

Applications of Artificial Intelligence in the Medical Field: A Survey

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Abstract

Artificial intelligence (AI) has revolutionized numerous industries, including healthcare. With its ability to process large volumes of data and make predictions, AI has shown significant potential in improving diagnostics, treatment planning, and patient care. This paper presents a comprehensive survey of recent research and applications of AI in the medical field. The survey covers various AI techniques such as machine learning, deep learning, and natural language processing, and their applications in areas such as disease diagnosis, image analysis, drug discovery, and personalized medicine. Furthermore, this paper discusses challenges and ethical considerations associated with the adoption of AI in healthcare, highlighting the need for careful integration to ensure patient safety and privacy.

Keywords: Artificial Intelligence, Medical Field, Survey, Applications, Healthcare, Diagnosis, Treatment, Patient Care, Medical Imaging, Disease Diagnosis.

1. Introduction

Artificial intelligence (AI) has gained significant momentum in recent years and is becoming increasingly prevalent in various industries, including healthcare. The rise of AI in healthcare has the potential to revolutionize the way medical professionals diagnose, treat, and prevent diseases, resulting in improved patient outcomes and enhanced overall healthcare delivery [1]. One of the significant impacts of AI in healthcare is in data analysis and interpretation. AI algorithms can harness large volumes of medical data, including patient records, medical literature, and research studies, to identify patterns and trends that may otherwise go unnoticed by human practitioners. This allows for more accurate and timely diagnoses, more personalized treatment plans, and the ability to predict potential medical issues [2]. AI can also assist in the monitoring of patient vital signs and warn healthcare providers of any abnormalities or potential risks.

Another area where AI is making a substantial impact is in medical imaging and diagnostics. Machine learning algorithms can analyze medical images, such as X-rays, MRIs, and CT scans, to detect abnormalities and assist radiologists in identifying potential conditions. This not only speeds up the diagnostic process but also improves accuracy and reduces the chances of misdiagnosis. AI-powered chatbots and virtual assistants are being used to improve patient engagement and support. These virtual agents can provide patients with access to medical information, answer FAQs, and even offer basic medical advice [3]. They can also schedule appointments and provide reminders for medication adherence, helping patients manage their healthcare more efficiently and reducing the burden on healthcare staff. In addition to the direct impact on patient care, AI is also enhancing administrative tasks within healthcare organizations. AI-powered systems

can automate tasks such as appointment scheduling, billing, and claims processing, improving efficiency and reducing human errors. This allows healthcare professionals to focus more on delivering quality care. However, the rise of AI in healthcare also brings challenges and concerns. There are concerns regarding patient privacy and data security as AI systems require access to sensitive medical information. Ethical issues, such as the need for transparency and accountability when it comes to AI decision-making, also need to be addressed. Additionally, there is a fear that AI may replace human healthcare professionals, leading to a loss of jobs.

Importance of AI in addressing challenges faced by the medical field

Artificial intelligence (AI) is becoming increasingly important in addressing the challenges faced by the medical field. Here are some key reasons why AI is crucial in healthcare:

- 1. Diagnosis and treatment:** AI has the potential to significantly improve the accuracy and speed of medical diagnosis. Machine learning algorithms can analyze vast amounts of data, including medical records, images, and research papers, to provide more accurate diagnoses and treatment options. This can help healthcare professionals make more informed decisions and improve patient outcomes [4].
- 2. Personalized medicine:** AI can assist in developing personalized treatment plans by taking into account individual patient data, such as genetic information, medical history, and lifestyle factors. By analyzing and interpreting these complex datasets, AI algorithms can optimize treatments for specific patients, leading to more effective interventions and better patient management.
- 3. Predictive analytics:** AI algorithms can analyze large volumes of patient data to identify patterns and predict disease outcomes. This can help healthcare providers identify high-risk patients and intervene before serious health issues arise. For example, AI-powered algorithms can predict the likelihood of readmission, allowing hospitals

to provide targeted interventions and reduce the burden on healthcare resources [5].

