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Review Article

Advancing healthcare: the role and impact of AI and foundation models

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Abstract: Background: The integration of artificial intelligence (AI) into the healthcare domain is a monumental shift with profound implications for diagnostics, medical interventions, and the overall structure of healthcare systems. Purpose: This study explores the transformative journey of foundation AI models in healthcare, shedding light on the challenges, ethical considerations, and vast potential they hold for improving patient outcome and system efficiency. Notably, in this investigation we observe a relatively slow adoption of AI within the public sector of healthcare. The evolution of AI in healthcare is un-paralleled, especially its prowess in revolutionizing diagnostic processes. Results: This research showcases how these foundational models can unravel hidden patterns within complex medical datasets. The impact of AI reverberates through medical interventions, encompassing pathology, imaging, genomics, and personalized healthcare, positioning AI as a cornerstone in the quest for precision medicine. The paper delves into the applications of generative AI models in critical facets of healthcare, including decision support, medical imaging, and the prediction of protein structures. The study meticulously evaluates various AI models, such as transfer learning, RNN, autoencoders, and their roles in the healthcare landscape. A pioneering concept introduced in this exploration is that of General Medical AI (GMAI), advocating for the development of reusable and flexible AI models. Conclusion: The review article discusses how AI can revolutionize healthcare by stressing the significance of transparency, fairness and accountability, in AI applications regarding patient data privacy and biases. By tackling these issues and suggesting a governance structure the article adds to the conversation about AI integration in healthcare environments.

Keywords: Foundation AI models, precision medicine, machine learning, deep learning, AI interventions, healthcare

Introduction

As Artificial intelligence (AI) tries to transform healthcare, obstacles remain. Research carefully points out potential roadblocks, such as the public sector's slow progress in implementing AI, and raises concerns about how equally its benefits should be distributed [1]. These difficulties highlight the necessity of integrating AI in healthcare with care and ethics [1]. Analyzing the moral issues raised by the use of AI assistance technology in healthcare settings, especially when it comes to their potential to replace human care, is one of the focuses of this study [2].

As technologies grew faster and wider with great advancement, AI in biomedicine is still in its early stages; however, future developments and discoveries should spur the field and broaden the spectrum of applications [3]. The subset of AI known as machine learning (ML), has especially intriguing applications in diagnostics. These technologies can quickly and accurately evaluate large amounts of medical data to find patterns, spot anomalies, and help diagnose diseases. These technologies have the substantial power to revolutionize the healthcare domain, healthcare management, and medical facility optimization. This can reduce the cost more efficiently and enhance the patient experience through resource allocation [4]. Healthcare systems globally encounter various challenges, including escalating disease-related costs, operational inefficien-

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cies, and constraints on resources. Focusing on the transformative potential of AI and ML, this study also explores how these technologies could adeptly address such issues. It highlights the significance of ML in enhancing health systems through the identification of concealed patterns in data [5]. The sustained advancement of AI and its growing impact are exemplified by a decline in self-references. This trend indicates an openness to change in the industry and reflects a flexible and inclusive approach to the advancement of AI [6].

In this review, we will explore the applications of AI and foundation models for effective diagnosis and prediction systems using various processing methodologies and algorithms.

The evolution of Ai in healthcare

The pursuit of non-biological intelligence transcends the inception of AI in 1956 [7]. Initially, the focus was on "designing" cognitive abilities, a perspective that evolved with Charles Darwin's fundamental work in 1859, which revealed that intricate and adaptive designs can organically emerge through the process of natural selection acting on random variations [7]. In the realm of healthcare, researchers and healthcare professionals are actively shaping regulations to enhance public access to cost-effective healthcare services through the integration of AI technologies [8]. The expansion of AI-based healthcare firms is expected to increase the availability of information, thereby augmenting the areas recommended for further study [8]. Notably, cancer-related research takes precedence, followed by heart diseases, stroke, vision Impairment, Alzheimer's, and depression, offering light on the primary focus areas within AI research in healthcare. A key insight identifies a gap in research on AI applications for high-burden diseases, providing directions for future AI research in healthcare [9].

Understanding foundation Ai models

The advent of foundation models like BERT, DALL-E, and GPT-3 marks a revolutionary shift in AI, with these models being trained on enormous datasets and applicable to a variety of downstream applications [10]. Artificial intelligence is defined as acomputer system capable of performing activities normally associated with human intelligence. This requires developing algorithms and models that enable machines to learn from data, analyze it, make decisions, and solve problems [10]. Subfields of AI include machine learning, natural language processing (NLP), computer vision, and robotics. ML algorithms, trained on large datasets to identify patterns and generate predictions or decisions. NLP aids in understanding and interacting with human language, while computer vision (CV) involves the development of algorithms enabling machines to comprehend and interpret visual data. Robotics integrates AI with physical systems to create intelligent devices capable of real-world interaction [10]. The ethical consideration of using LLM models in healthcare poses challenges, requiring careful attention to prevent the dissemination of misinformation and the propagation of harmful contents [11].

