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Emerging Artificial Intelligence in Healthcare

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A B S T R A C T

Artificial intelligence (AI) is the systems or machines that mimic intelligence to perform tasks and can iteratively improve themselves based on the information they collect. It is a branch of computer science capable of analysing complex medical data. The implementation of artificial intelligence (AI) is driving significant transformation inside the administrative and clinical workflows of healthcare organizations. It has the potential to revolutionize healthcare by improving patient outcomes, reducing costs, and enhancing efficiency. This paper addresses AI systems used in health care are succeeding with advanced algorithms for learning numerous characteristics from a huge amount of health care data that helps in problem-solving. There are different types of AI which can be used in the healthcare field like biomarkers, natural language processing, rule-based expert system, and physical robotics. AI is used in treatment design, disease progression, diagnosis aid, and health monitoring. This paper provides a comprehensive review of the current applications of AI in healthcare, including machine learning, natural language processing, and robotics. The paper also explores the future possibilities of AI in healthcare, such as personalized medicine, disease prediction and prevention, and drug discovery. There have been reports that technology based on AI can improve the quality of human existence by making life simpler, safer, and more productive.

Keywords: Artificial Intelligence; Healthcare; Machine Learning; Deep Learning

1. Introduction

Artificial intelligence (AI) is a rapidly growing field that has the potential to transform healthcare. AI encompasses a wide range of technologies that enable computers to perform tasks that typically require human intelligence, such as learning, reasoning, and problem-solving. The use of AI in healthcare has already shown promise in improving patient outcomes, reducing costs, and enhancing efficiency. This paper provides a comprehensive review of the current applications of AI in healthcare, as well as the future possibilities of AI in healthcare. The rapid advancements in artificial intelligence (AI) have brought about exciting opportunities for the healthcare industry. AI technologies, such as machine learning, natural language processing, and computer vision, have revolutionized various aspects of healthcare delivery. These advancements have the potential to significantly improve patient care, enhance diagnostics, streamline administrative processes, and drive medical research and innovation. One of the most notable applications of AI in healthcare is in diagnostics and medical imaging. AI algorithms can analyse medical images, such as X-rays, CT scans, and MRIs, to detect abnormalities, tumours, and other conditions with high accuracy. This has the potential to improve early detection and diagnosis, leading to better treatment outcomes.

AI-powered virtual assistants and chatbots have also found their way into healthcare settings, providing patients with personalized support and information. These intelligent systems can answer medical questions, provide guidance on self-care, and triage patients based on their symptoms. This not only improves accessibility to healthcare but also reduces the burden on healthcare providers.AI has shown promise in predictive analytics and patient monitoring. By analysing large amounts of patient data, AI algorithms can identify patterns and risk factors for diseases, enabling healthcare providers to intervene earlier and prevent adverse events. AI-powered wearable devices and remote monitoring systems allow continuous monitoring of vital signs, providing real-time alerts for critical changes in a patient's health status.

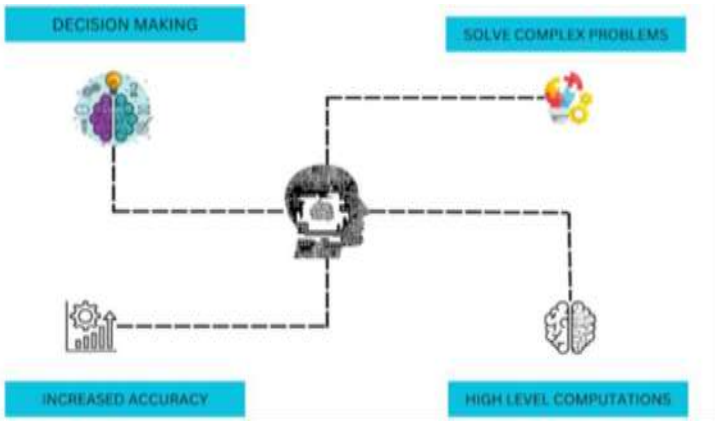

Fig.1.Artificial Intelligence in Healthcare

AI can also play a significant role in drug discovery and development. By analysing vast amounts of biomedical data and scientific literature, AI algorithms can identify potential drug targets, optimize drug design, and accelerate the process of clinical trials. This has the potential to bring new treatments to patients faster and more efficiently. While AI has already made substantial contributions to healthcare, its potential for the future is even more promising. Advancements in AI algorithms, coupled with the increasing availability of healthcare data, can further improve the accuracy and efficiency of diagnostic processes, enable personalized medicine, and enhance treatment recommendations. AI can also contribute to population health management by analysing health records and social determinants of health to identify trends, predict disease outbreaks, and allocate resources effectively.

