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AI BASED ROBOTS FOR MEDICAL APPLICATIONS

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ABSTRACT

The practice of medicine is changing with the development of new Artificial Intelligence (AI) methods of machine learning. Coupled with rapid improvements in computer processing, these AI-based systems are already improving the accuracy and efficiency of diagnosis and treatment across various specializations. The increasing focus of AI in radiology has led to some experts suggesting that someday AI may even replace radiologists. These suggestions raise the question of whether AI-based systems will eventually replace physicians in some specializations or will augment the role of physicians without actually replacing them. To assess the impact on physicians this research seeks to better understand this technology and how it is transforming medicine. To that end this paper researches the role of AI-based systems in performing medical work in specializations including radiology, pathology, ophthalmology, and cardiology. It concludes that AI-based systems will augment physicians and are unlikely to replace the traditional physician–patient relationship.

INTRODUCTION

The term "Artificial Intelligence" (AI) was first coined by John McCarthy for a conference on the subject held at Dartmouth in 1956 as "the science and engineering of making intelligent machines" (Society for the Study of Artificial Intelligence and Simulation of Behavior, 2018). After a period of reduced funding and interest in AI research, also referred to as the AI winter (Crevier, 1993), optimism in AI has generally increased since the low point in the early 1990s. Artificial intelligence (AI) is an important field of computer science that seeks to create complex machines with characteristics of human intelligence.

We can think of this concept as "General AI," which has machines that can think and reason and even see and hear like humans (Copeland, 2016). This concept which can be seen in movies like Star Wars (think C-3PO, a droid programmed for etiquette and protocol) is not something we can achieve at this time. However, what is achievable at this time falls under the concept of "Narrow AI" where technologies exist to perform specific tasks as well as, or better than, humans can (Copeland, 2016). Examples of such narrow AI include speech recognition, facial recognition, etc. These technologies exhibit certain facets of human intelligence. Such intelligence is derived from AI techniques known as machine learning and deep learning which have improved performance in areas such as image classification, text analysis, speech and facial recognition with a range of promising applications such as autonomous vehicles, natural language processing, and in medicine.AI is poised to play an increasingly prominent role in medicine and healthcare because of advances in computing power, learning algorithms, and the availability of large datasets (big data) sourced from medical records and wearable health monitors.

The health care market for AI is increasing at a rate of 40% and is expected to reach $6.6 billion by 2021 (Frost & Sullivan, 2016). Computing power is increasing rapidly due, in part, to the wide availability of Graphics Processor Units that make parallel processing even faster and the availability of seemingly infinite compute resources on demand in the cloud. Big data is also well supported by practically endless storage in the cloud. Learning algorithms are becoming more precise and accurate as they interact with training data, allowing newer insights into diagnostics, treatment options, and patient outcomes (Bresnick, 2018b). The flood of health care data is helping push the development of new AI applications that promise to improve the efficiency and effectiveness of patient care. Healthcare related big data is available from sources such as Electronic Medical Records (EMR) and wearable health trackers, which can be analyzed in new ways. The rise of AI in the era of big data can assist physicians in improving the quality of patient care and provide radiologists with tools for improving the accuracy and efficiency of diagnosis and treatment.

AI is well-suited to handle repetitive work processes, managing large amounts of data, and can provide another layer of decision support to mitigate errors. The research firm Frost & Sullivan estimates that AI has the potential to improve patient outcomes by 30% to 40% while reducing treatment costs by up to 50% (Hsieh, 2017a). Experts predict AI to have a significant impact in diverse areas of health care such as chronic disease management and clinical decision making (Bresnick, 2016). While still in the early stages of adoption, AI algorithms are showing promise in specializations such radiology, pathology, ophthalmology, and cardiology (Hsieh, 2017a).

DIAGNOSTIC RADIOLOGY

AI's, and specifically ML's, potential to analyze large datasets and extract meaningful insights is proving helpful in both radiology and pathology. Images from MRI machines, CT scanners, and X-rays can contain large amounts of complex data that can be difficult and time consuming for human providers to evaluate (Kent, 2018). AI/DL technology and its implementation into day-to-day clinical imaging is poised to transform the practice of radiology (Liew, 2018). AI can provide clinical decision support to radiologists and improve the delivery of care to patients. With regard to image processing, DL algorithms can help select and extract features from medical images as well as help create new features. With respect to image interpretation, DL algorithms can help identify and classify disease patterns from images and help the radiologist suggest suitable care pathways for a patient in consultation with other physicians involved in the care of the patient.

PATHOLOGY

The field of pathology depends on the trained eye of the pathologist to render a diagnosis of a biospecimen (Dyche, 2018). Given the many different types and subtypes of a disease and the avalanche of new data in the form of different biomarkers and genomics data, this is becoming an increasingly difficult task for the pathologist. In addition, fewer of the nation's senior medical students choose to pursue a career in pathology (Dyche, 2018). In this scenario DL based approaches have a significant role to play. For example, researchers at Google trained a DL based CNN to assist with the detection of metastatic breast cancer in lymph node tissue on specimen images with an accuracy comparable to that achieved by human pathologists (Hsieh, 2017). It is clearly a challenging task to look for very small deposits of cancer on a specimen slide and a human pathologist can get fatigued, but an AI-based system suffers from no such problem and can scan any number of specimen slides with no loss of accuracy due to fatigue.

Couple this with the expected amount of big data in the form of human genomic data, human pathologists will find it nearly impossible for pathologists to stay current with the emergence of new these biomarkers without the help of ML (Dyche, 2018).

