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Artificial Intelligence in Healthcare: A Review

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Abstract:
This study aims to provide a summary of the application of artificial intelligence in healthcare. Artificial intelligence has had a significant impact on this subject. Healthcare has undergone a paradigm shift due to the growing accessibility of healthcare data and the quick development of analytics. Machine learning technology like deep learning neural networks, support vector machines, and structured data is managed by natural language processing. Processing is done on unstructured data utilizing natural language processing.
AI has applications in healthcare that include the mining of medical records, the creation of treatment plans, the prediction of health events, the assistance of repetitive tasks, online consultations, the creation of drugs, the management of medications, the creation of healthier options, and the resolution of public health issues, among other things. AI has the potential to be tremendously beneficial in places like rural and distant areas where human resources are scarce. This research paper is a review of artificial intelligence in healthcare.

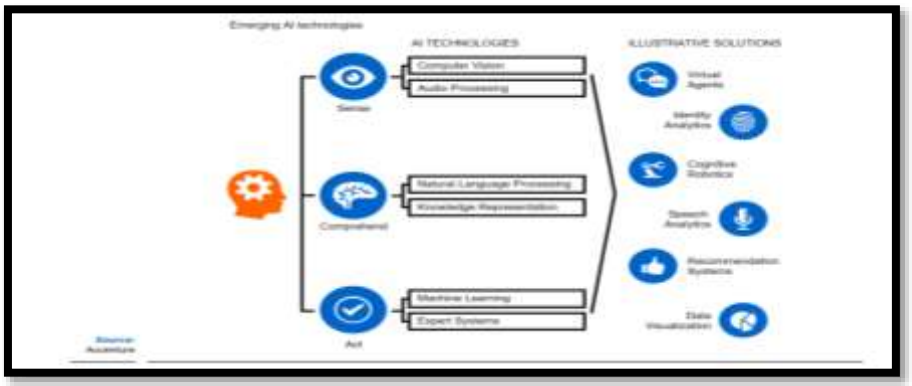
Keywords: Machine learning, artificial intelligence, neural network, healthcare

Introduction:

"AI refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem-solving, and decision-making."(NITI Aayog, Government of India 2018). Artificial Intelligence is the new general-purpose technology (GPT) that is capable of revolutionizing virtually every sector (Bajpai, Biberman, and Yip Yingxin 2020). Artificial Intelligence not only complements human labor but is a substitute for it altogether. Over the next few decades, AI would take over "human" tasks like logical reasoning, creativity in design, business management etc.

What is artificial intelligence?

