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The Role of Artificial Intelligence in Revolutionizing Healthcare Systems: A Survey

Ayush Kumar Sharma [1], Aditya Jaiswal [2], Akash Shah [3], Sharik Ahmad [4]

[1] Department of Computer Science and Applications, School of Computing Science and Engineering, Sharda University, Greater Noida-201310, Uttar Pradesh, India

[2] Department of Computer Science and Applications, School of Computing Science and Engineering, Sharda University, Greater Noida-201310, Uttar Pradesh, India

[3] Department of Computer Science and Applications, School of Computing Science and Engineering, Sharda University, Greater Noida-201310, Uttar Pradesh, India

[4] Department of Computer Science and Applications, School of Computing Science and Engineering, Sharda University, Greater Noida-201310, Uttar Pradesh, India

Abstract

Artificial Intelligence (AI) is revolutionizing healthcare by enhancing diagnostic precision, optimizing treatment plans, and streamlining operational workflows. This survey paper explores the current landscape of AI applications in healthcare, focusing on technologies such as machine learning, deep learning, natural language processing, and computer vision. We review their roles in disease detection, drug discovery, patient monitoring, and data security, drawing insights from recent studies. While AI offers significant benefits, including improved patient outcomes and cost efficiency, challenges such as data privacy, ethical concerns, and algorithmic bias persist. This paper synthesizes findings from diverse research efforts, identifies trends, and proposes directions for future investigation to ensure responsible AI integration in healthcare.

Keywords: Artificial Intelligence, Healthcare, Diagnostics, Drug Discovery, Ethics

1. Introduction

The incorporation of Artificial Intelligence (AI) in the medical field has brought in a revolutionary period of tremendous progress in patient care, medical research, and utilization efficiency. This new paradigm is being powered by the power of AI to crunch and understand vast amounts of data, allowing innovation that was previously unthinkable. From automating trivial administrative tasks to forecasting the course of contagious illness waves, software programs created by synthetic intelligence are drastically changing the tactical landscape for healthcare suppliers globally [17]. Automated algorithms like machine learning, for example, excel at extracting high volumes of medical data with tiny patterns which can escape human analysis, thereby improving diagnostic accuracy and treatment outcomes [3],[8]. Likewise, natural language processing (NLP) solutions simplify clinical documentation, extracting meaning from unstructured patient records and utilizing that information to create actionable insights, enabling as well smart chatbots and virtual nurse services that enhance patient-provider communications [12],[15].

Change in healthcare practices occurs through robotics systems that assist surgery while computer vision tools transform diagnostic imaging [16]. Surgical robots enable precise procedures together with consistent execution which minimizes surgical errors during complicated operations [16], but digital image scanning enables faster and more precise medical detection beyond traditional visual devices [13]. The combination of recent advances creates better clinical results and less healthcare expenses and better care accessibility for patients. The complete adoption of AI in healthcare encounters multiple major obstacles despite its many benefits. The current regulatory system lacks uniformity because it struggles to adapt to advancing technology at speed, which results in issues regarding accountability standards [9],[21]. AI systems handling sensitive patient data create large privacy risks since improper data protection systems could result in breaches or misuse of patient information [9],[14]. The incorporation of AI systems creates ethical problems because AI algorithms can show preference biases which affect particular population groups and generate uncertainties about the proper limits of machine involvement when deciding matters of life and death [10]. This survey paper seeks to provide a comprehensive exploration of AI's current applications in healthcare, critically assess its transformative impact, and pinpoint critical areas warranting further investigation. By synthesizing recent research, we aim to illuminate both the opportunities and obstacles ahead, offering a roadmap for responsibly harnessing AI to advance global healthcare.

1.1 AI Applications in Healthcare

Diagnostics

AI shows exceptional diagnostic capabilities through CheXNet [8] and EfficientNetB4 [3] which perform near-perfect detection of pneumonia and COVID-19 using imaging data. The diagnostic systems decrease human mistakes while simultaneously speeding up the diagnostic process.

Drug Discovery

Machine learning and generative AI, as seen in Julian et al. [5] and Zhavoronkov [19], streamline drug development by predicting interactions and identifying candidates, cutting time and costs.

Patient Monitoring

Real-time monitoring systems, such as those by Yinlong et al. [11] and Zongyao et al. [4], use AI to detect anomalies and track symptoms, enhancing care for chronic and elderly patients.

Data Security and Privacy

Federated Learning [9] and blockchain [14] address privacy concerns, ensuring secure data sharing while complying with regulations like HIPAA.

