ARTIFICIAL INTELLIGENCE IN HEALTHCARE: A POTENTIAL GAME CHANGER

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ABSTRACT

Artificial Intelligence (AI) is advancing rapidly and is playing an increasing role in our lives. The rapidly aging population and the rapidly rising costs of healthcare is currently placing a massive strain on the system, in terms of costs, speed and quality. One of the best uses of AI is in the field of healthcare as it could address all those concerns. In this paper, we explore the evolutionary role of AI in the healthcare space, specifically, how it can rapidly use the large volumes of data to make efficient and effective medical decisions both during a normal situation and a Pandemic such as COVID-19.

INTRODUCTION

Artificial Intelligence (AI) is the science and engineering of making machines, such as computers and robots, act and make decisions like intelligent human beings. AI is now beginning to be utilized in almost all aspects of our lives; from self-driving cars, media, finance, gaming industries, restaurants, factory automation, and healthcare (Barrat, 2015). Since the invention of the digital computers, human beings have been developing various machines smarter, with the aim of making businesses more efficient and profitable, along with making our lives safer and easier than before.

Healthcare is a very fertile area for applying AI. Our present COVID-19 pandemic also highlights how AI might be used to detect diseases and watch for contagion. An AI system called HealthMap in Boston's Children Hospital (Cho, 2020) was actually the first to warn of the COVID situation after analyzing data from social media, news reports, internet searches, and many other information streams related to diseases. For AI algorithms to work, several data points about a disease needs to be available, so that the algorithms "learn" the various nuances about the disease, and learn to recognize patterns of the disease. This is the training phase. In the next phase, the "trained" AI system is used in real world situations, to diagnose live data. With a stream of live data from the real world, the smart machine also "learns" new patterns, and is continuously updated with new facts. Artificial Intelligence technology is hence being rapidly applied in healthcare, and experts believe that AI will revolutionize it by allowing early diagnosis, and prediction of potential illnesses. Imagery Informatics, in particular, will be a leading topic because of the transformation that AI will be contributing to the process of diagnostic imagery (Das, 2017).

The purpose of this paper is to study the vast potential of artificial intelligence in making healthcare industry more efficient, less expensive and result in better healthcare outcomes. We

start with a general description of AI and explain the nature of machine learning. Next, we discuss the major uses and applications, advantages, and disadvantages of AI in the healthcare context. Then we discuss how AI could be so much beneficial specially for detecting COVID-19. The last section summarizes and concludes the paper.

METHODOLOGY OF THE STUDY

To understand the overall role of AI in Healthcare, we adopt a Systematic Literature Review (SLR) approach for collecting freely available online contents and articles. Schwarz et al. (2006) indicated that literature review studies in IS research has been a quite healthy type of efforts, especially for achieving objectives such as for developing annotated summary of existing works and explaining summarized results of existing studies. Rowe (2014) also supported similar arguments. In a case of SLR study, Brocke et al. (2015) suggested that IS researchers should make clear decisions on selecting database and journals, defining search terms, selecting criteria for including and excluding papers as well as for developing strategies for citation analysis. In particular for an analysis, it is important for conducting review widely in capturing qualitative attributes for cumulative knowledge-creation and by going beyond systematic review notion to a certain extent (Okoli & Schabram, 2010). Considering the innovative nature of AI and longer time frames for reviews, we focus on collecting sample articles through open-sourced Google Scholar database. We also reviewed technical report or prominent blogs to ensure the rapidly changing nature of AI is validly reflected for our study.

Further analysis of the identified papers was performed adopting content analysis technique which is an established research method for exploring content from human interaction process, verbal and written document with a purpose of analyzing data (Creswell & Poth, 2018). It is an influential method that allows analyzing documents as important sources of information to identify patterns of content quantitatively as well as qualitatively analyze meanings of content to identify or outline new phenomena. We employed a qualitative content analysis for analyzing selected articles. This approach has been widely used in prior research (such as Chan & Ngai, 2011) and is based on analyzing inputs and outputs and understanding the underlying processes, i.e., overview of AI and the nature of machine learning, major uses and applications of AI, advantages and disadvantages of AI in healthcare, and how AI could be beneficial specially for detecting COVID-19.

AI IN HEALTHCARE

The application of Artificial intelligence in various aspects of healthcare has resulted in improved service delivery (Bench-Capon, 2014; Cohen, & Feigenbaum, 2014). Use of artificial intelligence not only reduces costs for treating patients, but, more importantly, it also improves patients' outcomes. Currently, most health care centers are using machine learning (a subset of AI), which has resulted in improved diagnosis in comparison to humans.

AI based chatbots, like the IBM "cognitive computer" Watson, has the ability to use natural language to ask patients relevant questions, and make appropriate responses, initiate

business processes, or diagnose the illness (Barrat, 2015). These smart chatbots assist patients to make payments, provide virtual health assistance, follow up on appointments, and as well as to give medical feedback. Artificial intelligence systems have true potential to revolutionize the health care sector. Recently, Xavier University has launched the Xavier Center for Artificial Intelligence to accelerate the use of artificial intelligence to improve healthcare (Heyne, 2017 – they also host the AI Summit event to help participants in the healthcare sector learn about and share the advancements of AI in Healthcare. Doctors too are excited and eager to have new systems in place because AI can assist them in performing at a much higher level (Fornell, 2017).

