Role of Artificial Intelligence in Healthcare

Subjects: Health Care Sciences & Services

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Artificial Intelligence (AI) has emerged as a transformative technology with immense potential in the field of medicine. By leveraging machine learning and deep learning, AI can assist in diagnosis, treatment selection, and patient monitoring, enabling more accurate and efficient healthcare delivery. The widespread implementation of AI in healthcare has the role to revolutionize patients' outcomes and transform the way healthcare is practiced, leading to improved accessibility, affordability, and quality of care.

artificial intelligence machine learning deep learning clinical applications diagnosis

1. Introduction

Artificial intelligence (AI) is increasingly being used as a virtual tool in many countries around the world. With its ability to mimic human cognitive functions, AI has revolutionized industries, improved efficiency, and unlocked new possibilities. During the past few years, governments have adopted a variety of smart applications that can use AI and its subsets provide predictions and recommendations in various fields, such as healthcare, finance, agriculture, education, social media, and data security.

Since the outbreak of COVID-19 in 2019, AI technologies have experienced accelerated adoption and utilization across various domains within the healthcare sector. In response to the pandemic, AI has emerged as a valuable tool and is being used for disease detection and diagnosis, medical imaging and analysis, treatment planning and personalized medicine, drug discovery and development, predictive analytics, and risk assessment. In 2018, Loh E. [1] stated that AI has the potential to significantly transform physicians' roles and revolutionize the practice of medicine, and it is important for all doctors, in particular those in positions of leadership within the health system, to anticipate the potential changes, forecast their impact and make strategic plans for the medium to long term. In contrast, in 2021, Mistry C. et al. [2] assessed that the necessity for deploying advanced digital devices has become a requirement to offer augmented customer satisfaction, permitting tracking, checking the health status, and achieving better drug adherence.

The field of AI is continuously evolving and researchers are exploring various avenues to create intelligent systems with different capabilities. The authors employed a visual representation, in the form of **Figure 1**, to illustrate the diverse subtypes of AI. **Table 1** provides an overview of the definitions of terms related to AI and their integration within the healthcare sector.

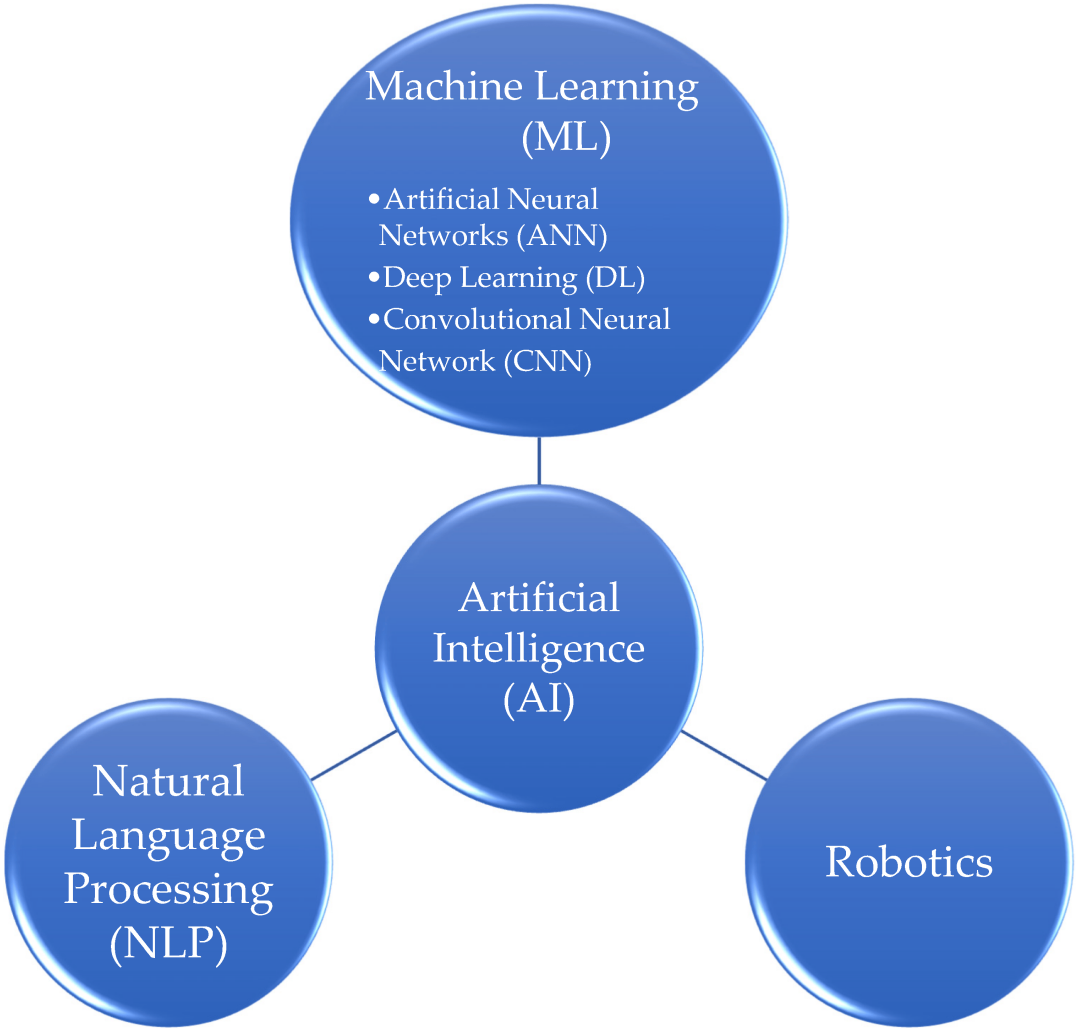

Figure 1. Illustration of the AI subtypes.