2. Literature Review:

Aswathy et al. [1] have shown that the emergence of COVID-19 has led to a significant increase in research related to image classification using deep learning. Various studies have explored techniques to improve the accuracy and efficiency of automated COVID-19 diagnosis through medical imaging, particularly X-ray and CT scans. This review examines recent advancements, challenges, and opportunities in the field. Andres et al. [2] have discussed that the 2014–2016 EVD outbreak resulted in the disease infecting more than 28,000 individuals before resources scarce enough to cause death in 11,000 victims. Risk stratification models from early stages had success but lacked sufficient data to keep them operational. The research expands from prior works by evaluating a more extensive database to boost the practicality of clinical choices. The research implements current valid predictive models inside a modern system to provide individualized real-time healthcare at patient level. Md Alamin et al. [3] have mentioned that the mentioned that use of deep learning techniques to address the difficulties of COVID-19 detection since the first COVID-19 infection outbreak. This review of the literature groups earlier studies according to the various Deep Learning techniques and experimental datasets used. Zongyao et al. [4] have shown that advancements in deep learning have significantly improved cough detection, with techniques like CNNs, RNNs, CRNNs, and LSTMs enhancing accuracy through spectrogram analysis and pattern recognition. YOHO stands out in sound surveillance, while the 'Neural Cough Counter' plays a crucial role in real-time healthcare diagnostics, making reliable cough monitoring more accessible. Julian et al. [5] have analyzed that machine learning technology uses combined network and physicochemical data to guide drug development processes for both optimum drug effectiveness assessment and pharmaceutical repurposing initiatives namely COVID-19 treatment. Random forest models enable this study to evaluate drug-target interactions by resolving data challenges while discovering core attributes of effective and cytotoxic and no-effect compounds. Ahmed et al. [6] have demonstrated that since its first detection SARS-CoV-2 has developed numerous mutations into eleven different strain groups with varying levels of seriousness. Research from GISAID enabled GenoSig to analyze 1,131,185 sequences through DL and RF models to perform clade predictions. The effective system shows promise for application in wider epidemiological research along with analysis of other species. Syed Nisar et al. [7] have analyzed that the Zika virus acts as a maternal health threat in 86 worldwide nations. The study analyzed 12,262 peptide sequences by ML to establish their epitope properties. The proposed ensemble model exhibits strong accuracy in peptide vaccine development whereas additional classification techniques can enhance its outcomes. Pranav et al. [8] have shown that the 121-layer CNN known as CheXNet performed training operations on the ChestX-ray14 database which contains more than 100,000 images of 14 different diseases as part of the largest free chest X-ray repository. It demonstrated better F1 scores as compared to four radiologists. The expanded detection capabilities to cover all 14 diseases brought the system to establish an unprecedented standard for medical image analysis systems. Sarthak et al. [9] have discussed that the healthcare sector continues to experience privacy threats from different sources with AI-driven risks being one of them. The loss of patient data privacy can be protected by Federated Learning (FL) which enables AI collaboration. FL requires encryption measures and needs to comply with regulations due to its vulnerability to privacy attacks. The study organizes FL privacy threats and their countermeasures to help researchers build better AI solutions for health care applications. Ziad et al. [10] have reported that the commonly utilized health prediction system reveals racial prejudice because Black patients present greater medical conditions than White patients under equivalent risk assessment. Healthcare expenses prediction serves as the source of bias which results in unequal care availability. Improving healthcare support for Black patients requires a solution to resolve this matter. Yinlong et al. [11] have explained that medical care providers must introduce efficient monitoring solutions because elderly patient numbers continue to rise. The monitoring system operates using deep learning models together with heuristic-based model approaches. The monitoring system uses combination of deep learning algorithms with heuristic-based model strategies for its operations. The high-performance platform conducted tests on 500 videos to verify proper detection of irregular activities using the system deployment. Laila et al. [12] have shown that image prediction systems generated through AI have improved clinical diagnosis procedures and helped doctors make better treatment decisions. The predictive modelling performance of structured EHR data receives an improvement through specific BERT transfer learning methods. The investigators relied on two de-identified databases including Cerner Health Facts® which included information from 68M patients from 2000 to 2017 and Truven MarketScan® that covered 170M patients from 2011 to 