AI in medical interventions

AI in healthcare refers to the advancement of technologies like Machine learning and Deep learning that are being used to analyze, assist, and detect the medical aspects of diseases and their interventions [12]. This emphasizes AI's transformational power across all domains of medicine, including but not limited to basic science, clinical practice, healthcare management, and financial elements. The core concepts of Machine learning, in which the computer learns from the data to make decisions, and describe how Artificial Neural Networks are used in the field of Deep learning to extract important insights from enormous datasets and to assist physicians in patient care [12]. **Table 1** Illustrates the comprehensive overview of various ML and DL models used in the healthcare. Artificial intelligence has the capacity to affect healthcare on numerous levels, including fundamental research, clinical practice, the administration of healthcare, and financial components. It also has the potential to improve resource usage, decision-making, and patient outcome [12]. With applications in radiology, pathology, genomics, and personalized medicine, artificial intelligence is becoming more and more prevalent in the healthcare industry [12]. Artificial neural networks, which focus on clinical tasks including diagnosis, prognosis, and survival analysis, are vital to supporting medical decision-making [13].

Table 1. Characteristics of included study

Author	Year	Title	Research Objective	Study Results	Future Directions
Kirill Dyagilev [58]	2015	Learning (Predictive) Risk Scores in the Presence of Censoring due to Interventions	Proposed ranking-based framework for disease severity score learning that can track changes in the severity, especially when there is therapy-related censoring.	It was shown using simulated datasets that DSSL outperforms other approaches in terms of generalization to changes in treatment patterns.	Examine the use of active learning in domains were, obtaining a large number of clinical comparison pairs.
Sarah A. Graham [59]	2019	Artificial Intelligence for Mental Health and Mental Illnesses: An Overview	Using artificial intelligence to classify, predict, or identify mental health disorders.	Shown high accuracy and the potential of using machine learning algorithms in mental health care and customize treatments based on certain traits.	Investigate how AI and human intelligence may collaborate to ensure accuracy and decrease potential errors.
Hongfeng Li [60]	2021	Skin disease diagnosis with deep learning: a review	Provide a conceptual analysis and in-depth assessment of current deep learning detection models.	Determined the difficulties and current uses in the diagnosis of skin diseases.	Integration of multimodal data sources, such as clinical information and genetic data, to enhance skin disease diagnosis with DL.
Michael Tran Duong [61]	2019	Artificial intelligence for precision education in radiology	AI framework to enhance radiology education by tailoring instruction to individual.	Guided decision-making can enhance individual trainees' decision-making skills, increasing the quantity and quality of case training.	Explore the full potential of AI in enhancing radiology education.
Bradley J. Erickson [62]	2017	Machine Learning for Medical Imaging	Explore the use of machine learning in medical imaging to detect trends and aid in medical diagnosis.	Machine learning has shown comparable accuracy to medical practitioners in recognizing multiple conditions from medical photos.	Continued research into DL approaches in medical imaging to optimize the benefits of feature detection.
Moor [23]	2023	Foundation models for generalist medical artificial intelligence	Enable GMAI models to interpret various medical modalities and produce advanced medical outputs.	Generalist medical AI algorithms are suggested to carry out various medical tasks with minimum task-driven data labelled.	Explore the potential of GMAI models in solving tasks with limited data.
Zeeshan Ahmed [36]	2020	Artificial intelligence with multi-functional machine learning platform development for better healthcare and precision medicine	The main aim of this paper is to analyze and explore various AI and ML methodologies, and viewpoints in healthcare to promote scientific solutions.	The use of precision medicine can enhance standard symptom-driven medical care by enabling previous interventions.	More research is required to develop academic solutions, opening the path for a new data-centric era of innovation in healthcare.
Stein JD [63]	2019	Evaluation of an algorithm for identifying ocular conditions in electronic health record data	The aim of this project is to design an algorithm that could examine both structured and unstructured EHR data for exfoliation syndrome (XFS).	The algorithm accurately identified the majority of patients with and without XFS among 122,339 eye care recipients, demonstrating the potential for similar algorithms to identify other ocular disorders and improve research applying big data.	Further research should focus on enhancing the methodology to detect additional ocular disorders besides XFS in EHR data.
Wong [64]	2018	Machine learning classifies cancer	Improve Cancer Diagnosis through Machine Learning.	Machine learning algorithms are effectively used to identify cancer types, assisting doctors in predicting diseases such as breast, lung, and liver cancer based on medical records and improve the treatment of patients.	Explore the potential of utilizing DNA methylation changes for accurate tumor classification.
Chunyu Wu [65]	2023	The future application of artificial intelligence and telemedicine in the retina: a perspective	The primary objective of the study is to examine the existing research and use of AI, telemedicine, and home monitoring devices in retinal conditions, and propose a future model for incorporating AI and digital technology in this field.	AI-based image analysis has been extended to DR, AMD and ROP showing promising results in the diagnosis and monitoring of these conditions.	The study further suggests deploying digital health solutions with technology and technical needs, such as smartphone-based fundus photography utilized in an automated AI DR screening programme in India, that has shown great accuracy in detecting DR.

