Applications of Artificial Intelligence in Biomedical Fields: An Overview

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ABSTRACT

Large-scale biomedical data sets are analyzed by artificial intelligence (AI), such as machine learning and deep learning, which helps with disease diagnosis, prognosis, and treatment. Medical photos, genomic data, electronic health records, and clinical notes are just a few examples of the types of complex data that AI algorithms can handle effectively to derive insightful information and support evidence-based decision-making. AI algorithms have been used in the field of medical imaging to improve the precision and effectiveness of picture interpretation, enabling the early diagnosis of diseases including cancer, Alzheimer's, and cardiovascular disorders. Additionally, AI-driven image analysis has aided in the creation of individualized treatment plans and improved radiology workflows. Biomedical research is not an exception. Artificial intelligence (AI) has emerged as a transformational technology with enormous potential to revolutionize different industries. This study presents an overview of AI's biological applications, highlighting the variety and significance of its contributions.

Keywords: Artificial Intelligence (AI), Medical Imaging and Diagnostics, Radiogenomics, Augmented Reality (AR) and Virtual Reality (VR)

INTRODUCTION

Biomedicine is only one of several industries that have been transformed by artificial intelligence (AI). AI has developed into a potent tool in biomedical research, diagnostics, treatment development, and personalized medicine due to its capacity to analyses enormous volumes of data, identify patterns, and make precise predictions. This article will examine how AI is used in many biomedical sectors, emphasizing its significance and future possibilities. By increasing the precision and effectiveness of image processing, artificial intelligence has substantially improved medical imaging and diagnosis. Radiological pictures like X-rays, MRIs, and CT scans can be analyzed by machine learning algorithms to look for anomalies, tumors, and other disorders. This makes it possible for earlier detection, quicker diagnosis, and better treatment planning. Astonishingly accurate breast cancer, lung cancer, retinal illnesses, and cardiovascular issues have all been detected by AI-based methods. Artificial intelligence (AI) has become a powerful force for change in a number of industries, and it has had a significant impact on healthcare, notably in the areas of medical imaging and diagnostics. The analysis and interpretation of medical pictures by medical practitioners is being revolutionized by AI algorithms and cutting-edge imaging technologies, improving accuracy, efficiency, and patient outcomes. This in-depth essay examines the uses, advantages, difficulties, and potential uses of AI in medical imaging and diagnostics.¹

Applications of AI in Medical Imaging and Diagnostics

Image Analysis: Medical imaging data from X-rays, CT scans, MRI scans, mammograms, and
ultrasound can be analysed by AI algorithms to look for abnormalities, identify anatomical structures, and help diagnose diseases.

Computer-Aided Diagnosis (CAD): AI systems can act as virtual assistants, providing second opinions and aiding radiologists in making accurate diagnoses by highlighting potential abnormalities or comparing images with vast databases of similar cases.

Image Segmentation: AI algorithms can segment medical images, separating specific organs, tumors, or other structures of interest from the surrounding tissues, enabling precise measurements and quantitative analysis.

Quantitative Imaging: AI can extract quantitative data from medical images, aiding in tracking disease progression, treatment response assessment, and personalized medicine.

Radiomics: AI algorithms analyze a large number of imaging features extracted from medical images to predict treatment outcomes, patient prognosis, and personalized treatment plans.

Benefits of AI in Medical Imaging and Diagnostics

Enhanced Accuracy: Improved diagnostic accuracy can result from radiologists using AI algorithms to help those spot small anomalies that human eyes would overlook.

Faster Diagnosis: Large amounts of medical photos can be quickly processed and analysed by AI systems, leading to quicker diagnosis, shorter wait times, and earlier treatment.

Improved Efficiency: In order to free up radiologists’ time to concentrate on challenging cases and increase overall workflow efficiency, AI algorithms can automate basic tasks like image preprocessing, analysis, and report production.

Decision Support: AI systems can offer evidence-based suggestions, supporting medical personnel in making decisions about patient management, diagnosis, and treatment planning.

Personalized Medicine: AI systems can examine clinical records, genomes, and vast amounts of patient data to develop customised treatment plans depending on the characteristics of each patient.

Challenges and Considerations

Data Quantity and Quality: AI models require a large amount of tagged, high-quality data for training. While preserving access to a variety of representative datasets, it could be challenging to guarantee patient privacy and data security.

Validation and Regulatory Approval: AI algorithms must undergo extensive testing and validation before being utilised in clinical settings to ensure their effectiveness and compliance with regulatory regulations.

Ethical Considerations: Consideration and ethical standards are required for matters like bias in algorithmic decision-making, openness of AI systems, and the accountability and responsibility for mistakes.

Integration with Clinical Workflow: Seamless integration of AI systems into existing clinical workflows, electronic health records (EHRs), and picture archiving and communication systems (PACS) is crucial for maximizing their potential benefits.

Advancements in Deep Learning: Convolutional neural networks (CNNs) and recurrent neural networks (RNNs), two deep learning algorithms, are anticipated to continue improving AI’s abilities in medical imaging analysis and diagnoses.

