Original Article

Overview of artificial intelligence in medicine

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Abstract

Background: Artificial intelligence (AI) is the term used to describe the use of computers and technology to simulate intelligent behavior and critical thinking comparable to a human being. John McCarthy first described the term AI in 1956 as the science and engineering of making intelligent machines. **Objective:** This descriptive article gives a broad overview of AI in medicine, dealing with the terms and concepts as well as the current and future applications of AI. It aims to develop knowledge and familiarity of AI among primary care physicians. **Materials and Methods:** PubMed and Google searches were performed using the key words 'artificial intelligence'. Further references were obtained by cross-referencing the key articles. **Results:** Recent advances in AI technology and its current applications in the field of medicine have been discussed in detail. **Conclusions:** AI promises to change the practice of medicine in hitherto unknown ways, but many of its practical applications are still in their infancy and need to be explored and developed better. Medical professionals also need to understand and acclimatize themselves with these advances for better healthcare delivery to the masses.

Keywords: Artificial intelligence, future of medicine, machine learning, neural networks, robots

Introduction

Alan Turing (1950) was one of the founders of modern computers and AI. The "Turing test" was based on the fact that the intelligent behavior of a computer is the ability to achieve human level performance in cognition related tasks.[1] The 1980s and 1990s saw a surge in interest in AI. Artificial intelligent techniques such as fuzzy expert systems, Bayesian networks, artificial neural networks, and hybrid intelligent systems were used in different clinical settings in health care. In 2016, the biggest chunk of investments in AI research were in healthcare applications compared with other sectors.[2]

AI in medicine can be dichotomized into two subtypes: Virtual and physical.[3] The virtual part ranges from applications such as electronic health record systems to neural network-based guidance in treatment decisions. The physical part deals with robots assisting in performing surgeries, intelligent prostheses for handicapped people, and elderly care.

The basis of evidence-based medicine is to establish clinical correlations and insights via developing associations and patterns from the existing database of information. Traditionally, we used to employ statistical methods to establish these patterns and associations. Computers learn the art of diagnosing a patient via two broad techniques - flowcharts and database approach.

The flowchart-based approach involves translating the process of history-taking, i.e. a physician asking a series of questions and then arriving at a probable diagnosis by combining the symptom complex presented. This requires feeding a large amount of data into machine-based cloud networks considering the wide range of symptoms and disease processes encountered in routine medical practice. The outcomes of this approach are limited because the machines are not able to observe and gather cues which can only be observed by a doctor during the patient encounter.

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On the contrary, the database approach utilizes the principle of deep learning or pattern recognition that involves teaching a computer via repetitive algorithms in recognizing what certain groups of symptoms or certain clinical/radiological images look like. An example of this approach is the Google's artificial brain project launched in 2012. This system trained itself to recognize cats based on 10 million YouTube videos with efficiency improving by reviewing more and more images. After 3 days of learning, it could predict an image of a cat with 75% accuracy.[4,5]

Materials and Methods

PubMed and Google searches were performed using the key words "artificial intelligence." Further references were obtained by cross-referencing the key articles. An overview of different applications utilizing AI technologies currently in use or in development is described.

Results

A lot of AI is already being utilized in the medical field, ranging from online scheduling of appointments, online check-ins in medical centers, digitization of medical records, reminder calls for follow-up appointments and immunization dates for children and pregnant females to drug dosage algorithms and adverse effect warnings while prescribing multidrug combinations. Summarized in the pie chart [Figure 1] are the broad applications of AI in medicine.

Radiology is the branch that has been the most upfront and welcoming to the use of new technology.[6] Computers being initially used in clinical imaging for administrative work like image acquisition and storage to now becoming an indispensable component of the work environment with the origin of picture archiving and communication system. The use of CAD (computer-assisted diagnosis) in a screening mammography is well known. Recent studies have indicated that CAD is not of a lot of diagnostic aid, based on positive predictive values, sensitivity, and specificity. In addition, the false-positive diagnoses may distract the radiologist resulting in unnecessary work-ups.[7,8] As suggested by a study,[6] AI could provide substantial aid in radiology by not only labeling abnormal exams but also by identifying quick negative exams in computed tomographies, X-rays, magnetic resonance images especially in high volume settings, and in hospitals with less available human resources.