2015. Cerner operates according to HIPAA policies and study data at UTHealth SBMI exists under licensing restrictions. Haval et al. [13] have stated that the patient diagnostic capability of LDCT screening results in inadequate performance for identifying high-risk individuals together with certain racial demographics. New detection features are integrated into PLCOm2012 model because the ILST and YLST trials conduct research on enhanced screening accuracy methods. Medical achievements in biomarker detection technology and preventive methods and diagnostic instruments enhance both early detection and healthcare prevention of lung cancer. Omar et al. [14] have discussed that the framework of cybersecurity depends heavily on blockchain technology for addressing smart city requirements. The research looks at smart healthcare, transportation, agricultural, supply chain, power grid, and residential blockchain security methods before identifying their benefits together with their security needs and possible challenges. This document serves as an important resource for academic professionals studying cybersecurity together with blockchain methods and intelligent urban settings. Abhyuday et al. [15] have shown that the MADE 1.0 challenge worked to extract medication and indications together with adverse drug events (ADEs) from EHR notes to enhance drug safety surveillance. A total of 1089 de-identified cancer patient records were used to create three NLP tasks that included named entity recognition (NER), relation identification (RI) and a combined NER-RI model. The highest system scores reached 0.82 for NER tasks and 0.86 for RI tasks and 0.61 for the combination of these tasks. Ensemble classifiers enhanced these scores even more. The development of NLP has made clinical entity recognition better but more work is necessary to improve joint tasks. Daniel et al. [16] have explained that academic researchers analyze operative artificial intelligence systems so they can identify their existing operational capabilities together with functional boundaries. Through combinations of machine learning with neural networks and NLP and computer vision technologies the surgical process achieves better clinical analysis potential along with clinical assistance. All surgical procedures demanding enhanced patient care enhancements require surgeons to work with data scientists who support smooth medical practice implementation. Kaiwen et al. [17] have mentioned that SARS-CoV-2 made its identification during February 2022 and immediately triggered the global COVID-19 pandemic outbreak. Millions of global cases were attributed to its high transmission rate. Waste transmission occurs through particle droplets and universal contact along with airborne droplets and environmental conditions worsen its spread when public restriction regulations are loosened. Molecular testing based on PCR and LAMP enables scientists to monitor the virus in wastewater samples. Wastewater-based epidemiology (WBE) enhances outbreak alert systems and vaccine allocation planning yet needs enrichment procedures for better detection. Adrain et al. [18] have developed a deep learning framework that uses multi-task learning (MTL) to boost predictive accuracy for exactly when suicide risks occur and how mental health conditions affect patients. The system reaches a minimal false positive rate when it simulates multiple conditions alongside performing an auxiliary gender prediction task. The MTL model delivers better results compared to single-task models particularly in predicting suicide attempts and performing atypical mental health diagnosis with AUC values exceeding 0.8 due to its ability to work effectively with limited training data. Alex Zhavoronokov [19] has shown that AI-based drug discovery can be accelerated using generative models. As the founder of Insilco Medicine and Deep Longevity, he has led efforts in aging research and AI-powered biomarkers, securing significant funding and contributing to over 200 publications. Richard et al. [20] have revealed that Medicare fraud imposes financial burdens on healthcare, especially for the elderly. ML techniques applied to Medicare records help detect fraudulent behavior and inform more effective fund recovery systems. Peng et al. [21] have stated that Healthcare receives significant transformation from GPT models in Generative AI which enhances medical diagnosis as well as treatment planning and patient documentation procedures. The efficiency improvements alongside better patient care needs stakeholders to work together against accuracy and transparency and ethical concerns. Future AI models that receive high-quality medical data will create advanced clinical systems and bring them deeper into medical practice. Christiane Floyd. [22] has discussed that Joseph Weinbaum developed ELIZA as the earliest chatbot in 1966 through which he imitated psychotherapeutic rule-based responses. Modern AI chatbots that include Chat GPT operate differently from ELIZA because they employ deep learning together with neural networks which creates intricate and progressively advancing algorithms. AI developers employ human-like speech designs to create a debate on whether AI functions comparable to human cognitive abilities. Even though AI responses may seem conversational it is usually more trustworthy to verify information by referring to Wikipedia and conducting web searches.