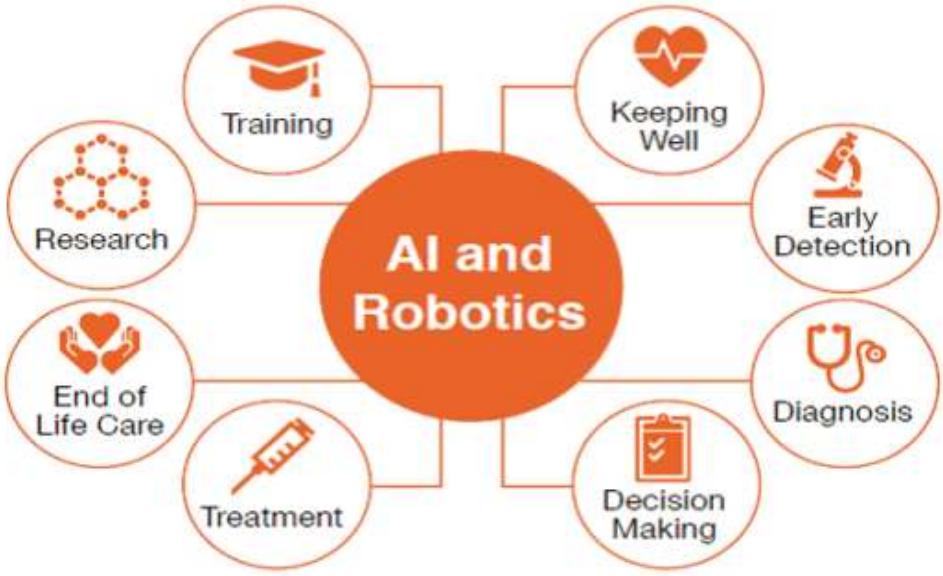
Figure 1: Artificial intelligence



Source: NITI Aayog, Government of India. 2018. "National Strategy for Artificial Intelligence #AIFORALL."

The current advancements in artificial intelligence technologies in healthcare have us wondering if AI tools will eventually replace human physicians. In practice, AI tools cannot replace human physicians, but they can help physicians achieve greater results and accuracy in the medical area. The availability of healthcare data is a key support for these AI systems growing in the medical industry. Artificial intelligence is a set of technologies, not just one. Some of these technologies, such as machine learning, are frequently employed in healthcare. Machine learning is a process in which you train models using previously collected data so that when someone feeds the data that you are testing, it will identify the test input based on prior learning. Precision medicine is the most common application of machine learning in healthcare. Precision medicine is the prediction of which treatment will be used. Protocols will be successful on a specific patient, and this is determined using patient data from the past. This way of determining from prior knowledge will necessitate training the model with datasets. This method is known as supervised learning.

Figure 2: Potential Use Cases of AI in Healthcare

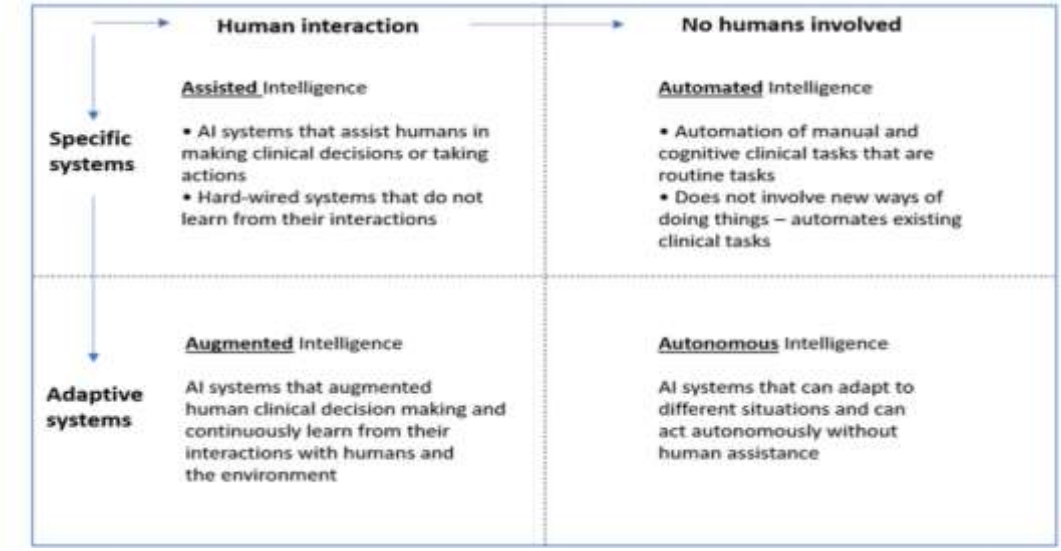


Source: PWC, "No longer science fiction, AI and robotics are transforming healthcare"

AI relevance to healthcare

In this part, we will look at healthcare services that use AI. These services include healthcare and support services, as seen in Figure 3.