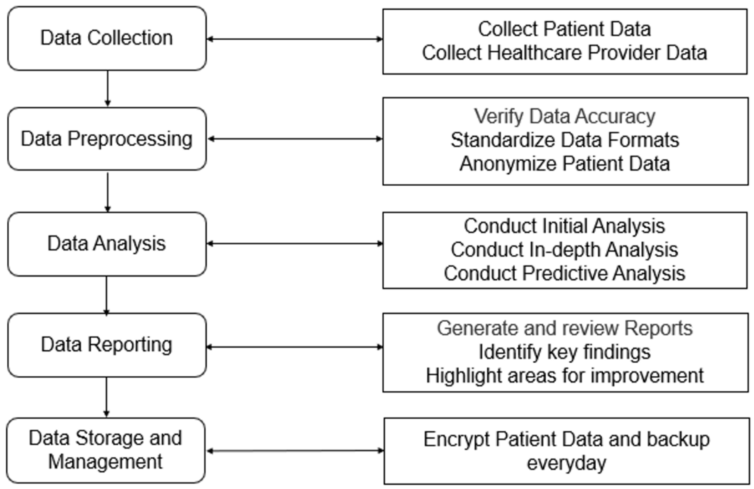

Figure 1. Managing healthcare data workflow.

Advancements in precise medical treatments and surgery have been made possible by the progress in robotics applications within the healthcare industry [14]. To overcome challenges and maximize AI's benefits in the healthcare industry, this continuous evolution and work is crucial. Additionally, fatigue-related concerns have been eliminated [14]. Exploring the advancements in AI and machine learning for accurate diagnosis and prognosticating patients' future health has real consequences for improving healthcare outcomes [14, 15]. The algorithms used produced positive outcomes in administrative operations in healthcare, streamlining processes and minimizing manual labor [15]. Precision medicine can benefit from AI by using it to anticipate therapy protocols based on patient characteristics and the treatment context. **Figure 1** Represents the data workflow pattern that are to be carried out. Through data analysis and pattern identification, artificial intelligence may change the healthcare business by enhancing diagnosis, treatment, and patient outcomes [15].

This study presents a ground-breaking and comprehensive overview of the use of generative AI in healthcare, with a focus on transformers and diffusion models [16]. These diffusion models can be worked on in various areas like medical imaging, clinical recording, diagnostic help, and medication design [16]. The two types of generative AI models in healthcare are diffusion models and transformer-based models. Generative AI models are used in a variety of medical imaging applications, including image reconstruction, image-to-image translation, image development, and categorization of images [16]. Beyond imaging, these models help with clinical decision support, radiological interpretation, and medical coding and invoicing, resulting in better medical decisions and data restoration [16]. Furthermore, generative AI plays an important part in protein structure prediction, allowing for a better knowledge of molecular representation and assisting in medication design [16]. The "curse of dimensionality" makes accurate forecasts difficult, although machine learning is useful in forecasting illness risk based on patient genetic data [17]. Machine learning models become more generalizable when important features are extracted and irrelevant ones are removed through the use of feature selection techniques [17]. There are many feature selection techniques, each with unique benefits, drawbacks, and applications. One technique that stands out is the identification of pertinent features (such as SNPs) that are essential for predicting the risk of an illness [17]. When choosing relevant features for a multivariate filter, MIFS (Mutual Information Feature Selection) draws into account the mutual information between the characteristics and the target variable [17]. A multivariate filter method called Fast Correlation-Based Filter removes duplicate features based on their correlation with other features and evaluates the relevance of each feature by looking at how it correlates with the target variable [17]. Using simulated datasets, the study carefully identifies scenarios in which neural network analysis outperforms Cox regression modeling [18]. The results refute the conventional wisdom that neural network analysis is a complex and enigmatic technique, highlighting its capacity to provide insightful information on survival analysis [18]. The deep convolutional neural networks play a key role in medical imaging applications, which include tasks such as the detection of prostate cancer, and identification of metastases or mitosis in breast cancer, which make them important for the foundations of artificial intelligence [19]. Transfer learning further enhances the capabilities of these models by fine-tuning established deep neural networks initially trained on extensive datasets of non-medical images with a vast collection of biomedical images [19].