- 4. Drug discovery and development:** The drug discovery process is time-consuming and expensive. AI can aid in the discovery of new drugs by analyzing molecular structures and identifying potential drug candidates. This can accelerate the drug development process and lead to more effective treatments for various diseases.
- 5. Remote monitoring and telemedicine:** With advancements in AI, remote patient monitoring has become more viable. AI-powered devices can continuously monitor vital signs, detect anomalies, and transmit data to healthcare providers in real-time. This can enable early detection of health issues, reduce hospital visits, and help manage chronic conditions from the comfort of patients' homes.
- 6. Automation of administrative tasks:** AI can automate various administrative tasks, such as coding, billing, and appointment scheduling. By reducing the burden of these tasks on healthcare professionals, AI enables them to focus more on patient care and improves overall efficiency in healthcare delivery.

2. AI Techniques

2.1 Machine Learning

Machine learning is a subset of artificial intelligence that focuses on developing algorithms and models that can learn from data and make predictions or decisions without being explicitly programmed. In the medical field, machine learning techniques have shown great promise in various applications, including medical diagnostics, disease prediction, and prognosis [6].

Overview of machine learning algorithms and their applications in healthcare:

There are several machine learning algorithms commonly used in healthcare applications, including:

- 1. Supervised Learning:** This algorithm learns from labeled training data to make predictions or classifications. It requires a dataset with input features and corresponding output labels to train the model. Supervised learning algorithms, such

as support vector machines (SVM), decision trees, and random forests, have been used in medical diagnostics, such as cancer detection and classification of diseases [7].

- 2. Unsupervised Learning:** This algorithm learns from unlabeled data to discover patterns or structures within the data. It does not have predefined output labels but aims to find hidden relationships or clusters. Unsupervised learning algorithms, such as clustering and dimensionality reduction techniques, have been used in healthcare for tasks like patient stratification and identifying disease subtypes.
- 3. Reinforcement Learning:** This algorithm learns through trial and error by interacting with an environment and receiving feedback in the form of rewards or penalties. Reinforcement learning has been used in healthcare for tasks like optimizing treatment plans and personalized therapy recommendations.

Use of supervised, unsupervised, and reinforcement learning in medical diagnostics:

Supervised learning algorithms have been widely used in medical diagnostics to create models that can accurately classify diseases or predict outcomes. For example, support vector machines (SVM) have been used to classify breast cancer based on mammogram images, achieving high accuracy rates. Unsupervised learning algorithms have been applied to identify patterns or clusters in large healthcare datasets. For instance, clustering techniques have been used to group patients based on similar characteristics, aiding in personalized medicine and treatment recommendations [8]. Reinforcement learning has also found applications in medical diagnostics. For example, reinforcement learning algorithms have been used to optimize treatment plans for chronic diseases like diabetes, considering patient-specific factors and long-term outcomes.

Case studies demonstrating the efficacy of machine learning in disease prediction and prognosis:

Numerous case studies have demonstrated the efficacy of machine learning in disease prediction

and prognosis. For instance:

- 1. Prediction of Cardiovascular Events:** Machine learning algorithms have been used to predict the risk of cardiovascular events, such as heart attacks or strokes, by analyzing patient data, including demographics, medical history, and biomarkers. These models have shown improved accuracy compared to traditional risk assessment tools.
- 2. Prognosis of Cancer:** Machine learning algorithms have been applied to predict the prognosis of cancer patients based on various factors, including tumor characteristics, genetic information, and treatment history. These models can provide insights into patient survival rates and guide treatment decisions.
- 3. Early Detection of Alzheimer's disease:** Machine learning techniques have been used to analyze neuroimaging and cognitive data to predict the onset of Alzheimer's disease. These models can identify early signs of the disease, allowing for timely interventions and potential disease-modifying treatments [9].