Figure 3: Categories of AI application in healthcare

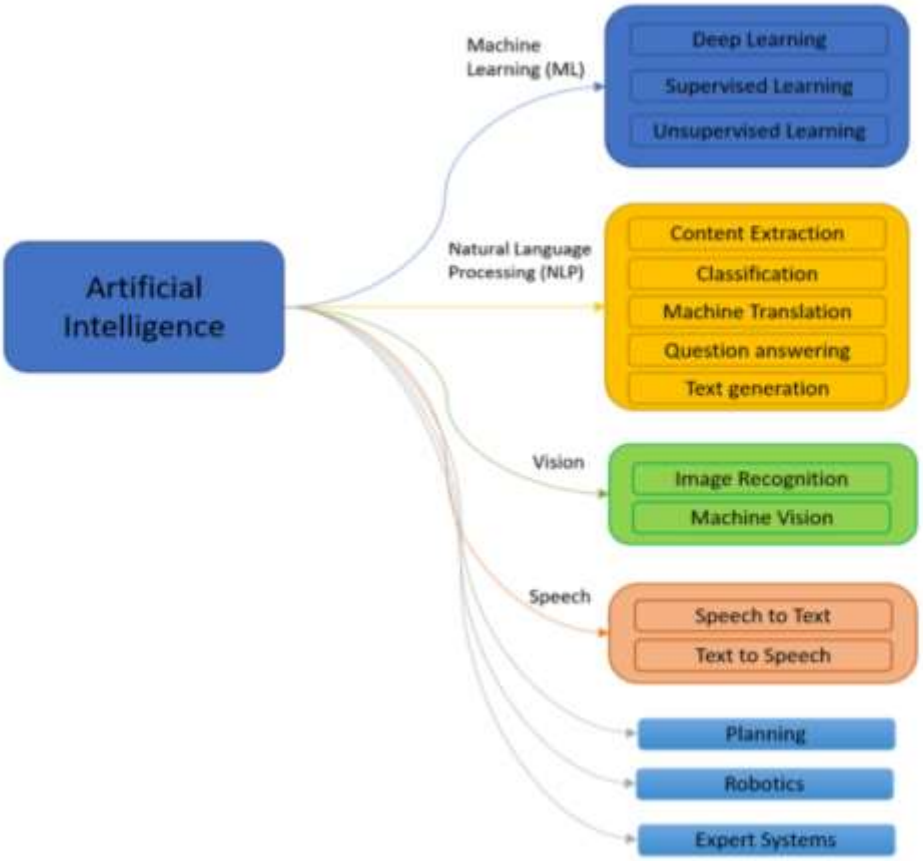


Source: AI in healthcare by Anti Vaananen

Artificial intelligence is a collection of technologies, not a single one. The majority of these technologies are immediately applicable to the subject of healthcare, although the exact processes and tasks they assist differ greatly. Some important AI technologies for healthcare are outlined and detailed here.

The services chosen for analysis are those that provide immediate care or direct assistance for care. These include robotic surgery, clinical trial participation, virtual nursing and consulting assistance, image diagnostics, dosage error reduction, medication management, preliminary diagnosis, and health monitoring.

Figure 4: AI methods and its applications



Machine learning: Machine learning (ML) is an area of AI that provides adaptive AI solutions. The ML can be divided into three categories. Supervised learning methods construct a mathematical model of a set of data that includes both the expected outputs and inputs5. Unsupervised learning methods use a data set with only inputs and detect structure in the data, such as data point grouping or clustering.

The algorithms in unsupervised learning learn from test data that has not been classed, labeled, or categorized. Reinforcement learning techniques do not require a precise mathematical description of a discrete-time stochastic control process. Reinforcement learning is utilized, for example, when a self-driving car is operating in an environment where real-time feedback on excellent or bad choices is unavailable.

Natural language processing (NLP): is a subfield of artificial intelligence that consists of tools and techniques that allow computers to read, understand, and derive meaning from human languages, as well as enable natural interaction between computers and humans to make computer systems understand and manipulate natural languages to perform desired tasks. In healthcare, NLP is used to forecast diseases based on patient speech and electronic health information, for example.