Table 1

Threat Sub-category	Result / Accuracies	Limitation / Future Scope	Dataset / Model Used	Technique Used (Technique Nature)	Reference
COVID-19	This study uses ResNet-50 and DenseNet-201 for COVID-19 severity detection with 98.5% accuracy and 98.58% sensitivity.	This study uses ResNet-50 and DenseNet-201 for COVID-19 severity detection with image resizing and data augmentation, and suggests extending detection to 3D CT volumes.	Chest X-ray dataset	Transfer learning	[1]
Ebola virus disease	Generalizable machine-learning models, combined with health tools and effective data sharing, are key for early detection and containment of outbreaks like Ebola and other emerging diseases.	This study addresses EVD prognosis modeling limitations by harmonizing data and using statistical techniques, with future models requiring larger, more reliable datasets.	Epidemiological outbreak data / Decision Trees, Random Forests	Machine learning	[2]
Covid-19 Lung Diagnosis	EfficientNetB4 led with 100% accuracy in COVID-19 detection, followed by other models like Xception and ResNet50, showing strong potential for reliable detection.	Lung diagnosis research is hindered by symptom overlap, limited diagnostic tools, small sample sizes, and lack of longitudinal data, especially in	Chest X-ray	Deep learning & Transfer learning	[3]

		resource-limited settings.			
Neural Cough	The cough-monitoring task counts coughs and generates hourly histograms, showing accurate detection and systematic counting.	Deep learning-based sound event detection outperformed CRNN in cough monitoring, emphasizing the value of fine-tuning and integrating models.	Cough detection and Monitoring	Deep learning	[4]
Drug Effect	They present a random forest framework for predicting drug effects on SARS-CoV-2, achieving higher accuracy and identifying key predictive properties.	Drug effect studies are constrained by individual variations, small sample sizes, short-term focus, and ethical concerns in vulnerable populations.	Drug response datasets	Machine learning	[5]
SARS-CoV-2	They developed a machine-learning framework using random forests to predict drug effects on SARS-CoV-2, integrating compound properties and network features.	SARS-CoV-2 research faced challenges from rapid virus evolution, incomplete data, small sample sizes, inconsistent testing, and limited long-term safety assessment of vaccines.	Drug-target interaction datasets	Machine learning & Deep learning	[6]
Zika virus	The study evaluates an ensemble model's performance using key metrics and K-	The ongoing Zika outbreak, with no available vaccine, poses significant health risks,	Vaccine trail datasets	Machine learning	[7]

	Fold Cross-Validation, demonstrating its robustness and real-life applicability.	particularly in third-world countries, making vaccine development a top priority.			
Disease Diagnosis Errors	95% accuracy in detecting pneumonia	Requires larger dataset for diverse cases	CheXNet (Chest X-ray dataset)	Deep Learning (CNN)	[8]
Data Privacy Breach	Improved encryption methods reduce risks	Ethical concerns remain	HIPAA compliance models	Federated Learning	[9]
AI Bias in Diagnosis	88% accuracy, bias in certain demographics	Needs unbiased training data	MIMIC-III	Explainable AI (XAI)	[10]
Cyber security Threats	92% malware detection accuracy	Evolving cyber threats require updates	Hospital network logs	Machine Learning (Anomaly Detection)	[11]
Incorrect Treatment Suggestions	90% recommendation accuracy	Requires human oversight	Med-BERT	NLP for clinical text	[12]
Radiology Image Misinterpretation	96% accuracy in tumor detection	Black-box AI issue	LIDC-IDRI, ImageNet	CNN + Transfer Learning	[13]
EHR Data Misuse	Improved patient data security	Struggles with interoperability	Electronic Health Records (EHR)	Blockchain AI	[14]
Medication Error Detection	94% precision in adverse event detection	Dataset bias affects performance	FAERS Database	NLP + Machine Learning	[15]
AI-Assisted Surgery Risks	89% success in robotic surgery	Requires real-time adaptation	Da Vinci Surgical System	Reinforcement Learning	[16]
Predicting Disease Outbreaks	Early detection of COVID-19 trends	Needs integration with real-time data	WHO & CDC data	Time Series AI Models	[17]
Mental Health Chatbot Limitations	85% accuracy in depression detection	Limited emotional understanding	Social Media Sentiments Dataset	NLP (Sentiment Analysis)	[18]

AI-Driven Drug Discovery	80% success in identifying drug candidates	High computational cost	DrugBank, PubChem	Generative AI	[19]
Insurance Fraud Detection	97% fraud detection accuracy	Adversarial fraud tactics	Medical claim datasets	Machine Learning (SVM, Random Forest)	[20]
Patient Monitoring Errors	93% accuracy in detecting anomalies	Requires continuous data collection	Wearable device data	IoT + AI	[21]
AI Chatbot Misdiagnosis	86% accuracy in basic consultations	Lacks human-like reasoning	Healthcare Chatbot Logs	NLP + Knowledge Graphs	[22]

3. Challenges and Limitations

Despite its transformative potential, the integration of AI into healthcare encounters several significant obstacles that must be addressed for widespread adoption: Data Privacy: The risk of breaches and unauthorized misuse of Electronic Health Records (EHR) remains a critical concern, as vast amounts of sensitive patient information are processed by AI systems [9, 15]. Patients depend on encryption and secure data-handling protocols such as those from Federated Learning to protect their personal health data from being exposed because exposure would decrease trust in AI-driven solutions.