2.2 Deep Learning

Deep learning is a subfield of machine learning that focuses on training artificial neural networks with multiple layers to learn hierarchical representations of data. Two commonly used deep learning architectures are convolutional neural networks (CNNs) and recurrent neural networks (RNNs).

Introduction to deep learning architectures:

- 1. Convolutional Neural Networks (CNNs):** CNNs are particularly effective for processing grid-like data, such as images. They consist of multiple layers, including convolutional layers, pooling layers, and fully connected layers. CNNs can automatically learn and extract relevant features from images, enabling them to perform tasks like image classification, object detection, and segmentation.
- 2. Recurrent Neural Networks (RNNs):** RNNs are designed to handle sequential data, such as time series or text [10]. They have loops in their architecture, allowing information to persist and be shared across different time steps. RNNs are

well-suited for tasks like natural language processing, speech recognition, and time series analysis.

Applications of deep learning in medical imaging analysis and diagnostics:

Deep learning has shown tremendous potential in medical imaging analysis and diagnostics due to its ability to learn complex patterns and features from images. Some applications include:

- 1. Image Classification:** Deep learning models, particularly CNNs, can accurately classify medical images into different categories, such as identifying specific diseases or abnormalities. For example, CNNs have been used to detect lung cancers from chest X-rays or mammograms.
- 2. Image Segmentation:** Deep learning models can segment medical images by identifying and delineating specific regions or structures of interest. This can aid in tumor segmentation, organ delineation, or lesion detection.
- 3. Image Reconstruction:** Deep learning techniques, such as generative adversarial networks (GANs), can reconstruct high-quality images from low-resolution or noisy medical images. This can improve image quality and aid in diagnosis.

Use of deep learning for drug discovery and genomics:

Deep learning has also been applied to drug discovery and genomics, enabling more efficient and accurate analysis of large datasets. Some applications include:

- 1. Drug Discovery:** Deep learning models can predict the properties and interactions of drug molecules, aiding in the discovery of new drug candidates. They can analyze large chemical libraries, predict drug-target interactions, and optimize drug design.
- 2. Genomics Analysis:** Deep learning techniques can analyze genomic data to identify patterns, predict gene functions, and classify genetic variants [11]. They can aid in understanding the genetic basis of diseases, personalized medicine, and identifying potential therapeutic targets.
- 3. Precision Medicine:** Deep learning models can

analyze patient data, including genetic information, medical history, and clinical data, to develop personalized treatment plans. This can help in selecting the most effective therapies for individual patients based on their unique characteristics.

2.3 Natural Language Processing (NLP)

Natural Language Processing (NLP) is a branch of artificial intelligence that focuses on the interaction between computers and human language. It involves the development of algorithms and techniques to understand, interpret, and generate human language in a meaningful way. In the healthcare domain, NLP techniques have shown great potential in various applications, including medical record analysis, clinical decision support, and patient monitoring [12].

Overview of NLP techniques and their applications in healthcare:

- 1. Text Classification:** NLP techniques can be used to classify medical texts, such as clinical notes or research papers, into predefined categories. For example, NLP models can classify clinical notes into different disease categories or identify specific medical conditions from patient records.
- 2. Named Entity Recognition (NER):** NER involves identifying and extracting specific entities from text, such as medical terms, drugs, or symptoms. NLP techniques can automatically identify and tag these entities, enabling better information retrieval and analysis [13].
- 3. Sentiment Analysis:** NLP can be used to analyze the sentiment or emotion expressed in patient reviews, social media posts, or online forums. This can provide valuable insights into patient experiences, satisfaction, and opinions about healthcare services.

Use of NLP for medical record analysis, clinical decision support, and patient monitoring:

- 1. Medical Record Analysis:** NLP techniques can extract valuable information from unstructured medical records, such as clinical notes or discharge summaries. This can aid in data mining, patient cohort identification, and clinical research. NLP can also identify and extract

relevant information, such as medication dosage, lab results, or adverse events, from textual data [14].

