning of Bayesian networks with the interpretability of decision trees, the pattern recognition abilities of ANNs, and the temporal interdependence of Markov models. This helps doctors to make more educated judgments based on a larger spectrum of information, leading to better patient outcomes. Healthcare workers can get to vital data from any place because to the cloud-enabled architecture's seamless scalability and accessibility. This not only increases the efficiency of decision-making, but also improves communication and cooperation between different medical professionals. This uses cutting-edge modeling strategies and cloud computing to pave a new path in clinical decision-making. This system has the potential to greatly enhance healthcare by integrating image-driven insights with CDSS, to the advantage of both patients and healthcare practitioners.

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1. INTRODUCTION

The ever-changing healthcare industry is posing new obstacles for tried-and-true clinical decision-making approaches. The accurate processing and interpretation of medical imaging, such as X-radiation (X-rays), magnetic resonance imaging (MRIs), and computed tomography (CT) scans, is one of the most serious concerns confronting the medical world today. The diagnostic value of these pictures cannot be overstated due to the abundance of information they convey regarding the patient's condition [1]. The presence of a human subject has made the time-consuming process of manually evaluating these images more challenging.

When these photos are added to the already massive volumes of patient data, the decision-making process becomes even more convoluted [2].

The ever-changing healthcare industry is posing new obstacles for tried-and-true clinical decision-making approaches. Accurately processing and interpreting medical imaging, such as X-rays, MRIs, and CT scans, is one of the most serious issues now confronting the medical world. When you take into account the complexity of today's illnesses and the ever-increasing abundance of medical data, it is now more important than ever before to make clinical judgments that are accurate, prompt, and well-informed [3]. Images obtained from medical procedures are very helpful in both the diagnosis and treatment of a wide variety of medical disorders. The visual information that they give is quite helpful and frequently reveals minute features that may be overlooked during a physical examination. It is of the utmost importance to include image-driven insights into the therapeutic decision-making process [4].

Image interpretations may be obtained in a quick, accurate, and consistent manner by medical experts when they make use of the aforementioned technologies. These insights not only help in the process of diagnosis, but they also contribute to the development of individualized treatment plans. Clinical decision support systems (CDSS) play a vital role in equipping healthcare providers with evidence-based guidelines and real-time suggestions. This is accomplished in combination with image-driven insights, which are also part of the CDSS [5]. CDSS draw on huge treasuries of medical knowledge, research results, and patient data to provide insights that aid doctors in the process of decision-making. The CDSS may be integrated into a cloud-enabled platform to provide healthcare practitioners quick access to a vast amount of information [6].

The capability of cloud-enabled integration in healthcare to transcend geographical obstacles is one of the most significant benefits of this kind of integration. Traditional healthcare systems made it difficult for professionals to work together, particularly those who were situated in various regions of the globe. This made global healthcare coordination difficult [7]. Patient information is protected by sophisticated encryption mechanisms and tight access controls, which ensures both patient confidentiality and compliance with applicable healthcare legislation. In the event that these security issues are addressed, healthcare practitioners will be able to comfortably shift to cloud-enabled solutions, knowing that patient data is safeguarded against unauthorized access and cyber attacks [8].

The combination of cloud computing with CDSS not only improves clinical decision-making, but also maximizes the efficiency with which healthcare institutions use their available resources. The responsiveness of the healthcare system improves, making it possible for a larger number of patients to get prompt and high-quality medical treatment [9]. The provision of care that is centered on the individual patient is of utmost importance in the process of integrating cloud-based image-driven insights with CDSS. This strategy, which is centered on the patient, encourages patients to feel a feeling of empowerment and confidence, which in turn strengthens the connection between the doctor and the patient and contributes to better overall healthcare results [10].

