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The Role of Artificial Intelligence in Healthcare: Applications, Challenges and Future Directions

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Abstract:
Artificial intelligence (AI) has significantly improved disease diagnosis, treatment, and patient care in healthcare. Applications include precision medicine, virtual assistants, and chatbots, which analyze vast amounts of data, identify patterns, and make predictions. These systems enable early interventions and personalized treatment plans. AI has been successful in disease diagnosis and prediction, particularly in cardiovascular, neurological, and cancer diseases. However, challenges such as data variability, quality, security, and technical issues with reproducibility and interpretability hinder its widespread adoption. The lack of labeled data in medical AI applications is a significant challenge. To overcome these challenges, careful consideration must be given to the ethical and safety implications of AI in healthcare. The future of AI in healthcare holds significant promise, with potential applications in disease diagnosis, treatment, and patient care. Addressing these challenges is essential to ensure AI systems are designed to augment human decision-making and improve patient care.

Keywords: Artificial intelligence, Healthcare, Precision medicine.

Introduction:
The field of artificial intelligence (AI) is concerned with intelligent machine learning, namely intelligent computer programs that produce outcomes akin to the human attention process [1]**.** To deal with intricate clinical problems Artificial intelligence (AI) solutions are being used more and more successfully in the processes of data gathering, analysis, and utilization. AI offers a productive way to handle enormous volumes of data more skilfully, with automation being crucial [2]**.** AI has given computer-aided drug research new life. This development is sustained by the unrestricted adoption of machine learning (ML), particularly deep learning (DL), across numerous scientific specialties as well as technological advancements in computer hardware and software, in conjunction with various facets of the problem. Computer-aided drug development has made substantial use of machine learning methods [3]. The application of AI in the pharmaceutical and biotech sectors during the past five years has revolutionized how researchers create new medications, treat illnesses, and more. Finding practical information processing issues and providing an abstract explanation is the primary goal of this artificial intelligence [4]. Therefore, the efficient use of cutting-edge technologies is required, and this has started during the past ten years with the automation of the pharmaceutical process, including the preparation and distribution of medications in community or hospital settings, to replace manual processes. The

reallocation of human resources to more valuable and patient-cantered duties, like clinical pharmacy services, has been made possible by this approach [5]. AI is already revolutionizing a number of industries, including healthcare, banking, and transportation, and its influence is only expected to increase. AI has been applied in academia to create intelligent tutoring systems, which are computer programs that can adjust to each student's unique demands. Students' learning outcomes in a variety of topics, including science and math, have improved because to these methods [6]. Healthcare is starting to use artificial intelligence (AI) and associated technologies, which are becoming more and more common in industry and society. Numerous facets of patient care as well as administrative procedures in payer, provider, and pharmaceutical organizations could be revolutionized by these technologies. Numerous studies have already suggested that AI is capable of doing as well as or better than humans in critical healthcare jobs including disease diagnosis. Algorithms are already surpassing radiologists in the detection of cancerous tumours and in assisting researchers with the creation of cohorts for expensive clinical trials [7]. Artificial intelligence (AI) in the medical field is mostly concerned with creating the methods and algorithms to assess if a system's actions are appropriate in cases of illness. Diagnosis. Medical diagnostic defines the sickness or diseases that explain a person's Symptoms and symptoms. The patient's history and physical examination are usually used to get diagnostic data. It is usually challenging because a lot of symptoms and indications are unclear and only qualified medical professionals can make a diagnosis [8]. Thus, there is appeal in automating the visually interpretive, experientially taxing processes that underpin clinical microbiology laboratory operations. Until recently, there were no possibilities for image-based Tasks involving interpretation were inadequate. But new algorithms for artificial intelligence (AI) that Excel in a picture Nowadays, discrimination makes automated clinical microbiology possible. Interpretation with corresponding increases in diagnostic precision and efficiency [9]. Effective health system management, such as the delivery of healthcare or public health, is essentially a collection of Information processing activities. To accomplish health system outputs (public health and health care services) and system goals, policymakers alter the organization, governance, financing, and resource management activities of the health system [10].