Autoencoders, particularly performing sparse autoencoding with sparing constraints and hidden layers of thousands of neurons, have been shown to be efficient in extracting features for classification. Recurrent neural networks excel at processing time-series data, and deep feedforward neural networks with multiple hidden layers excel at modeling complex relationships between inputs and outputs [19]. This cluster of crucial AI models exhibits the flexibility of fake insights in addressing different challenges inside the restorative space. The integration of exchange learning, autoencoders, repetitive neural systems, profound feedforward neural systems, and profound remaining neural systems collectively illustrates the potential of custom fitted AI models for different therapeutic applications [19]. This study builds on previous studies by examining the applications of AI in clinical decision-making and data management quality in healthcare [20]. Personalization of the treatment pathway for each patient, achieved through analysis of medical history, genetic data, and treatment response, provides a targeted intervention approach. In the area of clinical decision-making, it is important to develop reliable AI healthcare products [20]. The establishment of a supervisory authority is important for the necessary checks and balances. Particularly, ChatGPT is recognized in the medical community for its capabilities, as evidenced by its ability to pass the U.S. Medical Licensing Examination [21]. Large-scale language models like ChatGPT are poised to transform not only the healthcare industry but also a variety of fields. From streamlining administrative tasks to improving diagnostic accuracy and fostering patient engagement, it can serve as a valuable co-pilot tool for doctors. Its role extends to interpreting, summarizing, and completing reports, enhancing healthcare accessibility and effectiveness, and ultimately improving the accessibility and efficiency of the healthcare system [21, 22]. The integration of large-scale language models into healthcare not only provides peace of mind for healthcare professionals, but also contributes to the overall improvement of patient care within healthcare organizations [22].

Prudence, however, is necessary when contemplating the implementation of ChatGPT and similar models. A careful assessment is necessary to identify possible weaknesses such as inaccuracies, the possibility of fake knowledge, and ingrained prejudices [22].

General Medical AI (GMAI) is a revolutionary concept that uses flexible and reusable AI models to address medical issues without task-specific labeled data [23]. Recent core paradigm research advances like multimodal architectures, self-supervised learning strategies, and contextual learning capabilities, have the potential to transform the field. These methods refine GMAI models to understand a variety of medical modalities and produce exact results [23]. Self-monitoring is needed to overcome task-specific data restrictions. This proposal shows possible GMAI applications in several medical fields.

These programs analyze medical imaging, electronic health data, laboratory findings, genetics, graphics, and medical literature with advanced medical reasoning. GMAI's adaptability makes it a revolutionary force that can help the healthcare industry's complicated problems [23]. Maintaining and certifying AI systems for medical applications may be tough. In order to support GMAI-enabled applications, large medical datasets must be acquired using modified methods [23]. International medical advocacy organizations must expand their focus beyond finance and corruption. These organizations should aggressively push sanctions on dictators who support western military ambitions [24] in order to enhance global health by addressing the root causes of poverty and illness. Strong health systems and open governance are also stressed for improved living [24]. Forecasting algorithms use AI as a breakthrough tool. These models use AI algorithms trained on past data to find patterns and trends to make accurate forecasts. AI prediction models are useful in healthcare for predicting illness development, identifying high-risk people, and prioritizing therapy regimen [24]. Forecasting algorithms use AI as a breakthrough tool. By using AI algorithms trained on historical data to find patterns and trends, these models can accurately predict disease progression, identify high-risk individuals, and focus treatment regimens [24]. These diverse AI applications show the technology's versatility and influence across many industries, especially healthcare [24]. The study urges physicians and patients to learn data literacy and promotes training. AI can cut costs, shorten wait times, and improve patient care. It addresses public concerns and anxieties over AI used to help governments and healthcare institutions create appropriate laws and is a comprehensive resource for AI practitioners and researchers [25].

AI in healthcare: past, present and future

By using expanding amounts of medical data and enhanced analytical tools, artificial intelligence (AI) is transforming the face of healthcare, particularly inthe disease categories of neurology, heart disease, and cancer [26].

Important applications of artificial intelligence (AI) can be found in stroke treatment, with an emphasis on early detection, treatment, outcome prediction, and prognostic assessment. AI may exert an even larger effect on healthcare, with real-world ramifications for a wide range of those who are involved [27]. Medical professionals will benefit from better patient care, improved treatment results, and a more precise predictive outcome, particularly in conditions like stroke. The 4,444 patients in one study will also benefit from AI-powered healthcare systems by being provided with improved health monitoring, individualized treatment regimens, and quicker and more accurate diagnoses [27]. Although AI has the potential to revolutionize healthcare, there are currently obstacles to its practical implementation. Successful implementation of AI technology in healthcare will require overcoming several significant difficulties, including integrating AI into present medical care, resolving legal disputes, and guaranteeing data privacy and security [27, 28].