- 2. Clinical Decision Support:** NLP can assist healthcare providers in making informed decisions by analyzing and summarizing relevant information from medical literature or clinical guidelines. By automatically extracting and presenting relevant information, NLP can support clinical decision-making, improve patient outcomes, and reduce medical errors.
- 3. Patient Monitoring:** NLP techniques can analyze patient-generated data, such as electronic health records, wearable devices, or patient-reported outcomes, to monitor patient health and identify potential risks or anomalies. This can aid in early detection of deteriorating health conditions, remote patient monitoring, and personalized care management [15].

Case studies highlighting the impact of NLP in improving healthcare outcomes:

- 1. Clinical Document Classification:** NLP techniques have been used to classify clinical documents into different categories, such as radiology reports or pathology reports. This classification aids in organizing and retrieving relevant information, improving workflow efficiency, and facilitating research.
- 2. Medication Safety:** NLP has been employed to detect medication errors and adverse drug events from electronic health records. By analyzing unstructured clinical notes, NLP models can identify potential drug interactions, contraindications, or medication discrepancies, improving patient safety.
- 3. Disease Surveillance:** NLP techniques have been used to monitor and track disease outbreaks by analyzing textual data from sources such as social media, news articles, or online forums. This enables early detection and response to public health threats, such as infectious diseases or epidemics.

3. Applications of AI in Healthcare

3.1 Disease Diagnosis

The use of artificial intelligence (AI) in disease

diagnosis has shown great potential in enabling early detection and accurate diagnosis of various diseases. AI algorithms can analyze large amounts of data, including medical images, patient records, and genetic information, to identify patterns and markers that may indicate the presence of a disease. Here are some case studies on AI-based diagnostic systems for cancer, cardiovascular diseases, and infectious diseases:

1. Cancer Diagnosis

Breast Cancer: AI algorithms have been developed to analyze mammograms and assist radiologists in the early detection of breast cancer. These algorithms can detect subtle abnormalities or patterns that may indicate the presence of cancer, improving the accuracy of diagnosis and reducing false negatives.

Lung Cancer: AI-based systems have been developed to analyze chest CT scans and identify suspicious lung nodules or lesions. These systems can help radiologists in detecting lung cancer at an early stage, enabling timely intervention and improving patient outcomes.

2. Cardiovascular Disease Diagnosis

AI techniques have been applied to various cardiovascular diseases, including:

Arrhythmia Detection: AI algorithms can analyze electrocardiogram (ECG) data to detect abnormal heart rhythms, such as atrial fibrillation. These algorithms can aid in early detection and timely treatment of arrhythmias, reducing the risk of complications.

Coronary Artery Disease: AI-based systems can analyze cardiac imaging data, such as coronary angiograms or cardiac MRI scans, to detect and quantify the presence of coronary artery disease. These systems can assist cardiologists in assessing the severity of blockages and planning appropriate interventions.

3. Infectious Disease Diagnosis

COVID-19 Diagnosis: AI algorithms have been developed to analyze chest CT scans or X-rays to detect signs of COVID-19 pneumonia. These systems can help in the rapid screening and diagnosis of COVID-19 cases, particularly in resource-

constrained settings.

Malaria Diagnosis: AI-based systems have been developed to analyze blood smear images and detect malaria parasites. These systems can aid in the accurate and automated diagnosis of malaria, enabling timely treatment and reducing the burden on healthcare providers.

3.2 Medical Imaging Analysis

AI has made significant advancements in medical imaging analysis, revolutionizing fields such as radiology, pathology, and dermatology. The ability of AI algorithms to analyze large volumes of medical image data and extract meaningful information has enabled improved detection and classification of diseases. Here are some case studies highlighting the use of AI-based systems in medical image analysis:

Radiology: AI has been applied to various radiology imaging modalities, such as X-rays, CT scans, and MRI scans, to assist in disease detection and diagnosis. A study published in *Nature Medicine* demonstrated the use of deep learning algorithms to analyze chest X-rays and accurately detect pneumonia. Another study in the journal *Radiology* showed that AI algorithms could accurately identify and classify lung nodules on CT scans, aiding in the early detection of lung cancer [11].

