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The Role of AI in Modern Healthcare Systems

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Abstract

In the Indian pandemic, several issues in the healthcare system have brought to the forefront the imperative of hospitals shifting from manual medical records to computerized healthcare information systems. These solutions offer an effective method for integrating computer-based decision support tools and communicating e-healthcare information. With increasing dependence on AI-based solutions, a strong IT infrastructure is essential for improving healthcare quality, data security, and controlling increasing medical expenses. Advances in communication technology and networking are fundamental to the modernization of healthcare services and addressing both patients' and providers' needs. An AI-powered hospital system is not only necessary but also feasible despite its challenges. This paper discusses the uses of IT in hospitals and medical environments. They could improve clinical judgment, the recording of imaging and medical history, reduce duplication of diagnostic tests, and enhance reliability on medication with improved use of healthcare resources, and enhanced preventive health programs.

Keywords: Artificial Intelligence in Healthcare, Clinical Decision Support Systems, Electronic Health Records (EHR), Healthcare IT Infrastructure, Medical Data Management

INTRODUCTION

The article highlights the urgent need for context-sensitive decision-making in India's healthcare system to effectively combat the virus and provide real-time recommendations for prevention. There is a need for better clinical decision-making, a reduction in redundant diagnostic testing for improved imaging and documentation, better medication management, increased use of monitoring applications, and robust preventive health initiatives. This paper provides concise, proper details of AI applications in the healthcare sector. AI often mimics human intelligence when delivering outcomes, offering result-driven solutions for accurate data transmission, analysis, and prediction. By tracking patient history and utilizing this information for future applications, AI-based agent systems can be effectively deployed. Artificial intelligence (AI) operates as an independent program designed with specific instructions to perform tasks typically carried out by humans [1]. In the learning patterns, these programs can assist in language processing, sound, and object recognition, and problem-solving. Machine learning (ML), a rapidly evolving method, enhances algorithms over time through continuous refinement. This process relies on large datasets and is executed automatically, allowing algorithms to adapt and improve AI accuracy [1].

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LITERATURE REVIEW

The study [2] shows an application designed to predict adherence to treatment using common variables and organizing data through Support Vector Machine (SVM) for patients facing diseases related to the heart. This dataset consisted of 76 HF patients and these are pre-processed based on 10 key characteristics, including gender, age, monthly income, education, spouse, and time since HF diagnosis, daily medication frequency, EF, A./WISE-K, to medication with awareness, and functional class in NYHA. For the simulation, the researchers utilized the LIB SVM software library. Since SVM operates within a structured format, the collected data is properly converted through assigning numerical values accordingly.

Feature selection in this study was performed through a combination approach. The optimal model was determined by comparing SVM with its four kernel functions, including Polynomial, Linear with RBF, and Sigmoid. The study concluded that RBF and SVM yielded the highest accuracy. However, certain limitations were noted, including a small dataset, the lack of direct measurement of medication adherence, and the reliance on patient-reported data, which could introduce statistical inaccuracies.

With the use of historical and real-time data, this handy mobile application helps determine a patient's normal and emergency state and notifies them. Six agents made up the group, and each has a distinct function to play.

The Following Agents Made Up the Group [3]

- Monitoring Agent of Patient
- Agent for Gate
- Supervisor monitoring Agent
- Agent for Managers
- Doctor monitoring Agent
- Decision maker Agent

The Interconnected with System Architecture Consisted of Following

- Body Area Network (BAN) including sensors that collect biological signals, including WBSN (wearable body sensors) also the patient with personal devices.
- An intermediary hub connecting the patient and hospital through an Intelligent Medical Server (IMS).
- A hospital system that determines necessary actions. This system enhances cost-effectiveness by reducing the need for multiple medical tests through continuous monitoring, ensures security with RFID tags, and offers flexibility in data transmission via Bluetooth, Zigbee, and WLAN.

However, sensor-based real-time predictions may lack accuracy due to potential errors [4]. introduced a web-based SVM technique, c-Doctor, which automates medical diagnosis. There is statistical data for this system involving numerical or logical parameters. It is related to a disease with user input and provides predictive analysis.

The Study Explores Several Use Cases

- *Diagnosis:* This system generates the presence of a disease based on a predefined list of conditions.
- *New Disease:* Users can input new parameters along with a disease summary before proceeding further.
- *Training:* A fresh disease record is created or updated, and doctors are retrained on case usage, improving the system's learning.
- *Additional Use Cases:* These include removing disease records and reviewing a patient’s medical Record.