A revolutionary advance has been made in the realm of healthcare with the implementation of a cloud-based image-driven insights and CDSS. Patients' lives may be improved, and the future of healthcare delivery can be shaped, when medical professionals work together with cutting-edge technology to provide unmatched care for their patients [11]. Within the realms of emergency medical response and remote healthcare, the combination of cloud-enabled image-driven insights and CDSS carries with it an enormous amount of promise. It is now possible for medical personnel to diagnose illnesses, evaluate medical imaging, and give expert consultations remotely with the use of secure data transfer. This ensures that patients in even the most remote areas may get high-quality medical treatment [12].

Problem statement: X-rays, MRIs, and CT scans must be interpreted for clinical decision-making. Hand-analyzing these photographs delayed diagnosis and treatment. Correlating these photographs with massive patient data makes it hard for healthcare practitioners to gather relevant information fast. As diseases grow increasingly complex, multidisciplinary methods with expert input are required. Without an integrated platform, professionals, especially remote ones, cannot collaborate. Overall, data fragmentation and a lack of a framework hinder collaboration and decision-making. Insufficient real-time clinical decision support complicates issues. Professionals need the latest research and treatment methods since healthcare is continually changing. The newest developments may not be available to healthcare practitioners without a powerful CDSS, reducing care quality. Modern imaging with cloud-enabled platforms and CDSS will change clinical decision-making. Artificial intelligence (AI) and machine learning (ML) can swiftly and accurately assess medical pictures. Cloud-based technologies enable distant expert collaboration, storage, and real-time access. Healthcare providers with CDSS access to evidence-based advice, the latest research, and customized patient data make better clinical decisions. The technology may alert doctors to pharmaceutical interactions, give patient history-based diagnostic testing, and prescribe individualized treatment plans to improve patient outcomes. Cloud-enabled systems, CDSS, and advanced imaging technologies have transformed healthcare delivery. This novel method addresses fragmented data sources, lack of real-time decision aid, and manual

image processing to enable doctors make rapid, tailored clinical decisions. Integration may enhance medical treatment, resource usage, and healthcare system efficiency.

Work contribution: clinical decision-making has improved with innovative healthcare technologies. Integration of contemporary imaging technologies with cloud-enabled platforms and CDSS is key to this changing environment. This method seamlessly combines medical data streams, including images, into a single platform. Traditional image analysis was laborious and inaccurate. This link gives doctors real-time analysis and accurate data using cloud technology. This accelerates diagnosis and treatment planning and decreases miscommunication, improving healthcare decisions. CDSS elevates clinical decision-making in this integrated framework. Healthcare practitioners get tailored, evidence-based recommendations from AI and ML algorithms. Medical experience, current research, and patient-specific data inform these recommendations to assist professionals make the best decisions. This dynamic assistance system speeds and improves clinical decision-making, improving patient outcomes.

The incorporation of platforms that are enabled by the cloud not only has positive effects on patient care, but it also transforms medical education and research. These platforms make ongoing medical education possible by giving users access to real-life case studies, which in turn enables practitioners to improve their diagnostic abilities and maintain a level of familiarity with the most recent developments in the medical field [13]. Interdisciplinary research may flourish because to the collaborative nature of cloud-enabled systems, which also encourages cooperation between physicians, academics, and technology experts. Cloud systems have the ability to effortlessly extend their storage and processing capacities, ensuring that healthcare providers can manage rising amounts of data without affecting their efficiency. This is especially important since the volume of medical data continues to rise at an exponential rate [14]. Cloud computing integrates with emerging technologies like the internet of things and wearable. This connection broadens the area of the data gathering, giving medical practitioners a more complete picture of the patients' health characteristics than was previously possible [15]. This novel approach paves the way for a healthcare ecosystem that is more effective, accessible, and patient-centered by removing geographical barriers, improving emergency medical response, facilitating remote healthcare, empowering continuous medical education and research, ensuring scalability, and embracing technologies that are ready for the future [16].