Pathology: AI has shown promise in automating and enhancing the analysis of histopathology slides in pathology. A study in the journal *Nature Medicine* demonstrated the use of deep learning algorithms to accurately detect and classify breast cancer metastases in lymph nodes from pathology slides, achieving performance on par with human pathologists. Another study in the journal *JAMA Oncology* showed that AI-based analysis of prostate biopsy slides could improve the accuracy of cancer diagnosis and reduce unnecessary treatments.

Dermatology: AI has been utilized in the analysis of skin images for the diagnosis of various skin conditions, including melanoma and other types of skin cancer. A study published in the journal *Annals of Oncology* demonstrated the use of deep learning algorithms to analyze dermoscopy images and accurately classify skin lesions as benign or malignant. Another study in the journal *Nature*

showed that AI algorithms could accurately detect and classify different types of skin diseases from clinical images, aiding in the diagnosis and treatment recommendation.

3.3 Drug Discovery

The field of drug discovery is increasingly benefiting from the application of artificial intelligence (AI) techniques. AI has the potential to accelerate and enhance various stages of the drug discovery process, including target identification, lead optimization, and virtual screening. Here are some key areas where AI is being utilized in drug discovery, along with case studies on AI-assisted drug discovery platforms:

- 1. Target Identification:** AI techniques can help identify potential drug targets by analyzing large-scale biological data, such as genomics, proteomics, and transcriptomics. For example, BenevolentAI, an AI-assisted drug discovery platform, used machine learning algorithms to identify a novel target for amyotrophic lateral sclerosis (ALS). This discovery led to the development of a potential drug candidate that is currently in clinical trials.
- 2. Lead Optimization:** AI can assist in optimizing drug leads by predicting their properties, such as efficacy, toxicity, and pharmacokinetics. Atomwise, an AI drug discovery company, used deep learning algorithms to screen a database of small molecules and identify potential drug candidates for Ebola. One of these candidates is now being further developed and tested.
- 3. Virtual Screening:** AI can accelerate the process of virtual screening, which involves screening large databases of compounds to identify potential drug candidates that bind to a specific target. For instance, Insilico Medicine used deep learning algorithms to predict the activity of millions of compounds against specific protein targets. This approach enabled the identification of potential drug candidates for various diseases, including cancer and fibrosis.
- 4. Drug Repurposing:** AI can help identify new therapeutic uses for existing drugs by analyzing large datasets and identifying potential connections between drugs and diseases. For

example, Healx, an AI-powered drug discovery platform, utilized machine learning algorithms to identify existing drugs that could be repurposed for rare diseases. This approach led to the identification of potential treatments for Fragile X syndrome and other rare disorders.

3.4 Personalized Medicine

Artificial intelligence (AI) is revolutionizing personalized medicine by tailoring treatment plans based on individual patient characteristics and predicting treatment responses and adverse events. Here's a closer look at the role of AI in these areas:

- 1. Tailoring Treatment Plans:** AI algorithms can analyze large amounts of patient data, including genetic information, medical records, lifestyle factors, and treatment outcomes. By identifying patterns and correlations, AI can help healthcare providers develop personalized treatment plans that are tailored to each patient's unique characteristics. For example, AI can analyze genetic data to determine a patient's likelihood of responding to a particular medication or identify alternative treatment options based on their genetic profile [13].
- 2. Predicting Treatment Responses:** AI can analyze patient data and generate predictions about how individuals are likely to respond to specific treatments. By considering various factors such as genetic markers, biomarkers, and clinical data, AI algorithms can provide insights into treatment efficacy and potential side effects. This information can guide healthcare providers in selecting the most effective and safe treatment options for each patient.
- 3. Predicting Adverse Events:** AI algorithms can analyze patient data and identify factors that increase the risk of adverse events or treatment complications. By considering factors such as genetic predisposition, comorbidities, and treatment history, AI can help predict the likelihood of adverse events for individual patients. This information can assist healthcare providers in monitoring patients more closely, adjusting treatment plans, or considering alternative treatment options to minimize the risk

of adverse events.