Diverse types of Ai models

Artificial intelligence (AI) within the health care sector involves a broad range of technologies and applications that employ AI to enhance many aspects of the healthcare setting. Here are a few uses of AI in the medical field.

Natural language processing

Natural language processing (NLP) is an advanced field that uses foundation models in cardiology, pathology, ophthalmology, and radiology. This emphasizes the significance of factually-aware contrastive learning and section segmentation in improving radiology report comprehension, drawing on relevant studies involving models such as Bidirectional Encoder Representations from Transformers (BERT) and Robustly Optimized BERT Approach (RoBERTa) for medical record and radiology report classification [29]. It also demonstrates how transformer-based language models, as established by RadBERT (Radiology Bidirectional Encoder Representations from Transformers), can be used in radiology. By considering enhanced text categorization, improved hospitalization prediction, and the use of pre-training approaches such as BERT and RoBERTa, the publication gives vital insight for researchers and practitioners [29]. With the ability to analyze large amounts of radiology text data more accurately and efficiently, one can enable pre-training techniques, improve feature representation and prediction accuracy, allow for fine-tuning, and enable natural language understanding [29]. Beyond natural language processing, artificial intelligence (AI) in radiology also encompasses image analysis, automated report generation, workflow optimization, support for clinical choices, and predictive analytics - all of which are revolutionizingdiagnosis and patient care [29]. The implementation of foundation models in radiology can facilitate a range of surgical applications, increase the precision of text categorization, and improve comprehension of radiology reports [29].

Machine learning

In healthcare research, machine learning, a subset of AI, has proven to be a useful tool. ML uses real-world data to forecast outcomes and classify discoveries using models taught by humans [30]. It has a wide range of uses and significantly enhances healthcare operations. Databases, research methods, and electronic medical records all benefit from improved data quality and quantity thanks to machine learning [30]. Statistical models and algorithms are used to enable computers to draw insight from data and make predictions or assumptions without needing to be explicitly programmed

[31]. Machine Learning algorithms can analyze large amounts of patient data, such as genetic data (DNA), electronic health records, and imaging to detect trends, make diagnoses, gather results, and personalize treatment regimens. Predictive analytics, risk assessment, and public health management are further uses of machine learning that help healthcare organizations improve patient outcomes, safety, and efficiency [31].

Medical robots

AI-based medical robotics includes a range of products, including self-governing patient care systems, recuperation aids, and machine-assisted surgical robots. These robots, especially the AI-assisted surgical robots, use pre-operative medical record analysis to provide real-time guidance to operators during procedures [31]. They are frequently employed in laparoscopic, orthopedic, and neurologic surgical treatment. The low-risk nature of surgical procedures performed with robots reduces complications, errors, and hospital stays when compared to traditional treatments [31]. In addition to surgery, robots assist in the delivery of emergency medications, geriatric care, and stroke rehabilitation [31].

Deep learning and neural network

In ophthalmology, deep learning (DL) has become an indispensable technique used in medical imaging and decision-making. In this field, deep learning techniques and algorithms are used on fundus photos and large datasets to build AI systems that can recognize and classify a range of ocular conditions [32]. DL methods in particular have demonstrated promising outcomes in the diagnosis of cataract, age-related macular degeneration, glaucoma, and diabetic retinopathy with improved accuracy and efficacy in sickness identification [32]. Though many AI prototypes have been developed, only a few have found practical use. It is essential to address concerns such as security, privacy, limited mass distribution, trust, and explaining ability [32]. Deep learning makes a variety of contributions to disease diagnosis. It can analyze vast volumes of medical data, including photos, and recognize complicated patterns that human observers cannot see [32]. One notable application is the automated interpretation of medical images, such as fundus scans, which may correctly identify anomalies associated with diseases such as glaucoma and diabetic retinopathy. Deep learning reinforces the reliability of medical diagnosis in two ways: distinct, objective judgments and a reduction in human error [32].

Computer vision and image processing

Computer vision and Image processing techniques are used to analyze retinal images in order to diagnose diseases. AutoMorph, an automated retinal image analysis program, is used to preprocess CFP (Colour Fundus Photography) images [33]. The technology efficiently removes the background, allowing the focus to be on the ocular area of interest. All images, both CFP and OCT (Optical Coherence Tomography), are resized to a standardized dimension of 256 × 256 using cubic interpolation to maintain consistency in the input data. This standardization allows for more efficient processing and analysis [33]. Among these are random horizontal flipping, image normalization, scaling cropped portions to 224 × 224, and random cropping with bounds set between 20 and 100. These methods broaden the training database, which enhances the generalization and overall efficacy of the model in identifying diseases [33]. Machine learning is highlighted in this paper's examination of AI applications in medical microbiology image analysis in order to process diverse forms of microbiologic image data. AI algorithms are intended to automate tasks previously handled by microbiologists, such as classifying colony growth and recognizing diseases. According to the findings, when microbiologists and AI collaborate. Image-based AI analysis is a cost-effective solution for both local and digital diagnostics, paving the way for additional diagnostic capabilities [34].