Neural network (NN): is made up of digitized inputs, such as an image or speech that are routed through numerous hidden layers of connected artificial neurons, with each layer responding to distinct features and providing an output. Deep NNs (DNN) deserve special attention since, as a subset of NN, they are used in many AI solutions in field medicine, including recurrent, convolutional, transfer, generative adversarial, reinforcement, representation, and transfer. When there is a requirement to interpret data to certain patterns from different types of clinical images such as pathology, skin lesions, retinal, and endoscopy images and

to detect patterns from datasets such as medical scans, electrocardiograms, and vital signs, DNN is commonly used.

Deep learning (DL): is a subfield of machine learning (ML). DL is based on artificial neural networks (ANNs), which are inspired by information processing and distributed communication nodes in biological systems and use several layers to extract higher-level properties from raw input. Semi-supervised, supervised, or unsupervised DL is possible. The term 'deep' refers to the amount of levels (depth) that the data is changed through. DL is a type of AI in which computers may accomplish tasks based on existing data associations.

Machine vision/computer vision (MV/CV): refers to the methods and technology used to automatically extract information from images. The extracted information can be a signal, such as a good/bad section, or a set of data, such as the identification, orientation, and position of objects in a picture. Extracted data can be used in applications such as automatic inspection, security monitoring, industry robots and process guiding, and vehicle navigation.

Application of AI in healthcare

Robotics-assisted surgical systems (RASS) and computer-assisted surgery(CAS)

Robotic Surgery Systems (RASS) have been used since 1985 in various surgical fields, including cardiac, thoracic, gastrointestinal, gynecology, orthopedic, spine, transplant, urology, and general surgery. RASS is categorized into supervisory controlled surgery, telesurgical, and shared control surgery. RASS allows surgeons to perform procedures with precision, faster patient recovery times and reduced postoperative complications. It also allows for data collection for further analysis and learning of the surgery process. DaVinci, developed by Intuitive Surgical Inc., is one of the most used RASS.

CAS is a computer-based approach to assisted surgical systems, enhancing surgical planning and guidance. It includes techniques for direct participation in surgery and aiding in instrument positioning. CAS features include virtual image creation, diagnostics, image analysis, preoperative planning, simulations, and navigation, contributing significantly to the development of RASS.

Virtual Nurse Assistant for healthcare:

Healthcare organizations are increasingly using virtual assistants to reduce hospital visits and workloads. Embodied conversational agents (ECAs) have shown significant improvement in healthcare outcomes over the past two decades. Advancements in AI technologies, such as NLP, ML, and NN, have enabled the development of virtual agents that mimic human conversation. Your.MD, a platform using AI and machine learning, provides personalized pre-primary care using NHS data, with benchmark tests showing medical accuracy of 85% for 20 common conditions.

Sensely, a VNA platform, uses machine learning algorithms to monitor patients' medical history, track appointments, and predict follow-up treatments. It reduced readmission rates by 75% and patient monitoring costs by 66% in 2019 clinical trials.

Medication management and medication error reduction (MMMER)

Effective MMMER services can significantly reduce healthcare costs and prevent unnecessary injuries and deaths. Nonoptimized medication therapy costs the US $528 billion annually, equivalent to 16% of total healthcare expenditures. Prescription drug errors cause substantial morbidity and mortality, highlighting the importance of preventive measures. AI can improve medication safety, prevent overdoses, predict health risks, and monitor adherence.

Clinical trial participation

AI can enhance clinical trial participation rates by automatically finding patterns in large and unstructured datasets. Natural language processing (NLP) can improve patient-trial match and recruitment. AI can monitor patients continuously and automatically during trials, improving adherence, efficiency, and control. IBM's Watson AI platform led to an 80% increase in oncology clinical trial enrollment, demonstrating the potential of AI in enhancing clinical trial participation rates.