The integration of AI in personalized medicine holds great promise for improving patient outcomes, reducing adverse events, and optimizing treatment strategies. However, it is important to ensure that AI-generated insights are validated and interpreted in collaboration with healthcare professionals to ensure safe and effective personalized treatment plans. Ethical considerations, data privacy, and transparency are also crucial aspects that need to be addressed as AI continues to be integrated into personalized medicine.

4. Challenges and Ethical Considerations

AI continues to play a significant role in tailoring treatment plans and predicting treatment responses and adverse events in personalized medicine, there are several challenges and ethical considerations that need to be addressed:

- 1. Data Quality and Bias:** AI models heavily rely on data for training and generating insights. Ensuring the quality and reliability of the data is crucial to avoid biased or inaccurate results. Biases in the data, such as underrepresentation of certain populations, can lead to disparities in personalized treatment recommendations. Efforts should be made to address data biases and ensure representative and diverse datasets are used.
- 2. Interpretability and Transparency:** AI models often operate as "black boxes," making it challenging to understand how they arrive at their conclusions. In healthcare, interpretability is crucial to gain trust and acceptance from healthcare providers and patients. Efforts are being made to develop explainable AI models that can provide clear explanations for their decisions, making them more transparent and interpretable.
- 3. Patient Safety, Privacy, and Data Security:** Personalized medicine heavily relies on sensitive patient data, including genetic information, medical records, and lifestyle factors. It is essential to ensure robust data security measures to protect patient privacy and prevent unauthorized access or breaches. Compliance

with regulations, such as HIPAA (Health Insurance Portability and Accountability Act), is crucial in safeguarding patient data.

- 4. Human Oversight and Accountability:** While AI can provide valuable insights and recommendations, it is important to maintain human oversight and accountability in medical decision-making. Healthcare providers should use AI as a tool to support their decision-making process rather than relying solely on AI-generated recommendations. Human judgment, expertise, and ethical considerations should always be taken into account when making treatment decisions [14].
- 5. Bias Mitigation:** AI models can inadvertently perpetuate biases present in the data they are trained on. Efforts should be made to address and mitigate these biases to ensure fair and equitable treatment recommendations for all patients. Regular audits and ongoing monitoring of AI systems can help identify and rectify any biases that may arise.
- 6. Informed Consent and Patient Autonomy:** Patients should have a clear understanding of how their data will be used in AI applications and have the right to give informed consent. Transparency in explaining the benefits, risks, and limitations of AI-assisted treatment plans is crucial to ensure patient autonomy and foster trust in personalized medicine.

Conclusion

The survey findings highlight the significant role of AI in personalized medicine. AI is being used to tailor treatment plans based on individual patient characteristics and predict treatment responses and adverse events. It analyzes diverse patient data, identifies patterns, and generates insights that guide treatment decisions. However, several challenges and ethical considerations need to be addressed. Data quality, bias, and interpretability of AI models are concerns that need attention. Ensuring patient safety, privacy, and data security is crucial in AI applications. Human oversight and accountability must be maintained in AI-assisted medical decision-making. Bias mitigation and addressing data biases

are important for fair and equitable treatment recommendations. Informed consent and patient autonomy should be prioritized. For future directions, AI research in the medical field can focus on improving data quality, addressing biases, and developing more interpretable AI models. Collaborative efforts between AI experts, clinicians, and policymakers are essential for successful integration of AI in healthcare. Guidelines, regulations, and standards should be established, and ongoing research and monitoring are necessary to ensure the safety, effectiveness, and fairness of AI applications.

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