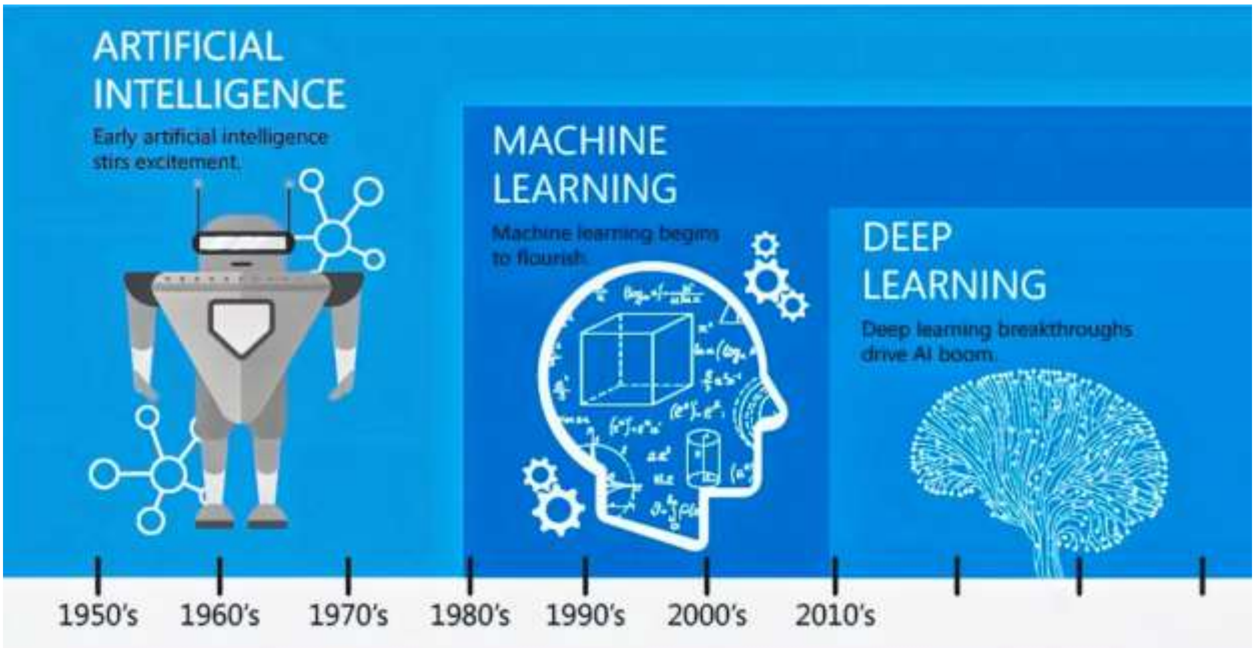
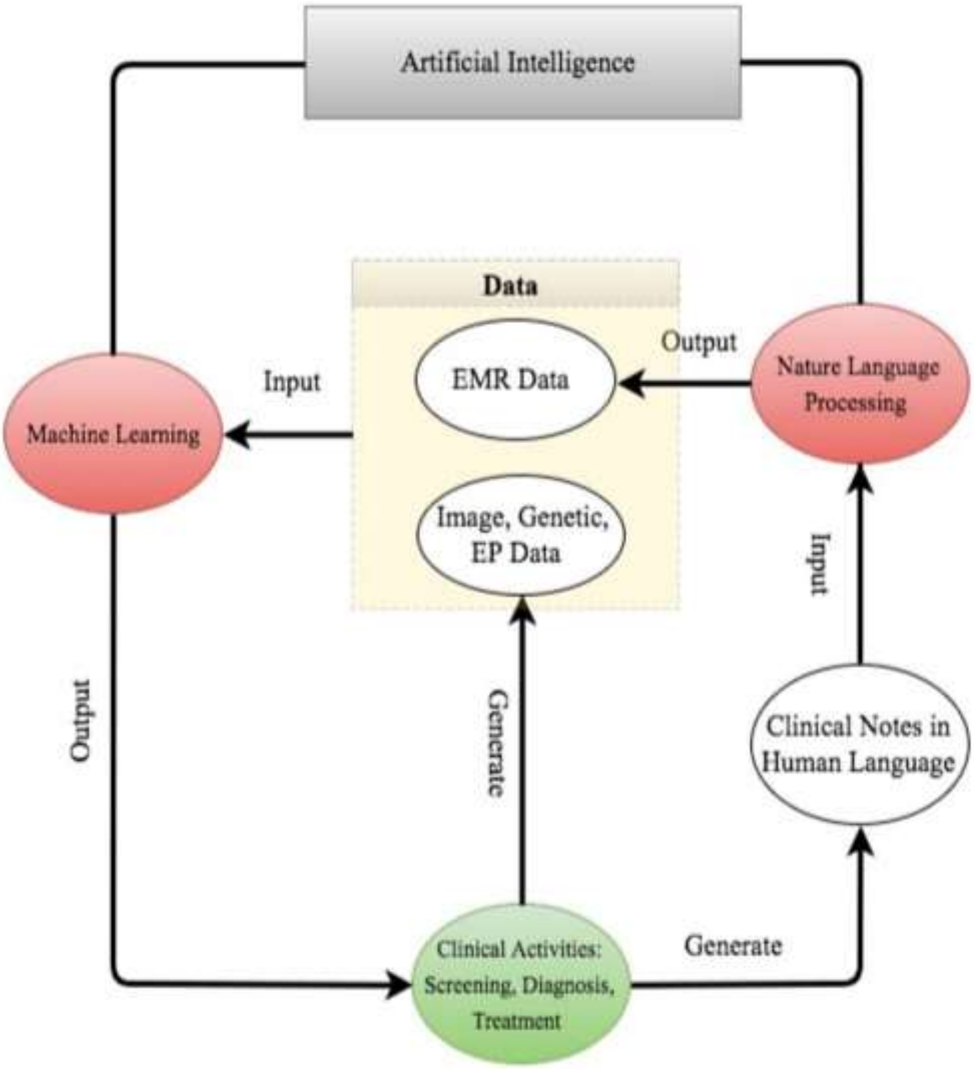