2. Types of AI

AI is a compilation of technologies instead of a single technology. Many technologies are directly concerned with healthcare, each supporting particular mechanisms and tasks. A few important AI technologies in healthcare are detailed as follows:

2.1 Machine Learning: neural networks and deep learning

One of the highest prevailing types of AI is machine learning which is a statistical method. The prevalent utilization of conventional machine learning is as precision medicine. It is beneficial for assessing the exact condition of the patient based on the peculiarities and medical background and it estimates the procedure for the treatment of patients. For many decades it has been ratified in healthcare research. It is utilized to find out whether a patient will develop a specific disease. Deep learning is useful in diagnosing lacerations and contusions by making use of radiology images. Deep learning is progressively utilized for speech recognition and fundamentally is a type of natural language processing (NLP)

2.2 Natural language processing

NLP utilizes unstructured healthcare data which is locked in electronic health record systems. NLP is utilized for converting data into a usable and analyzable form. NLP studies patients' records and extricates important information such as prescriptions, medication plans and medical issues. It can estimate customers' caliber or analyze tendencies in social media. It has been trying to embrace human language for speech recognition and text analyses. AI is employed to develop NLP algorithms for the assimilation and assortment of clinical papers.

2.3 Rule-based expert systems

The purpose of using rule-based expert system in health care is clinical decision support. It is purposed for over a few decades and is still in use. These are set of rules which are provided by numerous electronic health records (EHR). The rule-based expert system involves data scientists and it attempts to reason similarly to human beings.

2.4 Physical Robots

They execute pre-detailed functions such as lifting, repositioning, welding, assorting objects in places like factories, and warehouses and delivering supplies to hospitals. Robots have become synergetic with humans and are easily instructed by passing them through a required process. In 2000, surgical robots were certified and they provide a "superpower" to surgeons by enhancing their ability to see, constitute explicit and less intrusive incisions, stitch wounds and many more. The surgical protocol utilizing robotic surgery comprises gynecologic surgery, prostate surgery and head and neck surgery.

2.5 Robotic Process Automation

It only comprises of computer programs on screens rather than actual robots. In healthcare they are utilized for proceeding endorsements, revising patient records or billing. They can also be used to extricate data from a faxed image when combined with image recognition.

2.6 Artificial neural networking

The computation of simulations galvanized by the human brain is known as artificial neural networks (ANN). In ANN AI developments include voice recognition, images and robotics recognition. The main objectives of ANN are to reflect the activities of human brain nerve cells utilizing neural networks of algorithms and maintaining a correlation between a set of data like the human brain. The response is instantaneous for biological neurons but data processing is slower, hence response takes a longer time. But the advantage is that data processing is a continuous process.

2.7 Clinical Decision Support System(CDSS)

The main motive of CDSS is to diagnose the disease accurately by making use of previous patient data. CDSS allows clinicians to integrate their knowledge with CDSS information. CDSS applies web applications or integrates with electronic health records (EHR) and computerized provider order data (CPOE) systems. CDSS is categorized into knowledge-based and non-knowledge-based categories. Knowledge-based CDSS is utilized for AI in medicine but it cannot understand the reasoning to generate data availability issues.

2.8 Biomarkers:

Biomarkers testing also known as molecular study intricate numerous tests to identify molecular signs of health so that the best treatment can be provided to the patient. Machine learning-aided biomarker discovery is on trend. Machine learning algorithms assess a couple of hypotheses on the basis of input features. The algorithms can be categorized as classification algorithms and feature-based algorithms.

2.9 Arterial Spin Labelling Imaging (ASL)

It is a non-invasive system of assessing brain perfusion. It has multiple variety modes of functioning software to evaluate data that yields high diagnosis accuracy. It is successfully utilized to monitor Alzheimer's disease.