With the immense increase in medical data collection, AI also boosts workflow, improves efficiency and helps with cost effective, timely and accurate data analysis. For example, Arterys' cardiac MRI automates many routine steps in cardiac analysis, drawing on knowledge gleaned from several MRI images and applying its deep learning algorithms. Such automated analysis "frees up a lot of physician time and brings a huge amount of consistency to imaging and tracking changes over time in a patient," (Arndt, 2017) according to Arterys' head of strategy and marketing. The Arterys browser-based software is being used at 40 sites around the world.

Similarly, Zebra Medical Vision allows radiologists to deliver better care at lower costs, and improve patient diagnoses (Arndt, 2017). These AI systems, however, are still early in the testing stages, and are facing some roadblocks – such as the training of medical staff to use and maintain the system and process, along with meeting the tedious regulatory requirements to obtain FDA certification (Arndt, 2017). FDA approval is important as a first step of gaining trust in the medical community.

Machines with AI are put to use in sorting vegetables, identifying known criminals in a public gathering via CC cameras, driving vehicles on their own, or detecting cancer from MRI images. It is now useful to take a brief look at how machine learning is achieved. For example, if we want to determine whether an MRI image of a lung has cancer cells, we have to create an "AI Model" (based on neural networks) to answer the question. The first step is to "train" the model – which will need a large set of real-world data from past cases. The data is split into two sets – a larger portion for "training" the AI Model, and the remaining smaller portion for "validating" the Model. Clearly, it would not be prudent to test the model on the same data on which it was trained (much like it is not wise to use the same questions in a school homework in the Final exam to test students).

In the next step, one will have to determine the important factors/dimensions that differentiate the lung cancer cells from normal lung cells. It could be dimensions like shape, location, color, and contrast. A weight is then assigned to each of these four dimensions, and is represented in a Weights matrix (denoted by W). Another matrix called the "bias" matrix (denoted by w) has "bias" values, which can be also be adjusted, so that the predicted results of the model can account for input "bias, and better reflect reality. Google's DeepMind Health is now, for instance, using mammograms from Japanese patients to get rid of any bias (Wiggers, 2018b) when trying to diagnose breast cancer in different ethnic populations (breast tissue density differs considerably for different ethnic groups).

The weights matrix and the bias matrix are used along with the values for each dimension (input) to predict an outcome. The prediction is then compared to known results in the "training" data set, and the difference is known as the "loss function." Clearly, the initial results of the Model will not be an accurate prediction, but the *weights* and *bias* values (*w* and *b* values) are adjusted after each iteration, until the output of the model matches reasonably well with the actual known results of the test data. Essentially, we are trying to minimize the loss function in the training process. It is akin to a medical resident learning how to do a surgery. Initially he/she will not know how to use the tools safely and effectively, but after extensive training, will be able to get adept at the procedure. Figure 1 is a very simplified diagram of the AI training process assuming a single Layer. As we will see later, modern machine learning often uses a technique called deep learning, in which the system learns in hierarchical layers.

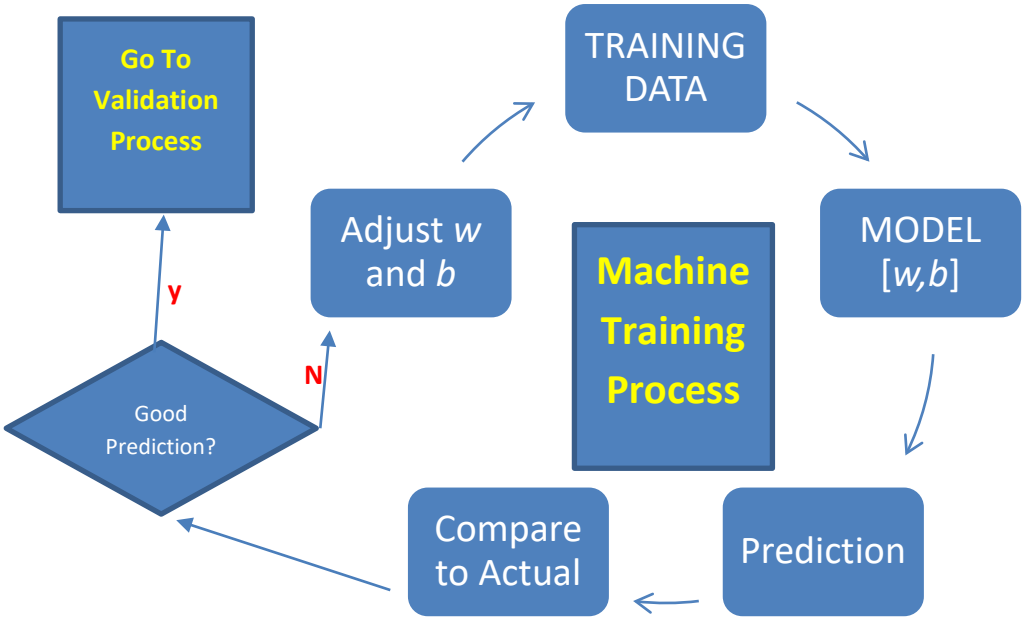

FIGURE 1: Machine Training

Once the training process is completed the adjustment of the *w* and *b* values so that the predicted answers are acceptably close to the actual answers in the testing data set, we run the AI Model against the "validation" data set that we had kept aside. This validation process allows us to see how well the "trained" AI Model can predict cases it has never encountered, thus simulating a real-life future situation. If the AI performs adequately in the validation process, doctors can start to use it with real patients in the production mode. The AI, however, will always be learning from new results, so it is a process of continuous improvement while it is on

the job – much like humans. If the AI-Model is performing poorly in the validation or production mode, the training process has to be studied, modified, and repeated until it performs well.