Mendel.ai research network has developed a clinical trial participation pre-screening service to identify patients eligible for clinical trials. In a study, Mendel.ai was used to retroactively pre-screen two oncology studies for breast and lung cancer. This resulted in a 24-50% increase in patient eligibility compared to standard practices. Mendel.ai also identified all patients correctly identified by standard practices, reducing the time between eligibility and identification.

Preliminary diagnosis and prediction

For decades, diagnosis services have utilized health history and diagnosis data to provide accurate diagnoses and prognoses. Advances in AI research have shown that AI outperforms physicians in speed and accuracy in some healthcare sectors.

Diabetes Prediction:

Diabetes prediction can be achieved through retinal screening, clinical decision support, predictive population risk, and patient self-management tools. Retinal screening detects diabetic abnormalities, while clinical decision support monitors diabetes and comorbidities. Predictive population risk stratification identifies diabetes subpopulations at higher risk for complications, hospitalization, and readmissions. Self-management tools include artificial pancreas, AI-improved glucose sensors, and dietary and activity tracking devices. Medtronic's Guardian Connect is an AI-powered continuous glucose monitoring system that can predict significant changes in blood glucose levels up to 60 minutes before an event. The system alerts patients about 98.50% of hypoglycemic events, allowing them to act proactively to normalize their blood sugar levels.

Cancer prediction:

Houston Methodist researchers have developed a NLP-based application that interprets mammography results using free text radiology and pathology reports from 543 patients and keywords. The application achieved 99% accuracy, saving time and reducing manual validation time from 50-70 hours for 54 patients.

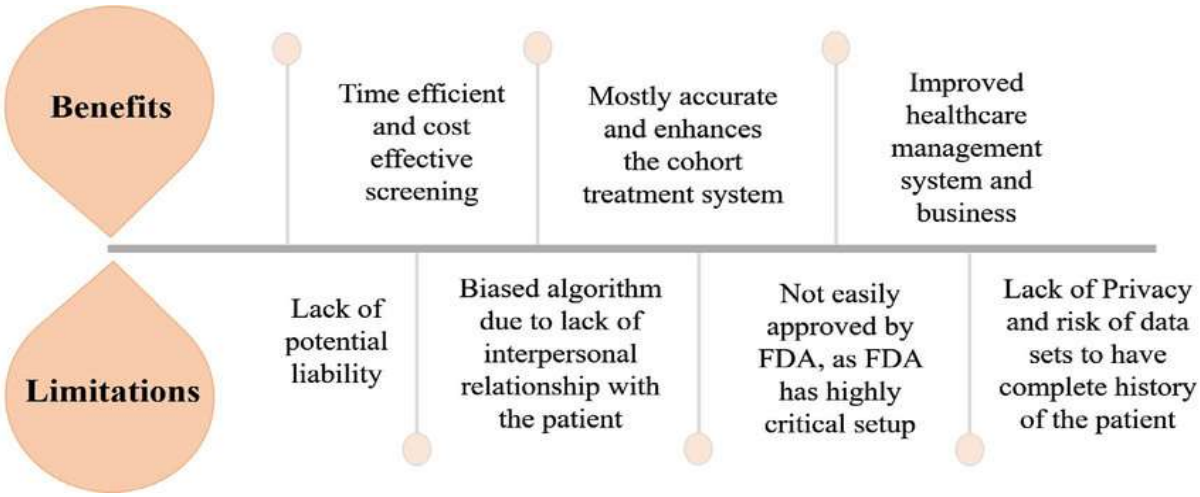
Psychiatric prediction

Columbia University's New York State Psychiatric Institute and IBM Watson Research Center have developed an AI application using automated Natural Language Processing (NLP) and machine learning to detect psychosis in susceptible individuals. The app analyzes speech patterns to differentiate patients, eliminating human error and making it more accurate than traditional diagnosis. The AI system eliminates the need for interviewers to miss essential signs, making it more effective than traditional methods.