3. AI in Disease Identification

AI refers to the simulation of human intelligence in machines that are programmed to think and learn. In the context of disease identification, AI utilizes algorithms and computational models to analyze medical data, such as imaging, genetic profiles, and patient records, to detect diseases more accurately and efficiently.

3.1 Key Technologies Used in AI for Disease Identification

Machine Learning (ML)

Supervised learning models are trained on labeled datasets to recognize disease patterns. Unsupervised learning can uncover hidden correlations in medical data.

Deep Learning (DL)

Convolutional Neural Networks (CNNs) for medical imaging analysis, such as detecting cancer in X-rays or CT scans.Recurrent Neural Networks (RNNs) for analyzing time-series data like ECG and EEG signals.

Natural Language Processing (NLP)

Processes unstructured data from electronic health records (EHRs), clinical notes, and research papers to extract insights.

Computer Vision

Identifies abnormalities in medical imaging (e.g., MRI, ultrasound) by comparing data against healthy baselines.

4. Artificial Intelligence in the Treatment of Diseases

Artificial Intelligence (AI) has made significant strides in revolutionizing the treatment process. AI's ability to analyze vast amounts of data, learn from it, and make predictions or recommendations is particularly valuable in enhancing treatment plans, personalizing care, and improving patient outcomes.

4.1 Personalized Treatment Plans

AI is playing a pivotal role in tailoring treatment plans to individual patients based on their unique genetic makeup, health history, and lifestyle factors.

- **Precision Medicine**

AI helps to identify genetic markers and mutations that can influence how a patient responds to a particular treatment. By analyzing genomic data, AI can suggest more personalized therapies, particularly in areas like cancer treatment.

Example: In oncology, AI-driven systems can analyze DNA sequencing to determine the most effective chemotherapy drugs based on the genetic profile of both the patient and the tumor.

- **Predictive Analytics**

AI algorithms can predict which treatment options will be most effective for individual patients based on a combination of their medical history, biomarkers, and treatment responses from similar patients.

Example: In diabetes, AI models predict blood sugar levels and suggest appropriate insulin dosages.

4.2 Drug Discovery and Development

AI is revolutionizing the drug discovery process by accelerating the identification of promising drug candidates and predicting their efficacy.

- **Drug Repurposing**

AI systems can analyze existing drugs to discover new uses for them. This is particularly valuable in the case of pandemics or rare diseases where drug discovery timelines are critical. Example: During the COVID-19 pandemic, AI helped identify existing medications that could be repurposed to treat the virus.

- **Predicting Drug Interactions and Toxicity**

AI can simulate how new drugs interact with various biological systems, helping researchers predict adverse drug reactions and side effects before clinical trials. Example: AI models have been used to predict how different drugs might interact with specific proteins involved in disease mechanisms.

- **Accelerating Clinical Trials**

AI tools are used to select suitable candidates for clinical trials, monitor patient responses in real time, and analyze trial data to speed up the approval process. Example: IBM Watson for Drug Discovery accelerates research by analyzing vast datasets of scientific literature, clinical trials, and patient records to suggest drug candidates.

4.3 Robotic Surgery and Minimally Invasive Procedures

AI-powered robotic systems are enhancing the precision of surgeries, improving recovery times, and reducing human error.

- **Surgical Robots**

AI-guided robotic systems like the da Vinci Surgical System assist surgeons in performing precise operations by providing real-time feedback, 3D visualization, and enhanced dexterity. Example: In prostate cancer surgery, robotic systems can remove cancerous tissues with high precision, leading to less invasive procedures and quicker recovery.

- **Minimally Invasive Surgeries**

AI can guide minimally invasive procedures like laparoscopy and endoscopy, improving accuracy and reducing the need for larger incisions, thereby shortening recovery times.Example: AI-based systems assist in arthroscopy for joint repair, minimizing the damage to surrounding tissues and improving outcomes.

4.4 AI in Radiotherapy and Cancer Treatment

AI is increasingly used in the treatment of cancer, particularly in enhancing the precision and effectiveness of radiotherapy.