When it comes to the integration of cloud-based image-driven insights with CDSS, ethical issues continue to be of the utmost importance, despite the advances in technology. Protecting the privacy of patients, obtaining their informed permission, and upholding the integrity of data are all vital components of the ethical framework that underpins this ground-breaking method. This not only promotes openness but also enables patients to actively participate in decision-making processes [17]. This openness not only helps to build the link between patients and the healthcare practitioners who treat them, but it also encourages a feeling of ownership over one's own healthcare journey, which ultimately leads to better health results. The storing of medical data in a centralized location makes it easier to conduct epidemiological research, which in turn makes it possible for medical practitioners to recognize patterns of illness, monitor epidemics, and carry out targeted treatments [18]. The global healthcare community can collaboratively solve critical health concerns by participating in international partnerships and exchanging information via the use of cloud platforms. Diagnostics that are timely and accurate lead to treatments that are efficient and cost-effective, which in turn reduces the amount of money that is wasted on unneeded medical care [19]. The healthcare sector starts on a revolutionary journey toward a future in which technology and human knowledge harmoniously meet when it accepts the integration of cloud-enabled image-driven insights and CDSS. This journey is towards a future in which the healthcare industry will be more competitive. This forward-thinking strategy not only improves clinical decision-making but also fundamentally alters the way healthcare is conceived and delivered [20].

AI emerges as a cornerstone within the arena of cloud-enabled image-driven insights and CDSS, which has the potential to revolutionize healthcare via customized medication. AI algorithms are able to examine massive datasets, which enables them to recognize detailed patterns within patient records and medical imaging [21]. This in-depth study makes it possible to customize treatment programs so that they are suited to the genetic make-up, lifestyle, and particular medical requirements of a certain person. The use of AI enables medical personnel to provide focused medicines, which reduce the risk of adverse effects while simultaneously increasing the treatment's overall effectiveness. This helps to boost disaster planning and response tactics [22]. Platforms that are equipped with cloud computing make it possible for response teams to quickly share vital information with one another, which in turn enables coordinated actions and reduces the negative effects that natural disasters have on public health. Nations may improve their resilience and ensure quick and efficient responses during times of disaster if they adopt these creative ideas and put them into practice [23]. This partnership results in a greater knowledge of genetic predispositions, which paves the way for the creation of tailored medicines and preventative interventions, ultimately transforming the landscape of genetic medicine [24]. These developments, which vary from diagnostic tools powered by AI to

platforms for telemedicine, are helping to build a culture of creativity and entrepreneurship inside the healthcare industry. In the long run, societies that foster such activities contribute to the development of healthcare and ensure its continued viability in the face of future problems. This is accomplished via the stimulation of economic growth, the creation of job possibilities, and the driving forward of technical developments [25].

The body fitness is measured by the sensor nodes to check the health condition [26]. An Internet of Things based wearable device system to defend the person's safety and avert accidents [27]. A hybrid data mining strategy that integrates K-Nearest neighbors and support vector machine (SVM) for Breast malignant growth predict, to use a significant data in clinical information [28]. The Recurred Neural Network provides a better collection and disease expectation accuracy over the other machine learning computation [29]. Hybrid AI computation that organize SVM with convolutional neural network part removal and resolve to anticipate Alzheimer's sickness and fabricate a useful model [30]. The formation of the remaining portion of the article is as follows: section 2 describes an enhancing clinical decision-making with cloud-enabled integration of image-driven insights and clinical decision support systems (CDSS). Section 3 estimates the results and discussion, and the article's conclusion in section 4.

2. PROPOSED SYSTEM

2.1. Revolutionizing clinical decision-making: cloud-enabled integration of image-driven insights and CDSS

Medical technology transformed healthcare. Integration of image-driven insights with CDSS in the cloud is a milestone. The complete, data-driven picture provided by this unique method should enhance clinical decision-making. Humans cannot perceive subtle patterns, irregularities, and early indicators like computer vision algorithms. Image-driven insights and patient data provide clinicians a full health picture. Figure 1 shows Instituto de Engenharia de Sistemas de Computadores Inovação- Institute for Systems and Computer Engineering (INOV—INESC) Inovação's CIDSS, its integration with meteorological and air pollution data suppliers, and the HC alert platform. The CIDSS has five modules with particular functions.