A more detailed discussion of the neural network AI modeling techniques and training is beyond the scope of this paper. For instance, the assignment of the initial values of *w* and *b* can make a significant difference in the "learning rate" of AI system. The learning rate is the degree to which the predicted results of the AI move towards the actual results after each training step. Most of the current systems use "deep learning," in which the machines learns in a hierarchical fashion from "understanding" at a higher level first, and then in each layer drilling down and learning more details – for example identify a living thing, then an animal, then a mammal, and finally a cat.

The type of machine learning described above is called *supervised learning*, because the objective is to train the system to come up with a function that takes the input and generates results that approximate known results in the real world as depicted in the test data. The common types of supervised learning are done for classification or regression, as shown in Figure 2 [Soni, 2018] below. In our lung cancer example above, we can ask the system to say whether the patient had cancer or not.

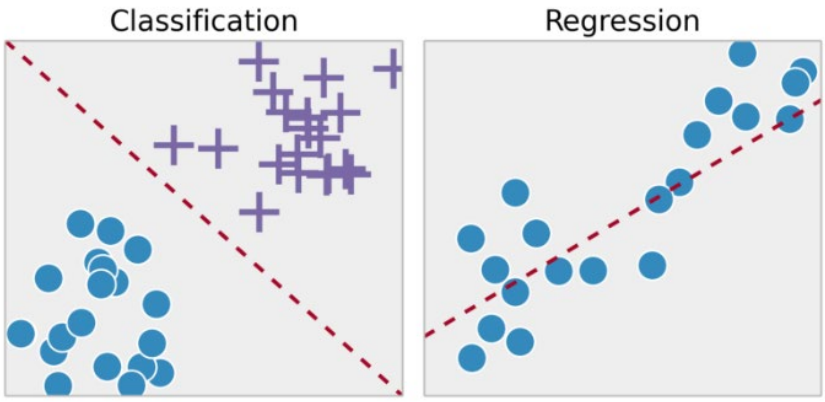

FIGURE 2: Supervised Learning

Another type of learning is called *unsupervised learning*, in which we do not have knowledge of what the correct results are. The AI needs to look for patterns by itself by studying the data set, and is often used in the context of clustering, representation learning and density estimation [Soni, 2018]. In our lung cancer example, the system employing unsupervised learning can group a given set of MRI images into subgroups for further analysis. In Figure 3 [Soni, 2018], for example, the AI groups the images into different types of animals. It will be up to us with coming up with labels for each group (for example, "ducks"). Hence, this type of machine learning is great for exploratory analysis because it can automatically find hidden

patterns in data. We can then use the groups to test other features in each group (say, analyze segments of customers)

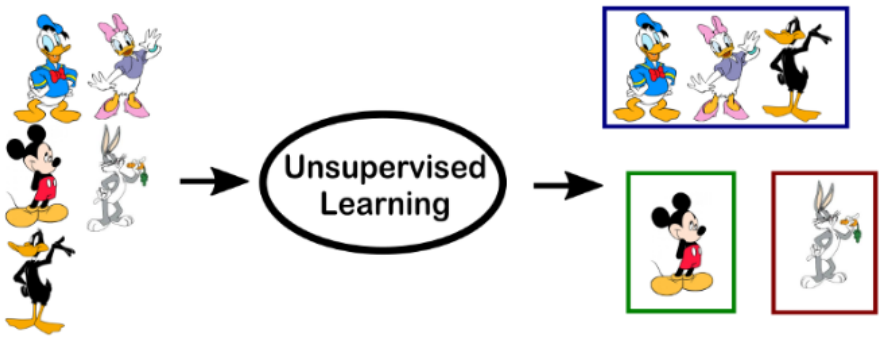

FIGURE 3: UNSUPERVISED MACHINE LEARNING

It is clear from above that the quality and quantity of data is critical for achieving machine learning and the use of artificial intelligence. We next discuss some specific advantages and shortcomings of AI in healthcare.

Healthcare Advantages And Disadvantages of AI

The use of AI in healthcare has now become a potentially powerful tool to diagnose and offer suggestions for treatments, as AI based systems now have the capacity to store and analyze large volumes of data efficiently and accurately. However, despite the vast advancement of AI, healthcare is still far behind than other industries such as auto manufacturers, financial institutions, communications, and aeronautics. In this section, we will explore the advantages and disadvantages of AI in the healthcare industry, specifically as it relates to Medical Imaging Informatics, along with the impact on patient care.