Multimodal Imaging: A more thorough and precise diagnosis and treatment monitoring may be made possible by integrating AI across many imaging modalities, such as by merging MRI and PET scans.

Real-Time Image Analysis: AI algorithms are evolving to provide real-time analysis of medical images, enabling immediate decision-making during procedures and interventions, reducing treatment delays, and improving patient outcomes.

Radiogenomics: The integration of AI with genomics data holds promise for predicting treatment response, identifying genetic markers, and tailoring treatment plans based on a patient’s genetic profile.
Virtual reality (VR) and augmented reality (AR): Medical pictures can be superimposed on patient anatomy using AI-powered AR and VR technologies, giving surgeons immersive visualization and direction during interventions, training, and procedures.

Explainable AI: The development of explainable AI models and algorithms is crucial for gaining trust and acceptance in the medical field. Interpretable AI systems can provide explanations and justifications for their decisions, assisting clinicians in understanding the reasoning behind AI-generated diagnoses and recommendations.

Collaborative AI: AI systems that facilitate collaboration between radiologists and other healthcare professionals, such as pathologists and oncologists, can enhance interdisciplinary decision-making and improve patient care through shared insights and expertise.

Global Access to Expertise: AI technologies can bridge the gap in healthcare access between regions by enabling remote interpretation and analysis of medical images, bringing expert opinions to under served areas and facilitating timely diagnosis and treatment.[4]

Drug Development and Discovery
Drug development takes a long time, costs a lot of money, and frequently ends in failure. AI has become a useful tool for accelerating and streamlining this process. To find prospective medication candidates, machine learning algorithms can examine huge datasets of molecular structures, genetic data, and clinical data. Researchers can prioritise the most promising ideas for additional research by using AI to forecast the effectiveness and adverse effects of medications.[5]

Genomics and Precision Medicine
The field of genomics has generated massive amounts of genetic data, and AI algorithms are crucial for extracting meaningful insights from this wealth of information. AI can analyze genomic data to identify disease-associated genetic variations, predict disease risks, and develop personalized treatment plans. It enables clinicians to tailor medical interventions based on an individual's genetic profile, leading to more precise and effective therapies.[6]

Genomic Data Analysis: AI algorithms can analyze vast amounts of genomic data quickly and efficiently. Machine learning techniques enable the identification of patterns, correlations, and variations in genetic information, aiding in the understanding of disease mechanisms, the discovery of novel genetic markers, and the development of targeted therapies.

Disease Diagnosis: By examining genetic data coupled with clinical data, AI can help in the diagnosis of diseases. Deep learning algorithms are able to recognise the patterns and characteristics that are linked to a given disease, facilitating early identification and precise diagnosis. This may result in enhanced patient care and better treatment outcomes.

Genomic Sequencing: Next-generation sequencing technologies generate massive amounts of genomic data. AI algorithms can analyze these complex datasets to identify genetic mutations, structural variations, and disease-causing genes. AI-driven genomics can accelerate the process of variant interpretation and prioritize potentially clinically relevant genetic alterations.

Drug Discovery and Development: The efficacy and safety of possible drug candidates are predicted by AI, which is a key factor in the drug discovery process. AI models are able to mimic drug-target interactions, spot drug repurposing possibilities, and enhance drug development. In contrast to conventional trial-and-error methods, this can save expenses and hasten the development of innovative medicines.[7]

Precision Treatment Selection: Clinical and genomic data can be analyzed by AI systems to match patients with the best possible treatments. AI-powered precision medicine can aid in the optimization of treatment plans, reduction of side effects, and improvement of patient outcomes by taking into account individual genetic variants and illness features.[8]
**Prognostic and Predictive Modeling:** AI techniques can generate predictive models that estimate disease progression, treatment response, and patient outcomes based on genomic and clinical data. These models can aid in treatment planning, patient counseling, and the development of personalized care plans.

**Patient Risk Assessment:** AI can evaluate a person's genetic susceptibility to specific diseases or disorders. AI algorithms can develop risk ratings and give individualised suggestions for illness prevention and early intervention by analysing genomic data and taking environmental and lifestyle factors into account.

**Privacy and Ethical Issues:** Important ethical and privacy issues are brought up by the use of AI in genomics and precision medicine. Implementing AI technology responsibly and fairly requires safeguarding patient data, obtaining informed consent, and addressing biases and fairness in algorithmic decision-making.\[9\]

**Electronic Health Records (EHR) and Clinical Decision Support**
AI can enhance the management and analysis of electronic health records (EHR) by extracting and organizing relevant information for clinicians. Natural language processing techniques allow AI systems to understand and interpret clinical notes, lab results, and other unstructured data, aiding in faster and more accurate diagnosis. AI-powered clinical decision support systems can provide evidence-based recommendations, alerting healthcare professionals to potential risks, drug interactions, or treatment options based on the patient's unique characteristics.

Healthcare is one of the many areas that artificial intelligence (AI) has revolutionised, and its use in clinical decision support and electronic health records (EHR) offers considerable promise. EHRs are computerised representations of patients' medical records that include detailed data on their medical history, diagnoses, current treatments, and other topics. Clinical Decision Support (CDS) systems offer medical personnel useful information and suggestions to improve patient care.