Large language models (LLM) and foundation models in electronic medical record (EMR)

The potential application of LLM models in electronic medical records (EMRs) to improve patient care and hospital efficiency has piqued the interest of researchers [35]. ChatGPT and AlphaFold are two examples of these models. The models stated above have been trained on clinical text and structured data from non-imaging EMRs, and they are highly proficient at

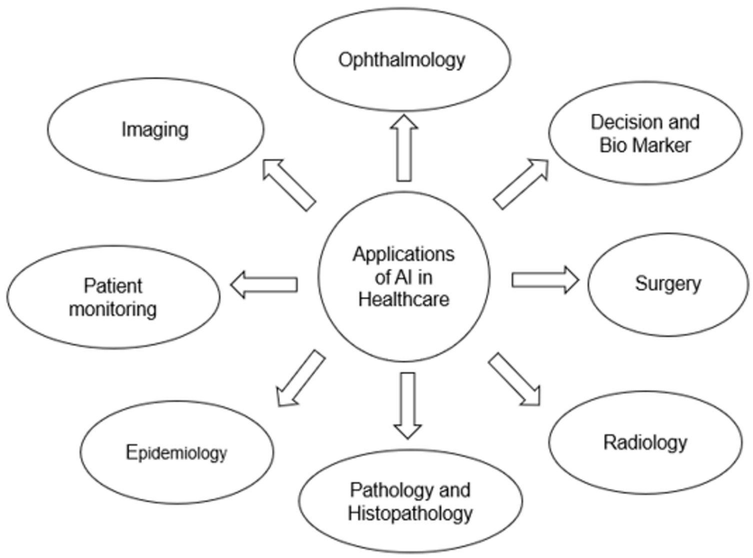

Figure 2. Applications of AI in healthcare.

decoding and interpreting medical notes, summary discharge summaries, and patient histories. Their utility includes coding, clinical recording, and record summarization, among other tasks, and has the potential to improve accuracy and efficiency in healthcare operations. More in-depth assessments of these models' usefulness in healthcare systems are thus required, as the current examination of these models inside EMRs is limited and generally based on tiny or widely-scoped datasets [35].

Precision medicine

Through the use of better diagnoses, more affordable medicines, and earlier interventions, precision medicine enhances standard practice. Machine Learning (ML) uses comprehensive patient data to distinguish between various medical diseases [36]. The use of electronic health records and the integration of several data sources are essential for an effective deployment. In order to optimize doctor decision-making and patient classification, precision medicine employs multipurpose machine learning systems for data collection, aggregation, management, and analysis [36].

Practical applications of AI

Artificial intelligence (AI) has become a major force in several sectors, including medical care, because of the availability of labeled big data, increased processing power, and cloud storage [37]. The two most common activities in the field of healthcare are image processing and diagnostic imaging, both of which have practical implications for artificial intelligence. Healthcare makes extensive use of deep learning techniques, for a variety of purposes [38]. Smart companion robots powered by AI can assist the elderly with everyday duties, equipment control, home automation, detection of safety and well-being, and emergency guidance in the outside world [39]. Using facial recognition models and speech data, these robots improve research on the health status of the elderly [39]. **Figure 2** Represents the Use case of AI and its application in healthcare.

Diagnosis and prediction

A comprehensive understanding of the disease and assistance with early detection can be obtained by integrating many high-dimensional data sources, including metabolite profiles, protein markers, and genetic data, through the use of machine learning [40]. To identify early indicators of neurodegenerative diseases, machine learning algorithms can analyze and interpret medical images such as CT and MRI scans, which is known as medical image interpretation [40, 41].

AI in ophthalmology

VisionFM is an AI model that can perform various ophthalmic tasks, including disease screening, diagnosis, and prognosis. It outperforms ophthalmologists in diagnosing twelve common diseases and accurately grades diabetic retinopathy using OCTA images, accelerating clinical decision-making and management [42]. In comparison to manual grading systems, the study compares two screening methods: a fully-automated model and a semi-automated DLS-based model, showing that both approaches are equally successful and economical in identifying DR [43]. Artificial intelligence algorithms can classify retinal color fundus images and discriminate between diabetic macular edema, diabetic retinopathy, and diabetic retinopathy that threatens vision with high sensitivity and precision [44]. This device, with early detection and care, has the potential to reduce preventable blindness in African populations with limited resources. AI models can also assist human graders in identifying risk factors [44].