AI Advantages To Healthcare

Healthcare providers and patients will both benefit immensely from the prudent use of AI, as it can potentially make the healthcare system more efficient, effective, and result in superior patient outcomes. AI-based systems are the next generation of clinical decision support – technology designed to enhance the ability to identify and correctly diagnose problems, especially using diagnostic images or data from medical sensors. The American Recovery and Reinvestment Act of 2009 ushered in the first use of electronic medical records (EMR). This was the beginning of centralizing patient information. AI researchers say the expansion of this data will serve as the foundation for programming systems for clinical analytics. This includes mining

imaging data to improve medical treatment. (Jackson, 2016). We next discuss the major expected advantages of these AI systems in healthcare.

Speed and Accuracy

AI has the immense potential to make accurate medical diagnosis using medical imaging data. Healthcare decisions and diagnosis are made after considering a vast number of factors, and this is where AI excels over humans – finding that proverbial needle in the haystack. AI imaging systems utilize enormous amount of data that we collect these days, such as CT scans, magnetic resonance imaging (MRI), ultrasound and nuclear imaging to both train the system in the initial phase, and then to make diagnosis (McKendrick, 2018). The systems also use abnormal cases as a part of the training to help with identifying rare anomalies. In the testing phase of the system, if the AI does make an erroneous diagnosis, software programmers and medical experts can refine the algorithm until the system gets it right. In addition, unlike with human diagnosis, where misdiagnosis could go undetected for long periods, artificial intelligence helps us catch errors/misdiagnosis in a shorter amount of time.

For some tasks, like medical image analysis, AI with their advanced deep learning capabilities seem to perform just as well, or even better than medical professionals do (Fornell, 2017). What is amazing is that, AI seems to outperform humans in the diagnosis of rare diseases. The reason for that is the ability of machines to rapidly refer to much greater amounts of data pertaining to illnesses than humans could ever hope to do, In addition, the humans might never come across these rare diseases during the span of their careers.

Google's DeepMind researchers plan to review 30,000 mammogram images from Japanese patients, along with 3,500 images from MRI scans and 80,000 historical mammograms (Wiggers, 2018b) from U.K.'s National Breast Screening System, to refine its AI system and investigate whether the system can accurately spot signs of cancerous tissue of people from all over the world. Every year, nearly five hundred thousand deaths are caused by cancer, and of those 90% are due to metastasis. Researchers at the Naval Medical Center at San Diego and Google AI have now developed promising AI based algorithms called Lymph-Node Assistant (LNA) that are an astounding 99% accurate. Surprisingly, LNA is far better than human pathologists who miss small metastases 62% of the time, especially when under time constraints (Wiggers, 2018c)

AI can help immensely in other healthcare settings as well. For example, Corti is a AI-powered device that looks like a Google Home Speaker, that listens to Medical Emergency calls in Copenhagen, and tells the human call operator if a cardiac arrest is likely. It does this by listening to the caller, the background noises. Corti was able to accurately diagnose 93% of calls compared to only 73% accuracy achieved by human operators – and it did so about 30 seconds faster (Marr, 2018). Speed is an important factor in such emergencies. Corti will be rolled out in other European countries as well, and the designers are also planning to expand its capabilities to diagnose stroke and drug overdosing.

In addition, AI based surgery simulators can assist surgeons perform even better, resulting in better patient outcomes. AI is also being used to help advance neurological medicine.

The systems are able to simulate brain functioning all in an effort to provide a diagnosis and recommend. Essentially, machine-learning AI algorithms, are trained to find patterns in images, and identify specific anatomical markers that are not easy or fast for humans (Channin, 2016).

Early Detection and Proactive Targeted Prevention

We may only be a few years away from using artificial intelligence, at scale, to detect and even prevent life-threatening diseases. AI could potentially be used to rapidly and routinely screen for diseases such as lung or breast cancer in a cost-efficient manner. Steve Tolle, the chief strategy officer and president of iConnect Network Services says that human radiologists miss about 15% of breast cancer diagnoses (Jackson, 2016), and predicts that AI can significantly reduce that rate due to its ability to incessantly and thoroughly look at each image, using all the knowledge that has been used to train it.

Earlier this year, medical imaging giant Arterys got the first cloud-based AI or deep learning algorithm for cardiac imaging approved by the FDA (Arndt, 2017). Many see this as a revolutionary benchmark for the industry, but most importantly for patients and improved health outcomes. Arterys specializes in medical image analysis, data visualization and software and has offices in the United States, Canada and France. The Arterys system is being developed to identify stroke victims even before they experience an episode, and its algorithm was trained on images of brains suffering an attack. By teaching the machine the characteristics of a stroke, it can be used in real life situations – and the system becomes even more accurate with time, as it constantly updates its algorithms with the new real-world data.

In another interesting study, scientists at the University of Adelaide in Australia programmed an AI machine to predict death, and it had an astonishing 69% accuracy rate. The test pool included 48 patients who had their CT scans feed into the deep learning system to tell if they would die within 5 years. The AI system was trained to analyze over 16,000 image features that could indicate signs of disease in all organs (Mesko, 2017).

Finally, AI can potentially use patient data to help doctors assess patients' health risks and even suggest prescriptions and treatment options along with possible side effects and drug interactions of medications – thus opening the door to personalized medicine.

Early Detection of Pandemics and Control

Sensors can report incidences by feeding data to AI powered servers via a network, and trained AI algorithms can rapidly detect any patterns that are developing and recommend a course of action. Centene (2018) for example is using advanced machine learning to assess health trends in communities and identifies the strengths and vulnerabilities. Centene's complex algorithms through machine learning displays the segments of populations that are at high risk for important health concerns, and provides targeted, personalized programs and interventions.