AI in EHRs helps automate and streamline various tasks, improving efficiency and accuracy. Natural Language Processing (NLP) enables the extraction and analysis of data from unstructured clinical notes, allowing for better organization and retrieval of information. AI algorithms can also assist in data entry, reducing the burden on healthcare providers and minimizing errors.

In addition, AI systems may examine vast amounts of patient data to find patterns, trends, and correlations that people might overlook. This aids in the early detection of diseases, the planning of individualised treatments, and the prognosis of patient outcomes. By analysing EHR data from a large number of patients, AI can enhance clinical research and produce insightful information and evidence-based recommendations.

In terms of Clinical Decision Support, AI plays a crucial role in providing real-time recommendations to healthcare professionals. By analysing patient data and comparing it with established medical guidelines and best practices, AI algorithms can suggest appropriate diagnostic tests, treatment options, and preventive measures. This assists clinicians in making well-informed decisions and improves patient safety.

When integrating AI in EHRs and CDS, it is crucial to take into account a number of issues and problems. To secure patient information, data privacy and security must be protected. To guarantee impartial and fair suggestions, ethical issues with bias, accountability, and transparency in AI systems should be addressed. Additionally, healthcare workers must have proper training in order to comprehend and evaluate insights and recommendations generated by AI.\[10\]

**Telemedicine and distant patient monitoring**
Particularly during the COVID-19 pandemic, AI technology has made remote patient monitoring and telemedicine possible. AI algorithms can examine data from wearable gadgets like smartwatches or biosensors to continuously monitor vital signs, spot anomalies, and give early warnings of potential health problems. Telemedicine platforms with AI integration can provide automated triage, symptom analysis, and
virtual consultations, enhancing access to healthcare services and lightening the load on healthcare institutions.

Healthcare has been transformed by artificial intelligence (AI), especially in telemedicine and remote patient monitoring. While telemedicine entails providing medical treatments remotely, remote patient monitoring refers to the use of technology to gather patient data outside of conventional healthcare settings. By utilising cutting-edge algorithms and machine learning approaches, AI significantly contributes to the improvement of these practises. Here are some crucial points about the use of AI in telemedicine and remote patient monitoring:

**Efficient data analysis:** AI enables the efficient analysis of vast amounts of patient data collected through remote monitoring devices. By using machine learning algorithms, AI can identify patterns, detect anomalies, and make predictions based on the data. This helps healthcare professionals in making accurate diagnoses and personalized treatment plans.

**Real-time observation:** AI facilitates real-time monitoring of patients' vital signs, such as heart rate, blood pressure, and glucose levels, through wearable devices or sensors. This continuous monitoring allows for early detection of potential health issues and timely intervention, reducing the risk of complications.

**Remote diagnostics:** Healthcare professionals can use AI-powered algorithms to remotely diagnose a range of medical disorders. For instance, medical images like X-rays, CT scans, or MRIs can be analysed by image recognition algorithms to look for abnormalities or help diagnose diseases. This makes it possible for patients to receive remote consultations and diagnoses, negating the need for them to physically visit healthcare institutions.

**Personalized care and treatment:** Personalised treatment plans can be created using AI algorithms that analyse patient data, medical history, and other pertinent information. Artificial intelligence (AI) can deliver individualised recommendations and therapies by taking into account a person's traits and health trends, improving patient outcomes.

**Bots and virtual assistants:** Artificial intelligence-powered chatbots and virtual assistants can interact with patients, answering their questions, providing basic medical advice, and even categorising cases based on symptom analysis. These AI-driven user interfaces enable people in remote locations with limited access to medical facilities and increase accessibility to healthcare services.

**Predictive analytics:** AI algorithms can predict disease progression, readmission rates, and treatment outcomes based on historical data and patient profiles. This helps healthcare providers in proactive decision-making, allowing for early interventions and preventive measures.

**Remote surgical assistance:** AI can enable remote surgical assistance by providing real-time guidance to surgeons during complex procedures. Using image recognition and augmented reality technologies, AI can overlay critical information onto surgical images, improving precision and reducing the risk of errors.

**Robotics and Surgical Assistance**

AI-driven robotics has revolutionized surgical procedures by enhancing precision, control, and efficiency. Surgical robots can assist surgeons in complex procedures, allowing for smaller incisions, reduced trauma, and improved patient outcomes. AI algorithms can analyze real-time surgical data, provide guidance to surgeons, and even perform certain tasks autonomously. These advancements have led to the emergence of minimally invasive surgeries and robotic-assisted procedures in various specialties.[11]

**CONCLUSION**

By enhancing diagnostics, drug discovery, personalised medicine, and patient care, artificial intelligence has the potential to fundamentally change the biomedical industry. AI-powered solutions will become more and more crucial in improving healthcare outcomes, cutting costs, and speeding up medical discoveries as technology develops. However, to ensure ethical and successful integration of AI in biomedical
applications, data protection, and the requirement for collaboration between AI experts and healthcare practitioners are vital.

Conflicts of Interest/ Competing Interests

The authors declare no conflict of interest.

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