Figure 1. Evolution of Artificial Intelligence [11].

1. Application of Ai in healthcare:

Precision medicine: This field is one of the most significant uses of AI in healthcare. The goal of precision medicine is to improve the prognosis, therapeutic intervention, and diagnosis process. It makes use of extensive, multifaceted biological data sets that document genetic diversity in individuals as well as other relevant variables like age, gender, and race, as well as medical treatment alternatives including immunological profile, metabolism, and environmental susceptibility. As a result, early interventions, whether preventative or treatment-focused, can be customized for each patient by professionals. Numerous efforts are being made in precision medicine [12]. Virtual assistants and AI chatbots: In primary care and community settings, patients are using AI chatbots, like those found in Babylo and Ada, to recognize symptoms and suggest additional courses of action. In order to help patients and caregivers improve their behaviour, sleep, and overall wellness, AI chatbots can be connected with wearable technology like smartwatches [13]. Between 6000 and 8000 uncommon diseases are known to exist, and 400 million individuals worldwide suffer from them. The average time to diagnose a rare disease is thought to be five years. As a result, individuals with uncommon illnesses invest a lot of time, energy, and money in trying to get a correct diagnosis. According to 3Billion, a biostartup that offers DNA diagnostic services for uncommon diseases, almost 1200 patients have received rare disease diagnoses through artificial intelligence. 3Billion can test for up to 7000 diseases simultaneously in suspected instances [11]. Chatbots with virtual assistants for patient education and assistance Based on each patient's unique requirements and preferences, virtual assistant chatbots can offer them individualized medical care and education. Chatbots can learn from patient interactions and modify their responses to fit the patient's language and style by using machine learning algorithms and Natural Language Processing (NLP), which makes the user experience more engaging and natural. Additionally, chatbots for virtual assistants can give 24/7 support, which is especially helpful for patients who can't reach medical professionals during regular business hours. Chatbots are available around-the-clock and can assist patients in getting the support and information they require at the right time [14]. When an AI system is used to control processes like manufacturing or clinical trials, the power of long-term learning is frequently eliminated after training. Since the relatively recent adoption of Quality by Design (QbD) methodology, the pharmaceutical business has improved; yet, the most recent industry initiatives appear to depict a sector in rapid development [15]. Disease diagnosis and prediction: Although artificial intelligence is being used more and more in healthcare, research focuses mostly on cardiovascular, neurological, and cancer diseases since they are the main causes of death and disability. But there has also been a lot of focus on chronic and infectious illnesses (such as Type 2 diabetes, inflammatory bowel disease, and E. coli infection). Many illnesses can now be diagnosed early because to advancements in the extraction of clinical information and its integration into a validated and well-trained system [16]. In the context of this study, artificial intelligence (AI) refers to systems that use machine learning (ML) to tackle relevant healthcare problems. "A family of statistical and mathematical modelling techniques that use a variety of approaches to auto-matically learn and improve the prediction of a target state, without explicit programming" is how Witten et al. define machine learning. The majority of expert systems and other fundamental knowledge-based AI systems that employ straightforward rule-based procedures or Boolean rules are excluded by this definition [17].

Figure 2: The road map from clinical data generation to natural language processing data Enrichment, to machine learning Data analysis, to clinical decision making. EMR (electronic medical record), EP (electrophysiological) [18].