Ethical Issues: AI models containing built-in biases cause ethical problems resulting in systematic mistreatment of different population segments because of unclear decision processes [10]. When training data primarily stems from particular populations algorithm development produces models that provide substandard services to other groups thus damaging healthcare provider and patient trust. Regulatory Gaps: Non-existent and incomplete regulatory protocols hinder the deployment of AI in the healthcare [9, 21]. Present-day regulations frequently are after present technological developments, leavings uncertainties regarding obligation, security requirements, and licensing processes, which hinders the implementation of latest artificial intelligence devices in clinical use.

Resource Constraints: Scalability of AI solutions faces two barriers that stem from high computational expenses and scarce extensive datasets [18, 19]. Advanced medical and monitoring systems need substantial financial and infrastructure support for maintenance and development yet these resources might exceed affordable budgets of healthcare facilities serving limited regions or resource-limited areas.

4. Future Scope

Advancing Fair and Interpretable AI Models: The mission of AI developers should focus on creating unbiased systems and decision explanation functionality for delivering equitable healthcare to all patients. The implementation of algorithms for medical practice needs better training data that captures global patient demographics and clear AI explanation techniques to develop trust throughout healthcare sectors for fair treatment access.

Improving Real-Time Data Integration for Epidemic Forecasting: Scientists should work on improving AI systems to process real-time data from wastewater monitoring and public health reports because this would enhance disease outbreak forecasting effectiveness [17]. AI solves pandemics through real-time time-series analysis of IoT data which enables early notification systems while assigning assets effectively. Bolstering

Data Security with Innovative Technologies: The development of collaborative AI requires essential enhancement of privacy-preserving methods which include Federated Learning (FL) and blockchain because they ensure patient data protection [9, 14]. Future research should develop integrated solutions which unify these technologies with encryption methods to fulfill regulatory compliance standards of HIPAA and GDPR along with data protection measures.

Broadening AI Applications in Tailored Healthcare and Mental Well-being: Artificial intelligence's contribution to the personalized medicine and mental health support holds a huge potential [18, 21]. This involves creating personalized treatment plans tailored to an individual's genetic and lifestyle profile, and improving AI-powered tools, such as chatbots, for empathetic, real-time mental health interventions to meet the increasing need for accessible care.

5. Conclusion

Artificial Intelligence is currently at an interesting phase within healthcare when it claims better diagnostic test tools and enhanced treatment results along with more streamlined business operations. Healthcare equipment that puts predictive modeling and advanced image analytics together discovers medical troubles before they happen and in turn therapeutic treatments are tailored according to the individual and automation allows the healthcare professionals to focus more on the patient than them being bogged down with administrative tasks. The deploying field holds incredible opportunities because medical professionals can diagnose cancers improperly free of and the health system can service more customers through expense diminutions. We cannot reliably forecast this promising escape because its certainty is still unclear. Three major obstacles remain: patient data has to be firewall-protected from breaches and questions arise around ethic of algorithm-based medical decisions while regulations governing these technologies remain in most cases unsatisfactory.

The processing of large medical datasets by institutions makes personal information worthless for unauthorized parties thus leading to trust breakdown. Data-learning processes that occur through biased information will cause systems to overlook specific groups leading to undesirable results. The entities involved face unspecified consequences when devices malfunction because the framework of laws remains nonexistent. These major issues become obstacles because appropriate solutions have not been found which could stop the advancement of technology. Research performed for this paper establishes that AI requires examination of both beneficial and detrimental elements for establishing its success pathway. Scientific work systems require medical expertise to establish clinical settings and legislative enforcement of safety protocols for their advancement. Healthcare development with AI technology necessitates appropriate digital evolution that leads to advanced services for all without any exclusion of benefits. The study serves as a starting point that motivates medical scientists and healthcare providers to work together constantly for implementing AI benefits and circumventing possible risks.

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