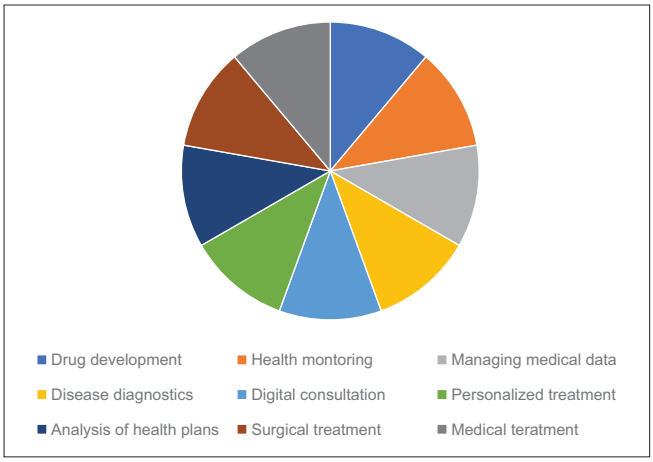

Figure 1: Applications of artificial intelligence in health care

A decision support system known as DXplain was developed by the university of Massachusetts in 1986, which gives a list of probable differentials based on the symptom complex and it is also used as an educational tool for medical students filling the gaps not explained in standard textbooks.[9] Germwatcher is a system developed by the University of Washington to detect and investigate hospital acquired infections.[10] An online application in UK known as Babylon can be used by the patients to consult the doctor online, check for symptoms, get advice, monitor their health, and order test kits. Apart from that, the spectrum of AI has expanded to provide therapeutic facilities as well. AI-therapy is an online course that helps patients treat their social anxiety using therapeutic approach of cognitive behavior therapy. It was developed from a program CBTpsych.com at University of Sydney.[11]

The Da Vinci robotic surgical system developed by Intuitive surgicals has revolutionized the field of surgery especially urological and gynecological surgeries. The robotic arms of the system mimics a surgeon's hand movements with better precision and has a 3D view and magnification options which allow the surgeon to perform minute incisions.[3] Since 2018, Buoy Health and the Boston children's hospital are collaboratively working on a web interface-based AI system that provides advice to parents for their ill child by answering questions about medications and whether symptoms require a doctor visit.[12] The National Institute of Health (NIH) has created an AiCure App, which monitors the use of medications by the patient via smartphone webcam access and hence reduce nonadherence rates.[13]

Fitbit, Apple, and other health trackers can monitor heart rate, activity levels, sleep levels, and some have even launched ECG tracings as a new feature. All these new advances can alert the user regarding any variation and let the doctor have a better idea of the patient's condition. The Netherlands uses AI for their healthcare system analysis - detecting mistakes in treatment, workflow inefficiencies to avoid unnecessary hospitalizations.

Apart from the inventions which already exist, there are certain advances in various phases of development, which will help physicians be better doctors. IBM's Watson Health being a prime example of the same, which will be equipped to efficiently identify symptoms of heart disease and cancer. Stanford University is making a program AI-assisted care (PAC). PAC has intelligent senior wellbeing support system and smart ICUs, which will sense any behavioral changes in elderly people living alone[14] and ICU patients,[15] respectively, via the use of multiple sensors. PAC is also extending its projects over Intelligent Hand Hygiene support and Healthcare conversational agents. Hand hygiene support is using depth sensors refining computer vison technology to achieve perfect hand hygiene for clinicians and nursing staff reducing hospital

acquired infections.[16] Healthcare conversational projects analyzes how Siri, Google Now, S voice, and Cortana respond to mental health, interpersonal violence, and physical health questions from mobile phone users allowing patients to seek care earlier. Molly is a virtual nurse that is being developed to provide follow-up care to discharged patients allowing doctors to focus on more pressing cases.