Unlike humans, AI can rapidly identify biomarkers (O'day, 2018) that allow healthcare professionals to zoom in on "at risk" humans, and perhaps prevent or start early treatments to avert expensive and dangerous human conditions. Another great advantage of analyzing massive

amounts of appropriate data in real time using AI is to detect pandemics (McKendrick, 2018) before they spread too much, and limit the harmful effects to society.

Round-the-clock Availability and Remote Access

This advantage is rather intuitive, as unlike human medical personnel, machines are available round the clock, and always at peak, consistent performance. They also do not complain, demand extra or overtime pay, or want more benefits. Patients can also access these systems from their network-connected devices from anywhere; so routine and non-emergency diagnosis and issues can be handled remotely, conveniently, and cost-effectively. The best aspect is that patients, even in remote isolated parts of the country, can have access to expert health care at all times.

Faster Discovery of New Pharmaceutical Drugs

Pharmaceutical companies spend enormous amounts of money, time, and personnel to discover new treatments and drugs. A start up called Researchably is now employing AI to "read" and "analyze" research papers in scientific journals, and past studies to rapidly and filter out relevant results to achieve their goals faster and cheaper. Researchably has built a specialized database of about 30 million papers, 340,000 clinical trial records, 750,000 patents, and tens of millions of company and researcher profiles. The AI system cuts the amount of time spent scanning a paper from 13 minutes to less than 1 second (Wiggers, 2018a). In addition, 3 out of 10 papers are currently categorized incorrectly, and so does not reach the right people who need it, but Researchably eliminates those kinds of mistakes that were made before. Pharmaceutical giant Sanofi is extremely happy with Researchability, as it totally disrupts the traditional slow, erroneous processes, and claims that it makes drug discovery much faster, simpler, cheaper and more accurate.

AI also has the potential to make new drug discovery much more time and cost efficient. Traditionally, the drug discovery process involved many trial-and-error procedures using large quantities of many chemicals, employing several scientists, buying and maintaining lab equipment, taking a lot of time, and expending a lot of money. Enormous number of failed attempts and serendipity was the norm. The newer approach using AI is far more efficient in identifying the right chemical structure, and hence increase the efficiency of both drug design and synthesis, making pharma companies more efficient, more profitable, and reduce chemical waste (Carbeck, 2018). AI algorithms analyze all known past experiments and then suggest new molecular formulas for drugs and possible ways to synthesize (manufacture) them. These automated systems using AI have dramatically accelerated the identification of new drug leads. BenevolentAI is among the many startups that are exploring AI for drug discovery. BenevolentAI is attempting to apply AI to the entire drug development process, from the discovery of new molecular structures, synthesis and finally the design and analysis of human clinical trials to establish effectiveness and safety for human use (Carbeck, 2018).

Help Humans with Emotional Decisions

In China, the PLA General Hospital in Beijing has developed an algorithm using machine learning to determine the probability of coma patients waking up in the future – so that doctors and family members can make a more informed decision on how to proceed in trying to revive or just say goodbye. They used functional MRI (fMRI) data from 1000s of coma patients to train the machine. Surprisingly, the machine also successfully predicted that a number of patients would regain consciousness, even when many of the human experts predicted that there was almost no hope. The system was about 90% accurate for the 300 initial patients (Tangermann, 2018) on which it was tested, and now China is hoping to roll it out for about 50,000 coma patients in China.

It must be noted that life-and-death suggestions from AI based systems, such as keeping coma patients alive or not, should not be seen as a final decision. The AI algorithms are only using past data to determine a probability (an "AI score") of regaining consciousness for a specific coma patient. The AI researchers at PLA General in Beijing recognize this, and tell the doctors and family members that the AI Score should only be weighted from 20% to 50% in the final decision. The final decision to keep the coma patient alive or not, is ultimately left to humans, such as doctors and family members, as it would be horrible to let a machine make that final decision to kill a human patient. The AI system designers at PLA General Hospital recommend that the AI score be considered only in cases in which the human doctors deem the patient as a lost cause, but the AI score indicates that there is hope of revival (Tangermann, 2018).

Lower Costs and Higher Profits

Many of the previously mentioned advantages invariably leads to cost reduction and higher profits to organizations. The ability to rapidly diagnose a patient correctly results in increased productivity of healthcare systems. An AI-infused system can likely use less human personnel for handling more patients in a given amount of time. Alternatively, the number of patients that can be handled in a day can be increased using the same number of healthcare personnel. In either case, there is potential for higher profits and/or lower costs for healthcare organizations. Lower costs, in combination with better patient outcomes is a winning proposition. Igor Barani, MD, chief medical officer of deep learning healthcare company Enlitic (Jackson, 2016), believes that the Deep Learning is particularly useful in radiology because there are a lot of data variables accessible in electronic formats, and that there is a clear to need to speed up radiology given the growth of medical imaging while keeping costs low.