OPHTHALMOLOGY

Many Ophthalmology practices are already using ML and DL to revolutionize vision care. The immediate impact has been observed in the field of retinal diseases. An AI-based device has already been FDA approved to detect diabetic retinopathy (FDA News Release, 2018). Schlegl et al. (2018) developed a deep learning-based system to "automatically detect and quantify intraretinal cystoid fluid (IRC) and subretinal fluid (SRF). This system accurately characterized the pattern of intraretinal fluid in patients with wet AMD or retinal vein occlusion (RVO) and distinguished between intraretinal cysts and subretinal fluid" (Schlegl et al., 2018). The authors conclude that deep learning in retinal image analysis provides an accurate means "for the differential detection of retinal fluid types across the most prevalent exudative macular diseases and OCT devices" (Schlegl et al., 2018).

CARDIOLOGY

A research study in the UK showed that ML can improve cardiovascular risk prediction by correlating complex interactions between risk factors (Weng et al., 2017). The researchers provided data on 295,000 patients to four ML algorithms (random forest, logistic regression, gradient boosting machines, neural networks) for training purposes for correlating medical history with heart attack rates. Next, the algorithms were made to predict which of additional 82,000 patients would have heart attacks based on their records (Hsieh, 2017; Weng et al., 2017). The best performing ML algorithm, neural networks, accurately predicted 7.6% more events than the American College of Cardiology/American Heart Association (ACC/AHA) method with 1.6% fewer false alarms (Hsieh, 2017a). For the given test sample size of approximately 83,000 records, this correlates to 355 more patients whose lives could have been saved (Hsieh, 2017a). The authors concluded that "Machine-learning significantly improves accuracy of cardiovascular risk prediction, increasing the number of patients identified who could benefit from preventive treatment, while avoiding unnecessary treatment of others" (Weng et al., 2017).

APPLICATIONS

When it comes to our health, especially in matters of life and death, the promise of artificial intelligence (AI) to improve outcomes is very intriguing. While there is still much to overcome to achieve AI-dependent health care, most notably data privacy concerns and fears of mismanaged care due to machine error and lack of human oversight, there is sufficient potential that governments, tech companies, and healthcare providers are willing to invest and test out AI-powered tools and solutions. Here are five of the AI advances in healthcare that appear to have the most potential.

AI-assisted robotic surgery

With an estimated value of $40 billion to healthcare, robots can analyze data from pre-op medical records to guide a surgeon's instrument during surgery, which can lead to a 21% reduction in a patient's hospital stay. Robot-assisted surgery is considered "minimally invasive" so patients won't need to heal from large incisions. Via artificial intelligence, robots can use data from past operations to inform new surgical techniques.

The positive results are indeed promising. One study that involved 379 orthopedic patients found that AI-assisted robotic procedure resulted in five times fewer complications compared to surgeons operating alone. A robot was used on an eye surgery for the first time, and the most advanced surgical robot, the Da Vinci allows doctors to perform complex procedures with greater control than conventional approaches. Heart surgeons are assisted Heartlander, a miniature robot, that enters a small incision on the chest to perform mapping and therapy over the surface of the heart.

Virtual nursing assistants

From interacting with patients to directing patients to the most effective care setting, virtual nursing assistants could save the healthcare industry $20 billion annually. Since virtual nurses are available 24/7, they can answer questions, monitor patients and provide quick answers. Most applications of virtual nursing assistants today allow for more regular communication between patients and care providers between office visits to prevent hospital readmission or unnecessary hospital visits. Care Angel's virtual nurse assistant can even provide wellness checks through voice and AI.

Aid clinical judgment or diagnosis

Admittedly, using AI to diagnose patients is undoubtedly in its infancy, but there have been some exciting use cases. A Stanford University study tested an AI algorithm to detect skin cancers against dermatologists, and it performed at the level of the humans. A Danish AI software company tested its deep-learning program by having a computer eavesdrop while human dispatchers took emergency calls. The algorithm analyzed what a person says, the tone of voice and background noise and detected cardiac arrests with a 93% success rate compared to 73% for humans. Baidu Research recently announced that the results of early tests on its deep learning algorithm indicate that it can outperform humans when identifying breast cancer metastasis. Prime minister Theresa May announced an AI revolution would help the National Health Service (NHS), the UK's healthcare system, predict those in an early stage of cancer to ultimately prevent thousands of cancer-related deaths by 2033. The algorithms will examine medical records, habits and genetic information pooled from health charities, the NHS and AI.

Workflow and administrative tasks

Another way AI can impact healthcare is to automate administrative tasks. It is expected that this could result in $18 billion in savings for the healthcare industry as machines can help doctors, nurses and other providers save time on tasks. Technology such as voice-to-text transcriptions could help order tests, prescribe medications and write chart notes. One example of using AI to support admin tasks is a partnership between the Cleveland Clinic and IBM that uses IBM’s Watson to mine big data and help physicians provide a personalized and more efficient treatment experience. One way Watson supports physicians is being able to analyze thousands of medical papers using natural language processing to inform treatment plans.

Image analysis

Currently, image analysis is very time consuming for human providers, but an MIT-led research team developed a machine-learning algorithm that can analyze 3D scans up to 1,000 times faster than what is possible today. This near real-time assessment can provide critical input for surgeons who are operating. It is also hoped that AI can help to improve the next generation of radiology tools that don’t rely on tissue samples. Additionally, AI image analysis could support remote areas that don’t have easy access to healthcare providers and even make telemedicine

more effective as patients can use their camera phones to send in pics of rashes, cuts or bruises to determine what care is necessary.

In the very complex world of healthcare, AI tools can support human providers to provide faster service, diagnose issues and analyze data to identify trends or genetic information that would predispose someone to a particular disease. When saving minutes can mean saving lives, AI and machine learning can be transformative not only for healthcare but for every single patient.

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