The paper shows the Support Vector Machine (SVM) [5], as well as the Smart Healthcare Monitoring System, which introduced a specialized device designed to track elderly and disabled individuals in real time. It achieves this by sending emergency alerts to caregivers when sensors detect critical health conditions in patients [6].

The System Operates in Four Stages

- *IoT Box:* This initial stage includes 3- IoT-based sensors including a temperature sensor with pressure monitoring and monitoring system and pulse sensor, all integrated with an IoT micro and microcontroller.
- *Personal Digital Assistant:* This component, equipped with internet connectivity, generates an emergency alert upon detecting any abnormal health changes.
- *Data Analysis:* At this stage, SVM is employed to classify cases based on sensor data.
- *Message Bot:* The final step involves an automated bot that sends alert notifications to both caregivers and the patient's doctor.

This system has the potential to enhance medical assessment and patient monitoring. However, its effectiveness may be compromised in cases of sensor malfunction or inaccuracies in data collection.

In [7], the authors showcase the application of mobile agents in addressing the highly complex and dynamic nature of healthcare crisis decision-making systems. The paper emphasizes the real-time deployment of ambulance services using mobile agents, highlighting its practical significance over theoretical concepts. The authors point out that a mobile agent is a self-sufficient program capable of autonomously navigating and executing tasks efficiently [8].

This paper discusses the management of healthcare institutions through computer applications located in medical centers. Typically, every organization has its own healthcare system, making data sharing between institutions challenging. The paper explores the use of mobile agent technology for distributed e-health applications, highlighting its role in integrating medical information and handling emergency situations. It explains how agents move between network nodes, carrying data and execution states, allowing seamless continuation of processes without requiring constant user intervention. These agents possess autonomy and collaboration capabilities, setting them apart from traditional systems [9].

The study on the application of Support Vector Machines (SVM) for predicting medication adherence in heart failure patients demonstrates the integration of statistical and machine learning techniques. A key advantage of SVM is its ability to handle high-dimensional data. It includes a large quantity of input variables relative to limited observations. Additionally, as a data-driven approach that does not rely on a predefined theoretical framework, SVM shows strong classification capabilities, even with small sample sizes. It has been widely applied in clinical disease detection and bioinformatics classification problems, proving to be a highly effective technique for predicting patient adherence to medication using standard variables [10].

In paper [11], "A Review of Medical and its Applications Using simple and multi agent Systems," there is a survey on various types of agent systems in medical applications and an overview of various implementations, especially in diagnosis and concept-driven ones. Beneficial features of agent-based systems are flexibility and reliability. It also contains extensibility with their uniformity and portability; it is also autonomous learning with good accuracy, reactiveness, and agent efficiency. However, the study also highlights certain limitations, including the lack of a universally accepted healthcare ontology.

The paper "Comparative Results of Machine Learning Techniques in the Medical Field" [4] explores different machine learning (ML) techniques used in healthcare to improve performance in medical applications. The study discusses AI and its subfields, including ML and image processing, emphasizing that ML-based algorithms demonstrate high accuracy and sensitivity in medical diagnostics. Various methodologies and algorithms used in different ML stages are analyzed to understand their effectiveness in clinical applications.

The study "Smart Assistant for Doctors" [12] focuses on the application of various aspects like artificial intelligence and machine learning algorithms in assisting doctors during medical treatments. The paper presents a scenario where real-time datasets are utilized to enable fast and accurate disease diagnosis based on input variables such as patient symptoms, medical history, age, and chronic illness. This AI-driven system aims to enhance decision-making efficiency and improve patient care.

Three new eHealth systems communities are highlighted in three complete cases. The first framework offers a mobile agent-based application that combines the key aspects of modern healthcare systems. It contains distributed data collection between medical institutions. The primary aim is to establish a virtual record of electronic patient medical data across different hospitals. By leveraging mobile agent technology, which conducts localized searches through roaming agents, the system eliminates the necessity for a centralized repository.

The paper "A Literature Review of Various Healthcare Mobile Agents and its Applications" [13] explores the development of mobile agent (MA) technology for mobile and distributed computing, which has been widely applied in areas ranging from network management to knowledge processing. Mobile agents facilitate collaboration in distributed environments like cloud computing and sensor networks by enabling autonomous migration between nodes. The study extensively reviews recent advancements in MA and its feasibility for healthcare applications [14–17].

The study "Telephonic Agent Technology for Teletracking Healthcare" [18] discusses the use of mobile computing for a global teletracking healthcare system. It focuses on the deployment of healthcare services and medical professionals, including physicians, emergency responders, and other healthcare providers, using mobile computing devices. The authors introduce an innovative teletracking assistant system based on mobile agents, allowing real-time access to shared medical data from any device, at any time, and from any location.