- **Targeted Radiation Therapy**

AI systems analyze medical images (CT, MRI, or PET scans) to identify and track tumors in real-time, helping radiation oncologists precisely target cancer cells while sparing healthy tissue. Example: AI can optimize the radiation dose distribution in treatments for brain cancer, ensuring that the tumor receives maximum radiation while minimizing damage to surrounding brain tissue.

- **Radiomics**

AI uses radiomic analysis to extract quantitative features from medical imaging and predict patient responses to cancer treatments. This helps in adjusting radiation therapy to individual tumor characteristics. Example: In breast cancer, AI algorithms analyze mammogram images to predict how well a patient will respond to radiation therapy.

4.5 AI in Monitoring and Managing Chronic Diseases

AI is being used to continuously monitor patients with chronic conditions, providing real-time data and suggesting adjustments to treatment plans.

- **Remote Patient Monitoring**

AI algorithms track vital signs and health metrics through wearable devices (e.g., smartwatches, fitness trackers) and transmit them to healthcare providers for ongoing management. Example: AI-powered devices can monitor heart patients, tracking ECG readings, and alerting doctors about irregularities that might require intervention.

- **Disease Progression Monitoring:**

AI models predict the progression of chronic diseases such as diabetes, heart disease, or chronic obstructive pulmonary disease (COPD), enabling timely interventions. Example: AI systems monitor glucose levels in diabetic patients and recommend lifestyle or medication adjustments to optimize blood sugar levels.

4.6 AI-Driven Decision Support Systems

AI-powered decision support systems assist healthcare providers by offering evidence-based treatment recommendations based on patient data.

- **Clinical Decision Support Systems (CDSS):**

AI systems analyze patient data and medical records to provide clinicians with actionable insights regarding diagnosis and treatment options. This reduces human error and aids in making evidence-based decisions. Example: In emergency care, AI systems analyze lab results and medical histories to suggest possible diagnoses and appropriate treatment plans.

- **Virtual Health Assistants:**

AI-driven virtual assistants guide patients in managing their conditions, reminding them of medication schedules, providing health tips, and tracking their health goals. Example: AI chatbots like Ada and Babylon use patient symptoms to suggest possible treatments and guide users through their care process.

4.7 AI in Rehabilitation and Physical Therapy

AI aids in developing personalized rehabilitation programs and monitoring patient progress in real time.

- **Robotic-Assisted Rehabilitation**

AI-powered robots and exoskeletons assist patients recovering from injuries or surgeries by guiding movements and ensuring exercises are done correctly. Example: In stroke rehabilitation, AI-powered robots help patients regain motor function by guiding their arm movements through repetitive exercises.

- **Wearable Devices**

AI-driven wearable devices monitor patient movements and adjust physical therapy exercises based on real-time feedback to optimize rehabilitation progress. Example: In spinal cord injury rehabilitation, AI wearables can detect muscle contractions and adjust exercises to ensure maximum recovery.

4.8 AI in Mental Health Treatment

AI is also being used to aid in the treatment and management of mental health disorders such as depression, anxiety, and PTSD.

- **AI-Powered Therapy Apps**

AI-driven apps offer cognitive-behavioral therapy (CBT) and other therapeutic methods, providing on-demand support to patients. Example: Apps like Woebot use AI to engage patients in therapy, offering personalized coping strategies and emotional support based on user input.

- **Predictive Modeling for Mental Health:**

AI analyzes patient data to predict the onset of mental health crises and provides recommendations for intervention. Example: AI tools can analyze speech patterns or facial expressions to detect early signs of depression or anxiety.

4.9 Challenges and Ethical Considerations

While AI offers great potential, its use in the treatment of diseases brings about several challenges and ethical concerns:

- **Data Privacy and Security**
    - Handling sensitive patient data and ensuring its privacy and security is crucial in AI healthcare applications.
- **Bias in AI Models**
    - AI models must be trained on diverse datasets to avoid biases that could result in ineffective or discriminatory treatments.
- **Human Oversight**
    - Despite its capabilities, AI should be used to augment human decision-making, not replace healthcare professionals.