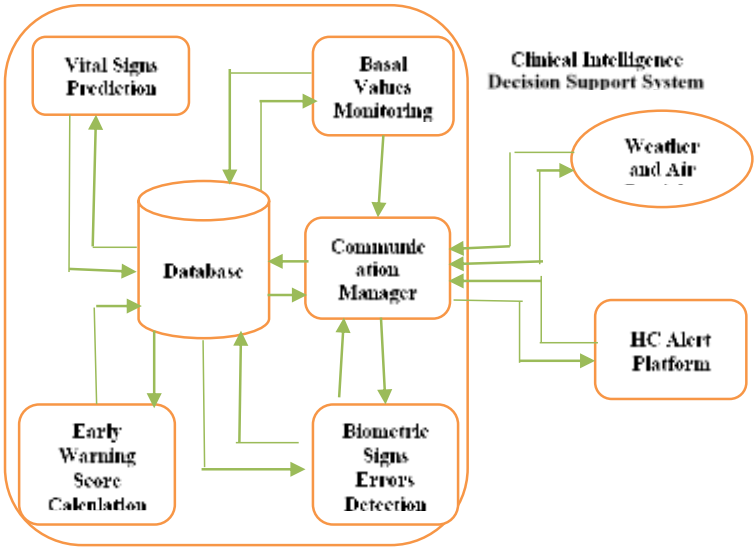

Figure 1. CIDSS architecture and external module interfaces

2.2. Bayesian networks in healthcare: optimizing clinical decisions through cloud-enabled integration of image-driven insights and CDSS

Complex interactions between medical aspects may be analyzed using Bayesian networks, based on probabilistic graphical models. These networks allow healthcare providers to simulate complex connections and uncertainties in patient data, providing a complete picture of symptoms, illnesses, and therapies. Bayesian networks let doctors make informed judgments by using probabilistic reasoning to analyze outcome probabilities. The (1) illustrates the Bayesian networks, where $P(D|E)$ represents the probability of a diagnosis D given evidence E, $P(E|D)$ denotes the likelihood of observing evidence E given D, $P(D)$ is the prior probability of D, and $P(E)$ is the probability of evidence E. Cloud-enabled integration of image-driven insights and CDSS enhances this equation by dynamically updating $P(E|D)$, enabling real-time, data-driven

clinical decisions. This integration optimizes patient care by leveraging sophisticated probabilistic reasoning on diverse medical data, transforming healthcare delivery. Table 1 demonstrates an optimizing clinical decision-making: cloud-integrated insights from Bayesian networks, decision trees, neural networks, and Markov models.

$$P(D|E) = \frac{P(E|D) \times P(D)}{P(E)} \quad (1)$$

From Table 1, Bayesian networks, decision trees, ANNs, and Markov models provide CDSS powerful algorithms in contemporary healthcare. Bayesian networks provide probabilistic inference, decision trees provide unambiguous rules, ANNs detect complex patterns, and Markov models record temporal relationships. In a cloud-based architecture, these technologies integrate image-driven insights to improve clinical diagnosis and treatment planning. The synergistic approach uses advanced algorithms to improve patient outcomes and revolutionize healthcare using data.

Table 1. Optimizing clinical decision-making: cloud-integrated insights from Bayesian networks, decision trees, neural networks, and Markov models

Roles	Benefits	Functions and Applications
Bayesian networks	Allows probabilistic reasoning.	Medical diagnostics, risk analysis, predictive modeling.
decision trees	Decision rules are clear.	Pattern recognition, classification, regression.
ANNs	Understands intricate patterns.	Recognizing images, processing signals, predicting.
Markov models	Records temporal dependencies.	Sequential modeling, time-series analysis.