AI in surgery

Artificial intelligence (AI) is being used in surgery for a variety of purposes, including preoperative planning, intraoperative guiding, and integration with surgical robots [45]. AI techniques are utilized in preoperative planning for tasks including anatomical classification, detection, segmentation, and registration using medical imaging modalities like X-ray, CT, ultrasound, and MRI [45]. They also use localization and visualization techniques to enhance surgical guidance. Surgical robots are combining perception, localization, mapping, system modeling, and human-robot interaction to provide precise and self-sufficient therapies [45].

AI in decision and bio-markers

The Clinical Decision Support System (CDS) and the gold standard, as well as the physician's impression and the gold standard, were assessed for agreement using Kappa statistics [46]. The study creates biomarker risk ratings (BMRS) for common diseases using solely blood and urine biomarkers rather than DNA information. These predictors can assist in identifying individuals who are predisposed to diseases such as cancer, diabetes, hypertension, liver and kidney disorders, coronary artery disease, and hypertension [47].

AI in radiology and imaging

Artificial Intelligence approaches are ideal for creating algorithms that analyze unimodal data from images, like digital pathology or radiology images [48]. Artificial Intelligence (AI) algorithms in imaging and radiology are excellent at making clinical choices, assisting in illness diagnosis, and discovering novel patterns related to patient characteristics [48, 49]. Because of an abundance of labeled data, computer capacity, and deep learning approaches, these algorithms achieve expert-level diagnostic precision. Their proper application has the potential to significantly transform medical patient monitoring, diagnosis, and sickness screening procedures [49]. AI in radiology covers knowledge gaps in remote places where specialists are scarce. The combination of digitized data, machine learning, and technology for computing widens the breadth of artificial intelligence applications, allowing them to infiltrate domains formerly assumed to be exclusive to human professionals, such as radiology [49].

AI in pathology and histopathology

Artificial intelligence (AI) has a significant impact on digital pathology, since it enhances diagnostic support and gives light on disease biology [50]. The primary application of AI is as an image analysis tool for mechanized diagnosis, case prioritization, and the extraction of novel insights. Some implementation challenges include multi center validation, training timeframes for artificial neural networks, and implementing costs in digital pathology [50]. Deep learning in artificial intelligence (AI) surpasses pathologists in the prediction of colorectal and breast cancer outcomes, according to research [50].

Particularly in the area of oral cancer diagnosis and prognosis, artificial intelligence (AI) technologies, including machine learning and deep learning, are making major advancements in the processing of histopathologic images of cancer tissues [51]. Artificial intelligence classification systems are useful for classifying various types of cancer cells and identifying particular characteristics that indicate the presence or progression of cancer. Machine learning algorithms play a leading role in the development of models that predict the survival of patients and the recurrence in oral cancer [51]. These modifications are especially noticeable in the case of oral cancer. Machine learning and deep learning approaches, in particular, offer promise for the prognostication of patient survival and locoregional recurrences in oral squamous cell carcinomas (OSCC) [51]. Machine learning algorithms aid in the creation of predictive models by assessing digital histopathologic images of OSCC with AI technology [51].

AI in epidemiology

The ability of machine learning (ML) to manage large datasets and find patterns for patient risk stratification is the main focus of this research project, which explores ML's possible applications in healthcare epidemiology [52]. It highlights the necessity of computational methods that are compatible with machine learning (ML) for electronic health records (EHRs) and offers suggestions for medical epidemiologists who are interested in incorporating ML into their work. There are no particular ML application examples provided in the abstract [52].

Patient monitoring

Artificial intelligence (AI) is essential for remote patient monitoring through a variety of applications. It includes classifying physical activity by analyzing data from wearable devices and offering insight into patients' general health [53]. AI monitors chronic diseases by analyzing multiple data sources to identify early signs of decline and provide tailored treatment. Federated learning is used to achieve personalized monitoring by accounting for personal health factors [53]. Additionally, AI picks up on human behavior patterns and uses methods like reinforcement learning to identify abnormalities and possible health hazards early on. This improves patient outcomes in distant patient tracking systems [53]. Cloud computing, artificial intelligence (AI), and the Internet of Things (IoT) are transforming patient monitoring in the healthcare industry [54]. Real-time data collection from body sensors and devices is made possible by the Internet of Things, which makes it possible to continuously monitor health metrics and vital signs [54]. AI uses deep learning techniques to evaluate medical records from the cloud, enabling healthcare professionals to make better judgments [54]. The analysis of different patient data, including vital signs, health indicators, and activity levels, obtained via IoT devices, depends heavily on AI algorithms. AI uses deep learning to examine trends and abnormalities in this data, enabling the early diagnosis of health risks [54]. Machine learning techniques ensure that the system adapts to each patient's specific needs and increases forecast accuracy by allowing AI to constantly gain insight from and enhance its analysis [54].