Table 1. Definitions of terms related to AI.

Term	Definition
Artificial Intelligence (AI)	The first definition was been given in 1950 by Alan Turing, the founding father of AI, as the science and engineering of making intelligent machines, especially intelligent computer programs [3]. According to Salto-Tellez M. et al. [4], AI represents a range of advanced machine technologies that can derive meaning and understanding from extensive data inputs, in ways that mimic human capabilities. In the present context of medical practice, a specific definition may be a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation [5].
Machine Learning (ML)	ML, a subset of artificial intelligence, exhibits the experiential "learning" associated with human intelligence, while also having the capacity to learn and improve its analyses through the use of computational algorithms [6][7]. Alpaydin E. [8] defined machine learning as the field of programming computers to optimize a performance criterion using example data or past experience. ML-based tools are used in the healthcare system to provide

Term	Definition
	various treatment alternatives and individualized treatments and improve the overall efficiency of hospitals and healthcare systems while lowering the cost of care [9].
Deep Learning (DL)	Deep Learning, a subset of Machine Learning, refers to a deep neural network, which is a specific configuration where neurons are organized in multiple successive layers that can independently learn representations of data and progressively extract complex features, performing tasks such as computer vision and natural language processing (NLP) [10]. In experimental settings across multiple medical specialties, DL performs equivalently to healthcare professionals for detecting diseases from medical imaging [11].
Natural Language Processing (NLP)	Natural Language Processing is a theoretically-motivated range of computational techniques for analyzing and representing naturally-occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing for a range of tasks or applications [12]. NLP techniques have been used to structure information in healthcare systems by extracting relevant information from narrative texts so as to provide data for decision-making [13].
Robotics	The robot has been defined as “a reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks” by the Robot Institute of America [14]. The term “robotics” refers to the study and use of robots. Robotic assistance has been shown to improve the safety and performance of intracorporeal suturing, which is heavily required in urological and gynecological procedures [15].
Artificial Neural Network (ANN)	An Artificial Neural Network, a subset of Machine Learning, is a computational model inspired by the biological neural networks in the human brain. These systems are mainly used for pattern identification and processing and are able to progressively improve their performance based on analytic results from previous tasks [16][17][18]. Many areas have been integrating the use of ANNs to facilitate the diagnosis, prognosis, and treatment of many diseases [19][20][21].
Convolutional Neural Network (CNN)	A Convolutional Neural Network is a Deep Learning algorithm specifically designed for image and video processing, primarily used in medical image analysis and diagnostics. CNNs have demonstrated superior performance as compared with classical machine learning algorithms and in some cases achieved comparable or better performance than clinical

healthcare sector and the patients’ overall well-being [22]. The fundamental goal of the diagnosis of a disease lies in determining whether a patient is affected by a disease or not [23]. The first step in the diagnostic process involves obtaining a complete medical history and conducting a physical examination. For instance, a technique can use sound analysis to recognize COVID-19 from different respiratory sounds, e.g., cough, breathing, and voice [24]. Additionally, for a precise diagnosis, AI algorithms can be used for the analysis of medical scans and pathology images. Imaging applications include the determination of ejection fraction from echocardiograms [25], the detection and volumetric quantification of lung nodules from radiographs [26], and the detection and quantification of breast densities via mammography [27]. Imaging applications in pathology include an FDA-cleared system for whole-slide imaging (WSI) and their integration into a laboratory offers many benefits over light microscopy [28].

3. Treatment Planning and Personalized Medicine

AI tools have the ability to analyze large amounts of data and detect patterns. Therefore, they can make predictions for efficient and personalized treatment strategies. Personalized medicine, as an extension of medical sciences, uses practice and medical decisions to deliver customized healthcare services to patients [29]. For example, CURATE.AI is an AI-derived platform that maps the relationship between an intervention intensity (input-drug) and a phenotypic result (output) for an individual, based exclusively on that individual's data, creating a profile, which serves as a map to predict the outcome for a specified input and to recommend the intervention intensity that will provide the best result [30].

4. Drug Discovery and Development

The use of AI has been increasing in the pharmaceutical industry, and as a result, it has reduced the human workload as well as achieved targets in a short period of time [31]. AI can recognize hit and lead compounds, and provide a quicker validation of the drug target and optimization of the drug structure design [32][33]. In January 2023, Insilico Medicine announced an encouraging topline readout of its phase 1 safety and pharmacokinetics trial of the molecule INS018_055, designed by AI for idiopathic pulmonary fibrosis, a progressive disease that causes scarring of the lungs [34].

5. Predictive Analytics and Risk Assessment

Disease risk assessment is the process of evaluating a person's probability of developing certain diseases, based on risk factors such as genetic predispositions, environmental exposures, and lifestyle choices. AI techniques have been adopted to address the various steps involved in clinical genomic analysis—including variant calling, genome annotation, variant classification, and phenotype-to-genotype correspondence—and perhaps eventually they can also be applied to genotype-to-phenotype predictions [35]. Moreover, Ramazzotti et al. accomplished a successful prognosis prediction for 27 out of 36 cancers by employing AI to analyze various types of biological data such as RNA expression, point mutations, DNA methylation, and omics data of copy number variation. The data used for analysis was sourced from The Cancer Genome Atlas (TCGA) [36].

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