Patient health monitoring

Continuous Patient Health Monitoring (PHM) can reduce hospital stays, increase recovery time, and decrease mortality rates. It offers AI-based services for continuous healthcare monitoring, assessment tools, and symptom checking. These services can be used by patients and healthcare professionals in hospitals or at home. AI-based health condition monitoring solutions are rated as the best of 15 technologies for healthcare and the second-best service among healthcare professionals.

Figure 5: Benefits and limitations of AI in healthcare:



Source: Abhishek Balakumar (Can deep learning revolutionize clinical understanding and diagnosis of optic neuropathy?)

Challenges of AI in healthcare

1. **Data security and privacy concerns**: Healthcare companies are a prime target for hackers because they manage enormous volumes of sensitive patient data. A data breach can have serious repercussions, including the possibility of financial fraud, identity theft, and compromised patient care. Healthcare companies must use strategies like strong encryption, access limits, frequent audits, and staff training to allay worries about data security and privacy.
2. **Lack of sufficient data:** For AI systems to generate precise forecasts and suggestions, data is crucial. In many situations, there might not be enough high-quality data available to properly train AI algorithms. This restriction may impair AI systems' accuracy and performance.
3. **Problems with interoperability**: Since integrating AI frequently necessitates exchanging data across multiple platforms and systems, interoperability issues pose serious challenges to the smooth integration of AI into healthcare systems. As a result, it is extremely difficult to guarantee the safe transfer of sensitive data while preserving its confidentiality and integrity. Healthcare businesses need to make investments in systems that can successfully communicate with one another in order to address interoperability problems. Interoperability and data sharing across various systems and technologies can be facilitated by the adoption of standardized formats and protocols.
4. **Adherence to regulations**: One of the biggest obstacles to integrating AI into healthcare is regulatory compliance. Strict laws, such as the Health Insurance Portability and Accountability Act (HIPAA), must be followed by healthcare institutions in order to safeguard patient privacy. It can be difficult to integrate AI whileadhering to these rules. Companies must keep abreast of the most recent regulatory standards and put policies in place to guarantee compliance. This entails implementing strong data security protocols, guaranteeing openness in AI-powered decision-making procedures, and taking responsibility for the results of such judgments. Additionally, frequent audits and training initiatives can guarantee that medical personnel understand and abide by legal obligations.
5. **Bias and ethical concerns**: The application of AI in decision-making processes raises ethical difficulties, particularly in key areas like diagnosis and treatment planning. To address ethical and prejudice problems, healthcare institutions must guarantee that AI technologies are created and

implemented responsibly. It is critical to conduct regular audits of algorithms for bias, ensure transparency in decision-making processes, and hold people accountable for the outcomes of AI-driven decisions. Furthermore, educating healthcare workers on the benefits and limitations of AI, as well as cultivating a culture of diversity and inclusion, can assist in alleviating bias issues.

6. **Adoption resistance**: Concerns about their effects on job security, changes in workflow, or just a lack of knowledge of the technology could make healthcare personnel reluctant to welcome AI-driven innovations.

Conclusion:

The study reveals the high potential of AI solutions in healthcare to reduce costs, improve patient quality of life, and provide preventive health services. AI-based solutions can be used in developing countries for preliminary diagnosis, preventive health services, patient health monitoring, and virtual nurse assistants. By 2026[2], AI solutions could save $150 billion in the global healthcare industry. The study recommends healthcare IT service development companies and research organizations fully adopt scientifically validated AI methods.

The US Food and Drug Administration has proposed a regulatory framework for AI and ML-based technologies, which should be used for developing new AI-based technologies in EU markets until the EU Medical Device Regulation (MDR) creates its regulatory framework. Healthcare AI service developers should join the Interest Group on Artificial Intelligence for Health, a joint initiative of the World Health Organization and International Telecommunications Union, to drive the application of AI in health by establishing an evaluation framework. This will help maintain and enhance the quality of service in the healthcare industry.

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