The study in [19] explores the competitive advantage gained through various healthcare services enabled by technology. It describes knowledge-intensive agents functioning as both providers and consumers of healthcare information. With the increasing reliance on information technology, the integration of human-centered tasks within healthcare systems has become essential. Given the data-intensive and technology-driven nature of the medical field, multiple computerized systems must be fused to enhance efficiency and service quality within a limited timeframe. The complexity of such systems necessitates methods that support seamless integration and adaptability.

In [8], the researcher discusses strategies for improving machine learning (ML) algorithms by exploring various techniques. The paper elaborates on ML methodologies and highlights the application of Extreme Learning Machines (ELM) in medical datasets for enhanced performance.

The authors of [20] focus on autonomous vehicles capable of making dynamic decisions and navigating independently. This article examines the integration of the Internet of Things (IoT) with ML algorithms, demonstrating how such technology can be used in hospitals to deliver in-patient department (IPD) medications. Particularly in pandemic scenarios like COVID-19, autonomous medical delivery vehicles can efficiently transport medicines along predefined routes. The paper also delves into different machine learning algorithms relevant to these applications [21–24].

In [25], research on data visualization in pandemic scenarios is presented. The paper analyzes statistical data from the 1920 pandemic and highlights how visualization techniques contributed to improvements in crisis management. The authors provide graphical representations of pandemic data using ML algorithms, big data, and Python, with a specific focus on COVID-19 data visualization.

In [26], research on advancements in federated learning for secure healthcare data analysis is presented. The paper explores how federated learning enables collaborative data processing while preserving patient privacy, making it a critical tool in modern healthcare. The authors discuss the integration of AI-driven models with federated learning frameworks, highlighting improvements in predictive analytics, disease diagnosis, and personalized treatment plans. The study demonstrates the effectiveness of this approach through real-world healthcare datasets, ensuring secure and efficient data sharing across institutions without compromising confidentiality.

In [27], research on quantum machine learning (QML) applications in medical imaging is introduced. The paper delves into how QML enhances image processing techniques for medical diagnostics, providing faster and more accurate interpretations of complex imaging data. The authors examine the use of quantum algorithms to improve feature extraction, anomaly detection, and classification of medical scans such as MRIs and CT scans. By leveraging quantum computing's superior processing power, the study showcases its potential in revolutionizing medical imaging, paving the way for more precise and early disease detection.

FINDINGS

Healthcare information systems have the expertise of skills and resources needed to collect, process, use, and exchange patient data using systematic healthcare delivery resulting in overall wellbeing. In light of the significant disruptions caused by the recent pandemic, there is an urgent need for automated healthcare systems capable of making informed decisions on behalf of users.

Given the recent pandemic’s disruptive effect, it is critical to upgrade and modernize healthcare information systems to meet new problems. Nevertheless, those limitations and their necessity for the development of automated intelligent healthcare systems able to make informed decisions on behalf of users have become more apparent with the pandemic.

Advanced technologies such as artificial intelligence (AI), machine learning, and big data analytics can be integrated into healthcare systems such that real-time decision-making, predictive analytics, and personalized patient care can be realized. Automation of healthcare also makes better operational efficiency, human error elimination, resource utilization, and easy management of healthcare (particularly in areas that are hard to reach) easier.

Continuity of care between healthcare providers may be increased through things like telemedicine, other aspects of EHRs, and interoperability standards that will streamline communication and reduce administrative burden. With the advancement of healthcare, it will also equally have a role in the implementation of secure, scalable data-driven systems that build a more resilient patient-centered one.

This study highlights the challenges of managing healthcare information, particularly in safeguarding privacy, ensuring security, and addressing technical issues. The paper explores various technological solutions designed to support the healthcare sector, including artificial intelligence (AI). It includes agent-based systems and machine learning. It provides a comprehensive review of AI-driven techniques applied to healthcare data and introduces a range of tracking systems that enable remote health monitoring.

Additionally, the study examines IoT-based techniques integrated with deep learning and machine learning, which facilitate the transfer of patient healthcare information across multiple nodes on the internet. Given the diverse formats in which healthcare data may exist, the use of distributed databases is widely recommended in literature. The paper also discusses the application of Extreme Learning Machine (ELM) algorithms to enhance accuracy in medical data analysis.

Furthermore, this article serves as a valuable resource for students and researchers, encouraging further exploration into the application of artificial intelligence technologies in the medical and healthcare domains for more precise and reliable outcomes. Table 1.1 provides an analysis of various techniques implemented over the past 16 years to enhance healthcare systems.