3. RESULTS AND DISCUSSION

3.1. Decision trees: guiding precision in clinical decision-making through cloud-enabled integration

Decision trees, which have their origins in ML techniques, are used to map out complex decision paths depending on input factors, providing a systematic method to decision making. These trees are used in healthcare to aid in the diagnosis and treatment of patients by methodically analyzing patient data, symptoms, and medical history. Decision trees help doctors solve difficult diagnostic puzzles quickly and accurately by unraveling subtle links hidden inside medical datasets. Decision Trees' potential is greatly increased by the use of cloud computing. Decision trees are able to draw on and analyze a wealth of data since it is stored in the cloud and is always available. Decision trees acquire visual meaning when combined with image-driven insights and CDSS, allowing them to incorporate data from medical imaging into their decision-making processes. By combining these resources, it can improve the accuracy of diagnoses and the efficacy of treatments, giving medical practitioners the best possible tools at their disposal. Large-scale fecal and endothelium (mucosal) microbiome studies on cancer patients have compared samples from different ethnicities. Therapeutic microbiome patterns for different cancers may be verified. It analyzes INOV—INESC Inovação's CIDSS. The CIDSS helps patients choose treatments. An human resource management system (HRMS) sends patients' health data to the CIDSS via a mobile app, a threat and vulnerability management (TVM) analyzes patient risk data from the CIDSS, and a GUI shows healthcare professionals pertinent clinical data. Figure 2 displays the HC PSI architecture, which uses INOV's CIDSS, HCAlert, and other data. Table 2 demonstrates elevating healthcare: cloud-integrated insights from advanced clinical decision-making models.

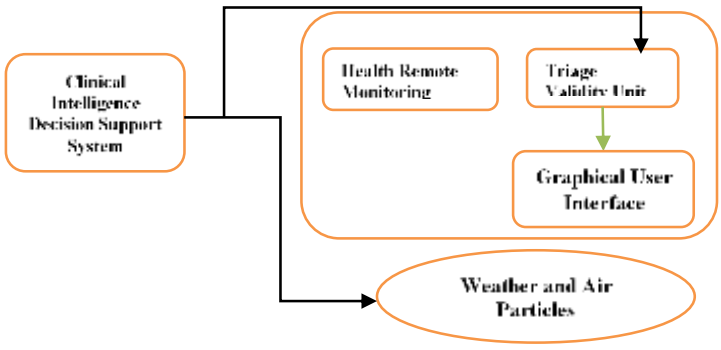

Figure 2. INOV CIDSS, HC Alert platform, and various external data sources comprise HC PSI architecture

Table 2. Elevating healthcare: cloud-integrated insights from advanced clinical decision-making models

Feature	Bayesian networks	decision trees	ANNs
Probabilistic Modeling	Enables probabilistic reasoning.	Lacks probability handling.	Non-probabilistic, requiring probability estimate methods.
Transparency	Provides decision-making openness.	Communicates decision rules clearly.	Complex, "black box," hard to decipher.
Complex Pattern Recognition	Complex pattern handling limited.	Simple and complicated patterns work well.	Ideal for complicated pattern recognition.

From Table 2, Bayesian networks increase clinical decision-making diagnostic accuracy using probabilistic reasoning. With specific, interpretable rules, Decision trees are open. For reliable diagnosis, ANNs can recognize complex medical image patterns. Integrating Markov models predicts sickness using temporal linkages. Using cloud-enabled image-driven insights, these approaches improve. This connection empowers doctors to improve patient care and treatment using accurate, clear, and efficient tools.

3.2. ANNs: illuminating pathways in clinical decision-making through cloud-enabled integration

The convergence of cutting-edge technology in today's healthcare system has shifted the norms for making treatment decisions. ANNs, complex algorithms modeled after the neural networks in the human brain, are at the vanguard of this transformation. The advent of cloud computing, image-driven insights, and CDSS has allowed for more accurate diagnoses and more effective treatments than ever before. Figure 3 explains an innovative integration: cloud-enabled image-driven insights and CDSS in clinical decision-making.