5. Applications of Artificial Intelligence

5.1 Healthcare drug creation

Machine learning algorithms are utilized to decrease drug discovery time. AI utilization to improve the discovery process parts will be faster, safer and more economical. It can assist in the discovery of new compounds as possible drugs for a disease. It can also be utilized for the identification of the application of previously tested compounds. For instance, two medicines for the treatment of the Ebola outbreak in West Africa were identified through AI in one day, which otherwise takes months to years. Thence, AI can be proficiently integrated with in-memory computing technology to be utilized in drug creation, and this leads to the enhancement of capacity to offer accelerated drug discovery and development.

5.2 Treatment design

AI has the ability to precisely identify and analyze the signs and symptoms of medical images such as X-rays, CT scans, MRIs, ultrasounds, and PET scans. It helps in faster diagnosis of disease. AI is of benefit collecting information about a patient, diagnosis records, testing process and assorting billing information with the help of medical assistant systems. Thence, AI techniques can be used for better care design and satisfaction of the patient.

5.3 Disease progression

By employing biomarkers, AI helps document the progression of disease at different stages. AI can find better ways to record, store and process patient data. All this is achieved through the use of artificial intelligence algorithms that come up with disease models.

5.4 Diagnosis aid

AI is used for the detection of diseases such as skin cancer more accurately than an experienced doctor.

5.5 Health monitoring

Numerous wearables and fitness gadgets can monitor the health of individuals. These gadgets work through AI to monitor health, analyze data and provide to users in order to determine their health status.

5.6 Managing medical data and record

AI has an important role in the management of data. AI helps in collecting, storing, normalizing and tracing data sources. Compilation and examination of data are important steps in healthcare; thus, AI is utilized for this purpose.

5.7 Possible uses of AI in clinical care include

• Medical imaging – medical scans have been systematically collected and stored for

some time and are readily available to train AI systems.27 AI could reduce the cost and time involved in analysing scans, potentially allowing more scans to be taken to better target treatment.

• Echocardiography – the Ultromics system, trialled at John Radcliffe Hospital in Oxford, uses AI to analyse echocardiography scans that detect patterns of heartbeats and diagnose coronary heart disease.

• Screening for neurological conditions – AI tools are being developed that analyse speech patterns to predict psychotic episodes and identify and monitor symptoms of neurological conditions such as Parkinson's disease.

• Surgery – robotic tools controlled by AI have been used in research to carry out specific tasks in keyhole surgery, such as tying knots to close wounds.

6. Future of AI

In the future, it is likely that AI systems will become more advanced and attain the ability to carry out a wider range of tasks without human control or input. If this comes about, some have suggested that AI systems will need to learn to 'be ethical' and to make ethical decisions. AI will extract important information from a patient's electronic footprint. Furthermore, because AI is able to simultaneously monitor millions of inputs, it will have a significant role in preventative medicine. AI could proactively suggest consultations when it determines that the patient's risk of developing a particular diabetic complication warrants intervention. AI-based systems will also bring specialist diagnostic expertise into primary care. Patients identified as low risk would receive instant reassurance while high-risk patients would experience lower referral waiting times because clinics would only be receiving selected cases. Integrating these systems into clinical practice necessitates building a mutually beneficial relationship between AI and clinicians, where AI offers clinicians greater efficiency or cost-effectiveness and clinicians offer AI the essential clinical exposure it needs to learn complex clinical case management. Throughout the process it will be critical to ensure that AI does not obscure the human face of medicine because the biggest impediment to AI's widespread adoption will be the public's hesitation to embrace an increasingly controversial technology.

7. Conclusion

There are many different AI techniques available which are capable of solving a variety of clinical problems. However, inspite of earlier optimism, medical AI technology has not been embraced with enthusiasm. One reason for this is the attitude of the clinicians towards technology being used in the decision-making process. Paradoxically, there is no qualm in accepting the biochemical results generated from an auto-analyser or images produced by magnetic resonance imaging. However, it is the obligation of researchers active in this field to produce evidence that these techniques work on a practical level. The need to undertake more randomised controlled studies to prove the efficacy of AI systems in medicine is, therefore, vital. There is compelling evidence that medical AI can play a vital role in assisting the clinician to deliver health care efficiently in the 21st century. There is little doubt that these techniques will serve to enhance and complement the 'medical intelligence' of the future clinician.

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