Discussion

AI is growing into the public health sector and is going to have a major impact on every aspect of primary care. AI-enabled computer applications will help primary care physicians to better identify patients who require extra attention and provide personalized protocols for each individual. Primary care physicians can use AI to take their notes, analyze their discussions with patients, and enter required information directly into EHR systems. These applications will collect and analyze patient data and present it to primary care physicians alongside insight into patient's medical needs.

A study conducted in 2016[17] found that physicians spent 27% of their office day on direct clinical face time with their patients and spent 49.2% of their office day on electronic hospital records and desk work. When in the examination room with patients, physicians spent 52.9% of their time on EHR and other work. In conclusion, the physicians who used documentation support such as dictation assistance or medical scribe services engaged in more direct face time with patients than those who did not use these services. In addition, increased AI usage in medicine not only reduces manual labor and frees up the primary care physician's time but also increases productivity, precision, and efficacy.

Searching and developing pharmaceutical agents against a specific disease via clinical trials take years and cost a gazillion dollars. To quote a recent example, AI was used to screen existing medications, which could be used to fight against the emerging Ebola virus menace which would have taken years to process otherwise. With the help of AI, we would be able to embrace the new concept of "precision medicine."

Some studies have been documented where AI systems were able to outperform dermatologists in correctly classifying suspicious skin lesions.[18] This because AI systems can learn more from successive cases and can be exposed to multiple cases within minutes, which far outnumber the cases a clinician could evaluate in one mortal lifetime. AI-based decision-making approaches bring used in situations where experts often disagree, such as identifying pulmonary tuberculosis on chest radiographs.[19]

This new era of AI-augmented practice has an equal number of skeptics as proponents [Figure 2]. The increased utilization of technology has reduced the number of job opportunities, which many doctors in the making and practicing doctors are concerned about. Analytically and logically machines may be able to translate human behavior, but certain human traits such as critical thinking, interpersonal and communication skills, emotional intelligence, and creativity cannot be honed by the machines.

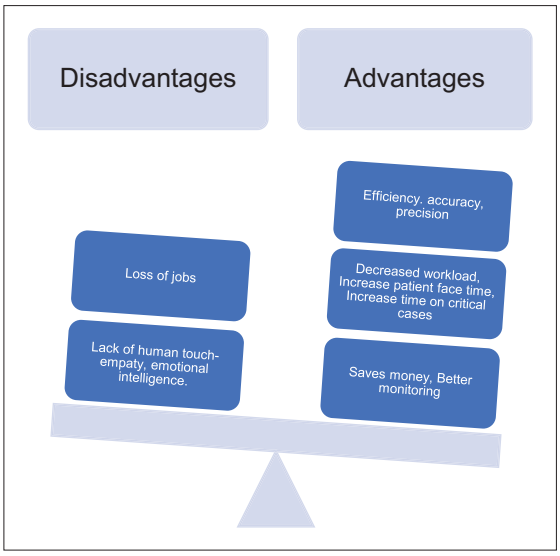

Figure 2: Advantages and disadvantages of artificial intelligence in medicine

In 2016, the Digital Mammography DREAM Challenge was done where several networks of computers were connected, and the goal was to establish an AI-based algorithm by reviewing 640,000 digital mammograms. The best which was achieved was a specificity of 0.81, sensitivity of 0.80, area under receiver operator curve was 0.87, which is roughly approximated to bottom 10% radiologists.[20] In conclusion, AI has potential, but it is unlikely that AI will replace doctors out rightly.

AI would be an integral part of medicine in the future. Hence, it is important to train the new generation of medical trainees regarding the concepts and applicability of AI and how to function efficiently in a workspace alongside machines for better productivity along with cultivating soft skills like empathy in them.

In conclusion, it is important that primary care physicians get well versed with the future AI advances and the new unknown territory the world of medicine is heading toward. The goal should be to strike a delicate mutually beneficial balance between effective use of automation and AI and the human strengths and judgment of trained primary care physicians. This is essential because AI completely replacing humans in the field of medicine is a concern which might otherwise hamper the benefits which can be derived from it.

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Conflicts of interest

There are no conflicts of interest.

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