2. Challenges and Limitations:

Data variability: One of the biggest obstacles to using DL in oncology is data variability such as staining intensity or staining characteristics may vary from lab to lab in immunohistochemistry. How DL systems would handle this intra- and inter-laboratory variability is still unknown. Establishing the precise processing used to create a sequence library and processed dataset is one of the main challenges for transcriptomic data. Multiple authorities publish and update lists of genes and reported spliceforms, and even properties as basic as “the list of human genes” are not agreed for this reason, each analysis should include the source and version of the gene model employed [19]. Despite the potential benefits of the examined AI applications, a number of drawbacks make it difficult to apply them in actual clinical settings. Shows the reviewed applications’ current level of development based on published data that is currently accessible, together with the general difficulties encountered and the milestones attained at each step [20]. Technical issues with reproducibility, interpretability, competing device accuracy, processing hardware costs, and the need for regulatory permissions for studies these serve as obstacles to adoption in terms of clinical utility. Approaches that combine algorithm performance with manual validation, with error margins comparable to or stricter than those used for manual pathology, are probably going to be the norm going ahead because some degree of mistake with digital pathology is expected to exist at this point. This method has already been tested in routine diagnostics, where pathologists conducted IHC-based intrinsic subtyping of breast cancers by interacting directly with an AI platform [21]. Data quality: Health care data are extremely varied, ambiguous, noisy, and incomplete, in contrast to other fields where the data are clear and well-structured. It Is difficult to train an effective deep learning model with such large and diverse data sets, and it must consider a number of factors, including data sparsity, redundancy, and missing values [22]. ROC curves, while a helpful visual depiction of sensitivity and specificity, do not address other significant clinical hazards, which is another significant drawback of the methodology used to compare AI models with dermatologists. For example, the algorithm may mistakenly misclassify more benign naevi as malignant (false-positives) in order to capture more melanomas (improved sensitivity). However, this might result in patients undergoing needless biopsies, which would put further strain on the already overburdened healthcare system in addition to endangering individuals [23]. Several issues need to be fixed in order to allow for the safe and effective use of this AI in public health. These include moral and legal issues, especially those pertaining to privacy and data security [24]. Additional thorough analyses of AI-generated content and its effects on human-performed jobs are required. Furthermore, there is a chance of over-reliance, which can lead to a decline in human participation and critical thinking. A more comprehensive approach is required to fully understand the extent and effects of integrating AI, like ChatGPT, into other sectors, as current studies usually lack a thorough study of the broader ramifications [25]. Among the biggest difficulties the absence of labelled data in medical AI applications, particularly in computational pathology, is made worse by the high data heterogeneity and multi-gigapixel nature of pictures [26].

3. Future of AI:

AI technology is a high-tech product that evolves with the modern world; as such, it is an unavoidable outcome of scientific and technological advancement and follows the passage of time. In human history, there have been two industrial revolutions: the steam revolution and the electricity revolution. Both of these revolutions significantly altered human life and advanced civilization [27]. There is a lot of data available for AI applications to employ because of the growing adoption of electronic medical record systems over the past few decades. AI can lessen the cognitive load on physicians by augmenting (supporting) functions like decision-making. This would be especially useful when making difficult decisions about diagnosis or treatment. Additionally, it may analyse background data so that during a consultation, providers have a more comprehensive record of their patient [28]. AI will be used in a variety of stomach cancer domains due to its benefits in terms of processing power and learning capacity. The impact of disease features, patient physiological and psychological states, and even social communication on the prognosis of patients with stomach cancer is becoming more well recognized. Physicians find it challenging to manually integrate complex data. An AI model can effectively integrate a large amount of data from the great majority of sources, which might significantly lessen the strain for clinicians. However, the predictions produced by AI need to be further assessed and interpreted by qualified medical professionals because to certain ethical and safety concerns [29].