The data analysis can be clarified by understanding the following Chart to classify various techniques 1.1 shown below. Then it shows the pie Chart 1.2 then with a chart that explains the usages of different techniques in this comparison.

Table 1. Data Analysis on Various Techniques Used for Improving Health and Healthcare System of Last 16 Years.

Papers	**Year**	**Technology /Techniques**
[1]	Up to 2008	AI and mobile based Agents
[2]	Up to 2010	SVM
[3]	Up to 2011	Pervasive with Computing
[8]	Up to 2013	SVM
54]	Up to 2018	SVM
[6]	Up to 2017	IoT
[7]	Up to 2018	Fuzzy Logic
[8]	Up to 2010	AI and mobile based Agents
[9]	Up to 2015	AI and mobile based Agents
[10]	Up to 2019	AI and mobile based Agents
[11]	Up to 2020	Optimization
[14]	Up to 2020	CNN
[9]	Up to 2023	Federated Learning
[10]	Up to 2024	Quantum Machine Learning

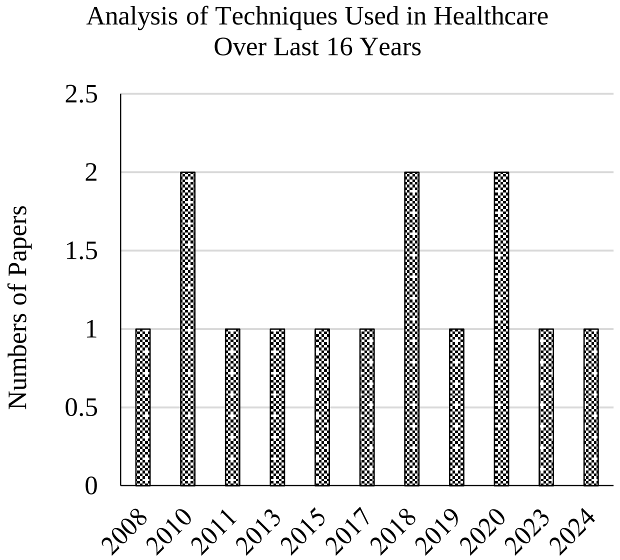

Figure 1. Data analysis on various techniques used for improving health and healthcare system of last 16 years.

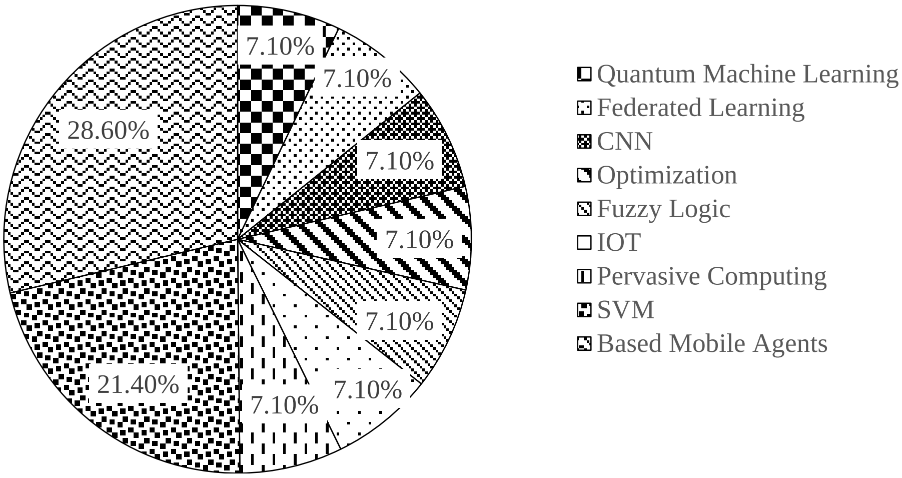

Figure 2. Comparative study to usage of various AI Techniques in health and HealthCare.

CONCLUSION

Between quality, affordability, disparities, and accessibility, the Indian healthcare sector faces many challenges. Investing in advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Big Data, and Machine Learning (ML) is necessary to solve problems arising around the world, especially emerging diseases, and to improve preparedness. A key technology for analyzing and improving healthcare preparedness is assumed by this study to be AI. The study explores how AI is able to research, anticipate, and fight against COVID-19 (Coronavirus) and other pandemics. There is a systematic review of different AI-driven ways of improving the healthcare system. Multiple challenges would be handled by advanced ML and AI techniques, including context-aware decision-making. It can also ensure timely access to appropriate medical care [28, 29].

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