In the modern world, it is important for healthcare organizations to deliver their services quickly, at lower cost, and with higher quality. Healthcare is very expensive in US, and we spent $3.3 trillion (17.8% of US GDP) – which is the highest among developing countries (Markman, 2018). The budget for physician and clinical services grew remains the fastest-growing portion of overall annual budget, and the use of AI to reduce escalating costs will serve well. Use of smart systems can take the screening and other routine activities off the Physicians workload and

free them for more value-added services. Proponents also believe that deep learning machines can best serve the healthcare industry by becoming the workhorse when it comes to performing repetitive or time-consuming tasks.

We have discussed many of the amazing benefits of using Artificial Intelligence in the healthcare area. Table 1 summarizes the important advantages of artificial intelligence to the healthcare area. In the next section, we discuss some of the major disadvantages of using AI in this area.

Table 1: Advantages to AI-based Healthcare

ADVANTAGE	REASON
Speed and Higher Accuracy	Able to Learn from vast amounts of past knowledge and Apply it consistently and quickly using superfast machines using Deep Learning
Early Detection and Proactive Targeted Prevention	AI can discover new biomarkers
Early Detection of Pandemics and Control	Sensors can report incidences and AI can see the pattern rapidly
Round-the-clock Availability and Remote Access	Advantage of Network -based services
Faster Discovery of New Pharmaceutical Drugs	Simulate several combinations of relevant chemicals and make predictions of the results
Help Humans with Emotional Decisions	Should treatment be continued – make decision less emotionally taxing
Increased Profit	Cheaper than human experts, works 24/7, Less errors

Ai Disadvantages To Healtcare

Like most technology, while AI does offer many benefits to healthcare; it also comes with its own unique set of potential problems. It is clear that AI deployment in healthcare will adversely affect many of its current stakeholders, and so naturally, there is pushback from opponents like healthcare providers, ethicists and government agencies. These disadvantages are primarily based on product limitations and the consequences of using these efficient, but increasingly non-human healthcare systems. We next explore some of these adverse consequences of deploying AI.

Loss of Human Jobs

Healthcare professionals are naturally apprehensive of AI, as it has the very real prospect of infringing on their employment. Radiologists see accurate and fast image-diagnosing AI systems as a real threat, as do many physicians and nurses. This threat is more than just a perceived threat, as these systems are already part of the plan for certain hospitals. One of United Kingdom's biggest Hospitals, the University College London Hospitals (UCLH) and the Alan Turing Institute are collaborating to bring the efficiencies of AI to the National Healthcare

System (NHS). UCLH plans to use AI to diagnose cancers using CT scans and speed up patient waiting times in Emergency Rooms (Devlin, 2018). They later plan to expand the system to also identify at-risk patients and proactively direct resources to prevent expensive treatments at a later stage, if they were left untreated.

Medical personnel can easily see the great advantages of artificial intelligence, but are also aware that they can eventually become a major threat to their livelihood. Proponents of deploying AI often counter this fear by stating that the systems will be a welcome relief to medical personnel as it eliminates the routine, boring and mundane tasks, and thus freeing up time for doctors and nurses. The extra time can then be devoted to more meaningful and higher-value patient care.

When employing "smart" technology, there is the danger of "learned helplessness," when humans become too reliant on machines. This could adversely affect human problem solving abilities, lateral thinking and multitasking abilities. With so much assistance from machines, if humans do not need to use their thinking abilities, these abilities will gradually decline, and they will just start accepting the machines' results as always correct. Even if machines are accurate 99.9% of the time, it would be prudent for a human to ultimately apply "common sense" and "approve" the machine's recommendations.

Inability to Explain AI Healthcare Decisions

One big hurdle for widespread AI adoption maybe the lack of any explanation of the healthcare decisions made by AI to existing human experts. When IBM tried to promote its AI Watson system to cancer doctors, it was met with extreme resistance for this reason, and the human doctors often just dismissed the systems diagnosis (Bloomberg, 2018). Perhaps as the next generation of medical professionals get more familiar and comfortable with AI and Machine Learning, AI in Healthcare might be embraced much more readily (ScienMag, 2018). There are new developments in the AI field, such as the IBM AI OpenScale Program that aims to encourage AI systems to be more transparent, increase the explainability of AI decisions and build trust. The inability to fully explain healthcare decisions by complex, but accurate AI-based healthcare systems also makes it hard to regulate them by the governmental agencies like the FDA.

Some AI experts, such as Harvard's senior researcher David Weinberger, however, caution that making a AI-system simple enough to explain to humans, will undermine the very reason of using an AI – as their main advantage is complexity and nuance (Gershgorn, 2018). Human models are necessarily constrained to a few variables due to our cognitive limitations, but machine models optimized for healthcare decisions cannot be reduced for human understanding – and still be effective. Instead, it is suggested that we should simply focus on what the AI-system is optimized to do, and then constantly improve the results with more data, when necessary, so that it yields the result we seek.

Loss of Patient Data Privacy

AI training is best when large samples of relevant data is available. If privacy is not a concern at all, the Healthcare systems could store and analyze the entire population's data to make very accurate diagnosis and decisions. But that would mean giving up data privacy. In countries like the USA and in the EU, data privacy is paramount (McKendrick, 2018), but that will likely limit the full potential of AI systems. Whereas in countries like China, where all the data is available for these systems, the AI based system might produce some amazing results.