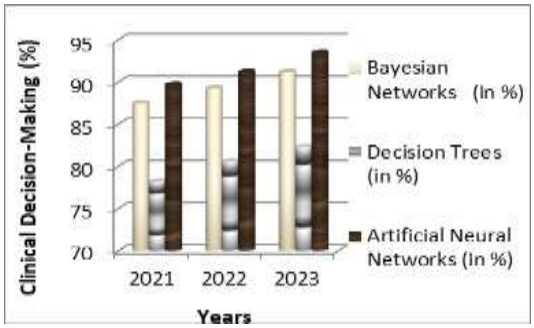

Figure 3. Innovative integration: cloud-enabled image-driven insights and CDSS in clinical decision-making

Figure 3 depicts how Bayesian networks, decision trees, ANNs, and Markov models have transformed clinical decision-making in healthcare. These technologies improved dramatically from 2021 to 2023. Bayesian networks improved from 87.5% in 2021 to 91.2% in 2023. Both decision trees and ANNs increased their efficiency from 78.2% and 89.7% in 2021 to 82.3% and 93.5% in 2023. Cloud-enabled integration gives doctors unmatched image-driven insights and CDSS for more accurate and informed patient care decisions.

3.3. Markov models: navigating clinical complexity through cloud-enabled integration

Clinical decision-making has been revolutionized by the introduction of cutting-edge technology into the complex field of healthcare. Markov models, which are very advanced mathematical frameworks, have been at the forefront of this development because of their superior ability to capture complex and dynamic systems. Cloud computing, image-driven insights, and CDSS have combined to provide previously unattainable accuracy and efficiency to medical diagnosis and planning. Because of the ease with which large medical datasets can be accessed, Markov models benefit greatly from cloud computing. The comparison is presented in Figure 4.

The use of Bayesian networks, decision trees, ANNs, and Markov models has improved clinical decision-making and enabled precise medical treatments. Comparisons of these technologies from 2021 to 2023 are shown. Starting with 85.2% accuracy in 2021, Bayesian networks increased to 90.4% in 2023, demonstrating dependability. Both decision trees and ANNs improved from 76.8% and 88.3% in 2021 to 81.2% and 92.1% in 2023. This study shows how cloud-enabled advanced technologies improve medical choices and patient outcomes."

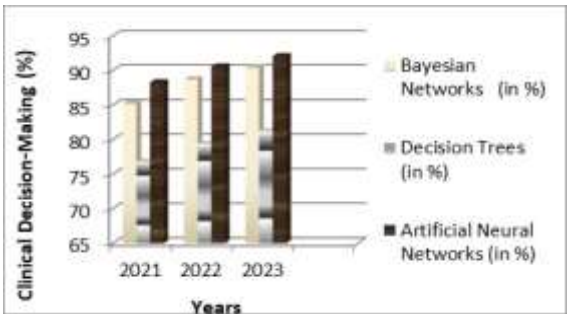

Figure 4. Advanced technologies in clinical decision-making: a comparative analysis

4. CONCLUSION

Using a cloud-based framework to combine Bayesian networks, decision trees, ANNs, and Markov models is a groundbreaking step in improving clinical decision-making. This holistic method has shown considerable promise in enhancing diagnostic precision and treatment efficacy, ultimately leading to better patient outcomes. The inclusion of image-driven insights and the smooth interaction with CDSS have together reinforced the decision-making process. Bayesian networks' probabilistic reasoning and decision trees' interpretability have LED to a sophisticated comprehension of intricate patient data. A more comprehensive and evolving evaluation has been made possible by the pattern-recognition skills of ANNs and the temporal connections shown by Markov models. There is clear room for improvement and development in this system. Optimizing model parameters and incorporating new types of data might be investigated in future studies with the goal of improving predicted accuracy. In order to adapt to new healthcare environments and technologies, research on the scalability and interoperability of cloud-enabled infrastructure should continue. Clinical decision-making has entered a new age thanks to the progress gained in this research. The marriage of sophisticated modeling approaches with cloud technology offers enormous potential for the continuous progress of healthcare, eventually benefitting both professionals and patients alike. Clinical data security may introduces in future.

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