Ethics and governance in AI

This guidance tackles opportunities and challenges in the healthcare system by providing insights on the use of artificial intelligence (AI) in healthcare data. The variety of electronic health record (EHR) data is covered, as are issues relating to different data types, time periods, and sample rates [55]. The limitations and prejudices in data collection are examined, as well as confounding effects and healthcare worker preferences [55]. The ethical aspects of AI in healthcare, provide a comprehensive summary of current debates and identify areas for future research. Ethical risks related to AI in the healthcare sector are classified into cognitive, normative, or traceability areas [56]. These risks manifest at multiple levels of abstraction, including the individual, interpersonal, group, institutional, and societal or industry levels. These considerations are meticulously mapped to the existing literature and classified into cognitive, normative or traceability related categories, depending on the level of abstraction involved [56]. The need to avoid the risk of eroding public trust in the benefits of AI for healthcare is of utmost importance. This erosion of public trust, dubbed "AI Winter", can lead to reluctance or skepticism toward AI technologies in healthcare. To ensure that AI continues to transform healthcare, it must be accompanied by proactive ethical considerations and actions in order to maintain public confidence in its transformational potential [56]. In the proposed governance paradigm, fairness, openness, trustworthiness, and accountability are the four key elements. It highlights how crucial it is for AI models used in healthcare to be transparent and explainable, and how important it is to educate healthcare providers about AI in order to foster a culture of trust and empower them to actively participate in the control of the technology [57].

Limitations of Ai adoption in health care

Developing an AI system for healthcare has challenges such as data privacy and security, potential biases in data openness, restrictions, and a lack of understanding. Along with these challenges, AI applications in healthcare must address issues such as data quality, system compatibility, expertise deficits, infrastructure limits, and expense considerations. By recognizing and overcoming these challenges, healthcare organizations may empower developers, and researchers, to pave the way for a future in which AI efficiently integrates into healthcare systems.

Discussion

This review paper provides a comprehensive overview of the evolving landscape of artificial intelligence applications in healthcare. It highlights the transformative potential of AI across various domains, including diagnosis, patient monitoring, surgery, pathology, and epidemiology. By synthesizing information from diverse sources, the paper offers valuable insights into the current state of AI in healthcare and its implications for clinical practice, research, and healthcare delivery.

The strength of the paper is its wide coverage, encompassing a wide range of AI technologies and their applications in different medical specialties. From natural language processing and machine learning to computer vision and deep learning, the paper explores the diverse array of AI techniques being leveraged to improve healthcare outcomes. By discussing practical applications in areas such as radiology, ophthalmology, and pathology, the paper illustrates the benefits of AI in enhancing disease diagnosis, treatment planning, and patient care.

Moreover, the paper acknowledges the ethical and governance considerations inherent in the deployment of AI in healthcare. It recognizes the importance of transparency, fairness, and accountability in AI systems, particularly concerning patient data privacy and algorithmic biases. By addressing these ethical concerns and proposing a governance framework, the paper contributes to the ongoing dialogue on responsible AI implementation in healthcare settings.

However, the paper is not without limitations. While it provides a broad overview of AI applications in healthcare, it may lack depth in certain areas, potentially overlooking specific challenges or controversies. A more systematic methodology and critical analysis of the quality and diversity of the existing literature will ensure a balanced representation of perspectives, and considering a wider range of literature sources is recommended.

Overall, the review paper serves as a valuable resource for researchers, practitioners, and policymakers interested in the intersection of AI and healthcare. By synthesizing existing knowledge and identifying areas for future research and development, the paper contributes to advancing the understanding of AI's role in transforming healthcare delivery and improving patient outcomes.

Conclusion

AI integration in healthcare has immense potential, but it also raises issues and worries about ethics. Taking care of these difficulties is crucial to reaching AI's full potential in healthcare. The study emphasizes the significance of ongoing research and development in order to maximize its benefits. AI models can be used in a variety of difficult medical activities, including neurology, cardiovascular illness, and cancer. However, real operational problems, legal complications, and data privacy issues persist. The research advocates for a focus on data literacy to address social concerns and anxieties about AI adoption. It also emphasizes the importance of governments and healthcare organizations adopting appropriate legislation as well as providing opportunities for training and education. The study acknowledges AI's promising future in healthcare, but highlights the importance of overcoming present obstacles to its widespread and ethical adoption.

Disclosure of conflict of interest

None.

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