Some prudent measures to safeguard confidential data is an important aspect of any large medical information system. The UCLH AI Program in UK mentioned before does not want to repeat the privacy mistakes made by predecessors such as the Royal Free Hospital and Google's DeepMind project, in which the hospital inadvertently shared the identifiable health records. All the AI algorithms and training will be done on the hospital's private servers and data will not be shared with any private company (Devlin, 2018).

Built-in Bias from Non-Representative Healthcare Data

Machines are supposed to be unbiased, in theory, and under ideal situations. However, the objectivity of an AI system depends on its algorithms, which in turn depend on the nature of the data used for training the system. So, for example, if a Healthcare AI system is trained on data that represents predominantly Caucasian patients, then it may not be accurate or effective when diagnosing patients of other ethnicities, as there may be significant differences in risk factors and natural propensities. The AI system will then lead to misdiagnosis and suboptimal treatments for the non-Caucasians, because of the inadvertently built-in bias.

One study (Knight, 2020) reported that when they analyzed 94 data sets with more than 500,000 images to spot Eye diseases, it discovered that almost all of the data came from patients in North America, Europe, and China. They concluded that AI based eye-exam algorithms were less reliable to work for racial groups from under-represented countries. It is therefore, very critical to be aware of the possible bias in the data, and include a very wide sample of data from well diversified populations and situations, so that the AI system can account for the differences in the population.

Unethical Use of Healthcare Data

Confidential healthcare Data can be used for questionable purposes, regardless of the use of Artificial Intelligence. For example, an employer might be reluctant to employ a person known to be predisposed to cardio vascular health issues, or a degenerative condition (like Parkinson's Disease, Muscular dystrophy or Alzheimer's), or cancer because of possible absenteeism and higher healthcare costs. What makes the introduction of AI into that mix particularly concerning is the ability to do real time analysis of data of all applicants or all employees – and without even asking for the data. Just observing video feeds from interview

rooms or from activities an office building can trigger potentially "unhealthy" employees or applicants.

Certainly, the diagnosis from these "healthcare surveillance" AI systems can also be used for good purposes. For example, that same system from above can also be used to inform the employees of early stage Parkinson's Disease so that they can seek early intervention treatments and possibly prevent major damage. However, the sheer ease of analysis and the ability to do it at scale, unobtrusively can be easily abused as well. With the installation ubiquitous sensors and cameras, the potential for using AI for unethical purposes is not trivial.

Machines Making Vital Human Healthcare Decisions

It was noted in the advantages section above that AI decision making can assist humans make emotional decisions more objectively, with less pain. The bigger question is whether we should defer our critical healthcare decisions to AI algorithms. It is true that machines would have access to a lot more relevant, current data, and be able to analyze it consistently, thoroughly, far faster, and better than humans can ever hope to do. However, even AI-machines are not truly "intelligent" like human experts, and do not think as creatively. They are not yet able to bring in "unusual" factors that can affect specific cases and situations. So, even though machines will often make decisions based on facts and not be affected by emotions, human society still has to decide whether we should cede control to machines. There is also the potential of machines to be controlled by rogue humans for selfish purposes, which might not be in the best interest of the patients.

Dependence and Vulnerability

As with many technologies, humans and healthcare organizations can eventually get very comfortable with healthcare decisions being made by machines. These would likely come a time when we may not be able to function effectively without these smart systems. That naturally makes the healthcare organizations vulnerable to system malfunctions, bugs or cyber hacks. Many medical personnel in the future may not even know how to deliver healthcare without these systems. Consequently, many redundancies may be necessary to keep the system operational under many adverse conditions.

Ongoing Cost of Maintaining AI System

It is well known that the initial cost of developing a computer system is only 20% to 35% of the total cost. The remaining costs are for maintaining and improving the system, and can be anywhere from 65% to 80% of the total cost (Reynolds, 2020). This regular and significant maintenance cost must be accounted for in the organizational budget. Maintenance of software can be to correct past errors and bugs, make it adapt to new data sources or devices, add new functionality for improvements, and finally to prevent any possible future problems by increasing system reliability. These costs could be for hardware, software, cloud based or other

outsourced services, and specialized personnel. It is hoped that AI based healthcare will eventually reduce the cost of healthcare, but recent surveys (Landi, 2020) indicate that AI has increased healthcare costs rather than decreasing. Increased costs, though, is only one factor, the other important factor being the final outcome for the patients.

Table 2 summarizes the various shortcomings and disadvantages of utilizing artificial intelligence based healthcare systems.

Table 2: Disadvantages to AI-based Healthcare

DISADVANTAGE	REASON
Loss of Human Jobs	AI taking some of the work done by humans previously. Enable humans do more in the same time.
Inability to Explain AI Healthcare Decisions	AI Decision Making logic is so complex with so many factors that even human experts may not be able to understand. Blackbox Approach.
Loss of Patient Data Privacy	The more data the system has, the better the training the results. Incentive to collect more types of data from more people.
Built-in Bias from Non-Representative Healthcare Data	Data reflects past behavior, which may have human bias baked in.
Unethical Use of Healthcare Data	Use of AI and data for doing harm or for very selfish reasons.
Machines Making Vital Human Healthcare Decisions	Handing over critical life-and-death decisions to machines. This could be good also as it will be more objective and consider more factors, but humans lose control.
Dependence and Vulnerability	Healthcare is compromised if the system malfunctions, stops working or is hacked.
Ongoing Cost of Maintaining AI System	The initial cost of a system is usually on 20% of the Total cost of the system. The remaining 80% is for maintaining and updating these systems.