4. Benefits of AI in Health Care:

GenAI differs greatly from traditional AI in terms of the complexity of jobs it can perform, its usability, and the low cost of the technology for the general population. GenAI models that assist with diagnosis by producing differential diagnoses are one well-liked use that is frequently explored. It could appear tempting at first to speed up diagnostics in order to boost output. Currently, though, doctors are still accountable for incorrect diagnoses, so incorporating a tool like this into a clinical workflow that requires double-checking is likely to reduce their productivity [30]. Finding appropriate and bioactive drug molecules within the enormous amount of chemi-cal space, which is in the order of molecules, is the most difficult and discouraging stage in the drug discovery and development process. Additionally, the process of finding and developing new drugs is thought to be time-consuming and expensive [31]. Healthcare as a large data repository: A complex system designed specifically for disease prevention, diagnosis, and treatment is known as healthcare. The primary components of healthcare are health Practitioners (nurses and doctors), medical facilities (clinics, medication delivery Centres, and other technologies for testing or treatment), as well as a financial organization that provides funding for the former. Healthcare professionals work in a variety of health-related fields, including dentistry, pharmacy, medicine, Allied health sciences, psychology, nursing, and many more. Depending upon how severe the Furthermore, there are various levels at which health care is offered [32]. The dependent variable's predictor variables can be found via discriminant analysis. When the values of predictor variables are known, it can also be used to forecast the value of the dependent variable. When the risk factors or predictive factors are known, it can be used in conjunction with cluster analysis to determine the subject's location in cases or controls [34].

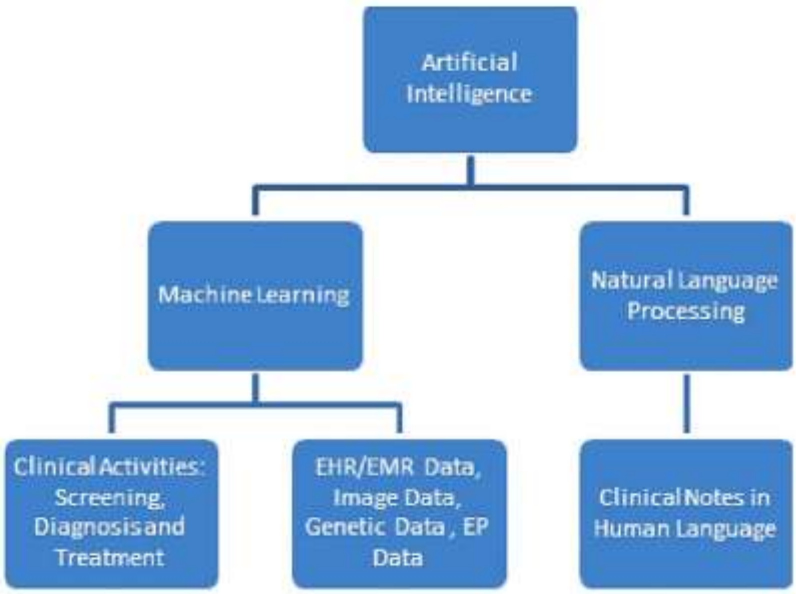


Figure 3: Clinical data to clinical decision making using Natural Language Processing and Machine Learning Analysis [33].

As the usage of AI systems grows, human oversight and comprehension of these systems are required for both patient safety and accountability for harm to patients. Deliberate investments in data quality, care access, and bias-minimization procedures will be necessary for further protections, all of which will contribute to credibility. For example, the National Health Service in Northern Ireland and the United Kingdom of Great Britain rely on transparency, accountability, and trust to successfully integrate artificial intelligence into routine patient care [34]. AI improves formulation development by helping develop complex formulations, forecast physicochemical characteristics, and optimize drug stability, solubility, and viscosity for injectables and biologics [35]. A variety of data inputs can be used by artificial intelligence, even while most of the early medical applications relied on visual images, such as those employed in pathology (such as pictures of cells and tissues), radiology (such as Positron Emission Tomography scans), or ophthalmology (such as retinal images). Over time, this has grown to include the examination of a variety of physiological data, including that produced by echocardiography, and more complex three-dimensional images, like those acquired during a colonoscopy, usually with the goal of diagnosing a condition. Data are occasionally linked in creative ways. For example, analysts have linked radiographic and longitudinal clinical data to provide a prognosis and guide further monitoring and therapy, and they have effectively integrated data on symptoms with recordings of coughs to precisely diagnose respiratory infections [36].

5. Conclusion:

The future of AI in healthcare holds significant promise, with potential applications in disease diagnosis, treatment, and patient care. As AI technology continues to evolve, it is essential to address the challenges and limitations associated with its adoption. This includes ensuring data quality, security, and integrity, as well as addressing technical issues with reproducibility and interpretability. Furthermore, careful consideration must be given to the ethical and safety implications of AI in healthcare, including the potential for bias and errors. By acknowledging these challenges and working towards solutions, we can harness the power of AI to improve patient outcomes and enhance the delivery of healthcare services. Ultimately, the successful integration of AI in healthcare will require a collaborative effort between healthcare professionals, researchers, and technology developers to ensure that AI systems are designed to augment human decision-making and improve patient care.

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