AI FOR DETECTION OF COVID-19

The world is currently in the grip of a COVID-19 pandemic; hence it is very pertinent to study the current and potential role of AI during this challenging time. The outbreak of the novel Coronavirus SARS-CoV-2 known as COVID-19 started in December 2019, and has turned out to be one of the deadliest viruses in the history. COVID-19 has now spread almost all over the world, and has caused immense global harm in terms of health, safety, and economy.

Researchers around the world are attempting to help build AI-based tools to fight the deadly COVID-19 virus in various ways such as early detection of the virus, combating the

virus, patient monitoring, drug development, and support the healthcare professionals. Some of these are discussed below.

AI has been played a very important role in the detection of the COVID-19 infection. Jamshidi et al (2020) illustrated that some Deep Learning AI methods could accelerate the process of diagnosis and treatment of the COVID-19 disease, including Generative Adversarial Networks (GANs), Extreme Learning Machine (ELM), and Long /Short Term Memory (LSTM). Ilyas, Rehman, and Nait-ali (2020) studied some AI based approaches for the detection of COVID-19 that showed promising results such VGG19 with 98% of accuracy, ResNET with 96%, ResNet50 with 95% of accuracy, and InceptionV3 with 96%. They used x-ray images to train the AI Algorithm.

Soltan et al (2020) developed two AI-based early-detection models to identify COVID-19 using routinely collected data typically available within one hour (laboratory tests, blood gas and vital signs) during 115,394 emergency presentations and 72,310 admissions to hospital, and the AI models perform effectively as a screening test for COVID-19 in emergency departments and hospital admission units, offering high impact in settings where rapid testing is unavailable. Allam, Dey, and Jones (2020) documented the power of AI-driven algorithms for the early detection of the novel coronavirus (COVID-19) through the work of two companies, BlueDot and Metabiota, in China. There are several other studies conducted in regards to the detection of COVID-19 using AI and AI-based models and algorithms (Kumar & Rana, 2020; Mohamadou et al., 2020; Arni et al., 2020; Wong, Ho, & AR, et al., 2020; Simsek & Kantarci, 2020; Mei et al., 2020).

AI is also being investigated as a potent tool for patient monitoring and drug development. Online medical chatbots can be helpful for patients to recognize any symptoms and provide people guideline for hygiene (Ting et al., 2020). To fight this deadly virus, the world needs suitable drug for treatment. AI can be a helpful tool for the discovery of drugs for COVID-19 treatment by speeding up drug testing which may not be possible by using human labor (Ting et al., 2020; Vaishya et al., 2020). A recent research utilizing AI methods by Benevolent AI and Imperial College London reported that a drug named Baricitinib used for rheumatoid arthritis can be used against the COVID-19 virus, and another Hong Kong based company Insilico Medicine argued that it was able to design 6 new molecules that could stop viral replication utilizing AI algorithms (McCall, 2020). A deep learning system "Alpha Fold" created by Google DeepMind discovered valuable information about protein structures related with COVID-19 which can be beneficial for vaccine formulation and the process is significantly faster than the traditional experimental approaches (Alimadadi et al., 2020).

Ćosić et al. (2020) also addressed the need for timely detection of high distress situations of frontline healthcare workers during the COVID-19 pandemic, and proposed AI based multimodal neuro-psycho-physiological features to detect mental health disorders early enough to prevent and reduce the emergence of severe mental illnesses. Healthcare workers may develop mental disorders, such as elevated rates of anxiety, depression, posttraumatic stress disorder (PTSD), or even suicidal behaviors. AI-based tools could play an important tool in our healthcare arsenal to prevent or minimize distress for Healthcare workers (or any one).

Additionally, McCall (2020) also discussed how AI could be used for protecting the health-care workers and curbing the spread.

SUMMARY AND CONCLUSIONS

Healthcare is a very important component of society and the global economy. As the human population grows, along with longevity, healthcare also comes at a very large cost. In this paper, we have demonstrated that technology, and specifically the use of artificial intelligence (AI), is a promising way to increase the quality and speed of healthcare in a cost effective manner. AI is also a great tool for detecting health problems at an earlier stage, thus preventing crisis situations and pandemics like the current COVID-19 one that is ravaging us. AI, however, does have some drawbacks such as jobs displacement, loss of human control, and the potential loss of privacy and excessive dependence on the technology.

As promising as AI is for superior healthcare outcomes, speed and cost reduction, it does face some formidable barriers to adoption. A major barrier may be the resistance from humans in the medical industry, who may fear rapid changes and potential threats to their jobs. Another hurdle may be the liability issues and jumping regulatory hurdles. Finally, the initial costs and effort needed for obtaining unbiased, but large quantities of relevant data for training these AI systems, and maintaining data privacy, may be a formidable obstacle as well.

Despite the hurdles, it is very likely that AI will rapidly get adopted by the healthcare industry, as the potential benefits may far outweigh the disadvantages. Major technology companies such as Apple and Google are also pushing hard for a much more tech-centric healthcare industry by providing cost-effective solutions. It will be an understatement to state the AI is about to completely revolutionize healthcare.

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