EC601 A1 - Product Design - Project 1
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ARTIFICIAL INTELLIGENCE IN HEALTHCARE

Abstract:

For decades now, the healthcare industry has been making use of technology for a variety of reasons. Diagnosis of illnesses or diseases, prognosis, design of prosthetics or for improving administrative efficiency, Artificial Intelligence (AI) has been at the forefront of such advancements. This paper provides an overview of all the areas in which AI can be used to solve problems in healthcare and also discusses the potential pros and cons of its use. In addition to that, this paper also analyzes many topics of recent or ongoing research in these areas, with a detailed review of an instance where AI could enable or assist in the early detection of cancer.
Keywords: Artificial intelligence, machine learning, deep learning, healthcare, diagnosis, predictive modeling

1. Introduction:

Technology has made quantum leaps possible in all industries. In the healthcare industry, the use of technology to solve problems may not have been a seamless transition, given its ethical and potentially life-threatening concerns. In spite of this, the progress that has been made so far is nothing short of revolutionary. Such advancements are truly a sign of hope for what the future holds with respect to using technology in healthcare.

What is Artificial Intelligence?
AI can be thought of as the science of making a machine smart enough to think and act like a human. Being able to make a machine mimic what the human brain does instinctively is what makes AI fascinating. Every industry has its own set of problems and lately, AI has been the solution to these. In healthcare, it is not just the problems that can be solved using AI; one can also automate certain redundant tasks and make it easier for doctors and/or patients to address concerns. Diagnosis, prognosis, increasing administrative efficiency and remote patient monitoring are just some of the aspects that have been made better using AI. It also brings with it certain challenges and ethical concerns that need to be addressed with future research. It is important to keep in mind that no technological advancement should come at the expense of or take advantage of those very users that it is trying to help.

2. An overview of AI in healthcare:

2.1. Diagnosis of diseases:

It is possible to train a machine to make a diagnosis or at least, assist in the diagnosis of diseases or other medical conditions. Machine Learning (ML) models can be trained using large amounts of real-world data comprising medical records, medical images (X-rays, scans, and so on. Merely by analyzing and studying past datasets, one can train a machine to make predictions about the future. Say that an oncologist has been meticulously maintaining patient data pertaining to cervical cancer for the past 10 years. One can find patterns of the progression of cancer by studying this dataset. However, when done manually, it is an almost impossible task that is also prone to human error. On the other hand, when this task is carried out by feeding data into a machine, making it learn and telling us what we need to know simplifies the whole process significantly. This machine can also analyze the various intricacies of the same dataset. For instance, if one were to find the effects of a certain drug used to treat cervical cancer on a particular population group, i.e., categories based on age, ethnicity, lifestyle, genetics and so on, a machine can give us answers much faster than and much more accurately than if a human were to carry out the same task. This is where automation using AI can help change how we see and approach the whole diagnostic process.

Similarly, there has been a recent increase in the use of Deep Learning (DL) models (a subset of machine learning) to diagnose or detect breast cancer. In a recent report published by Lancet, AI-driven models were able to detect 20% more cancers using mammogram readings than conventional methods of detection [1]. Such research was also expanded to other medical conditions, including but not limited to skin cancer, brain tumors and so on. Essentially, what all these AI models do is detect abnormalities: deviations from normal and standard values or expectations. They do this by learning and storing past data. Genetic algorithms can be trained using AI to see if a person carries a recessive gene that could potentially lead to cancer thereby facilitating early intervention and treatment. The analysis of Circulating Tumor DNA (ctDNA) in blood looks out for biomarkers that cause malignancy and lead to the formation of cancer cells in the body [2]. This process can be automated and be made more accurate by using ML models for analysis and prediction. AI in this case is truly revolutionary owing to the fact that it facilitates the prediction of potential cancer in asymptomatic individuals. Recent studies in cardiovascular health show that ML and DL algorithms are effective in analyzing the effects and patterns of cardiovascular diseases [3]. This particular study takes into consideration various factors that could potentially influence cardiac health such as gender, age, ethnicity, Body Mass Index, length of torso, renal and liver functions and

cholesterol levels. Further advancements can also be made in the cardiothoracic field by combining the functions of both the heart and the lungs for analysis.
Whether it's by making use of numerical datasets or images or genetic data, AI as a diagnostic tool has been proven to be very successful.

2.2. Tracking disease outbreaks:

Epidemiology is a branch of medicine that studies the incidence, outbreak and patterns of human diseases and is an integral part of the public health system. This study of diseases makes use of biology, data and statistics to identify patterns and predict possibilities. This type of statistical predictive modeling can be carried out using ML algorithms. The various factors that influence the outbreak of a disease, and other underlying causes that can affect its spread can be analyzed using what is called data-driven disease monitoring. In regions where proper epidemiological data is available, a study has shown that time-series DL models are even better than traditional ML models in disease forecasting, well into the future as well [4]. This study is fascinating for yet another reason that it makes use of data from Google Query trends to provide rough but useful estimates of outbreaks weeks before its incidence. This really goes to show the various extraordinary possibilities of AI in the field of epidemiology.

2.3. Drug testing and discovery:

Discovering new drugs to treat illnesses is a constant in the field of medical sciences. Consequently, testing the effects of drugs on different populations or age groups is also a necessity. The COVID-19 pandemic has only emphasized the need for more novel methods of drug discovery followed by rapid testing to allow time for adjustments and approval. Medical data pertaining to molecular screening profiles, pathology records, personal patient health records and so on, have the potential to be of immense use in the field of drug discovery. For instance, when combined with AI, one can use these data to analyze and determine the type of protein binding to determine the drug's likely properties. This type of drug combination analysis with AI can also help us predict the efficacy of drugs in particular population groups. Recent studies published in the PubMed journal discuss in detail the use of AI in the overall drug discovery pipeline: starting from target identification all the way up to quality assurance [5]. In this study, conventional ML was seen to be useful to identify the target protein that the drug must work with. DL Neural Network models were capable of being able to determine the drug-target interaction and their binding affinity. In order to effectively optimize the properties of a molecule in a drug, Reinforcement Learning (a method of ML) produced favorable results. Natural Language Processing (NLP) methods were capable of analyzing scientific literature to carry out repurposing, review and post-market analysis. The techniques proposed in the study only serve as a small example of the various avenues that AI opens

up for drug discovery and testing. Further research in these areas could drastically change the way drugs are produced.

2.4. Hospital administration:

Running a hospital is a mammoth task and is one of the prime areas of medicine where automation can save both time and money while also reducing the incidence of human error. Many patients admitted in hospitals, especially the older patients, are at a fall-risk. Requiring doctors or other medical professionals to always be by every patient's side reduces the efficiency of the hospital. Preventing a patient from falling is important for both safeguarding the patient's life and to avoid the high costs that the hospital may incur. A recent research article published by the University of San Francisco explored the use of predictive analytics using AI and statistics to predict fall-risks in patients [6]. Yet again, the use of AI was proven to be very effective in predicting fall-risks and consequently, in reducing the number of such falls. Given that there are many redundant tasks in a hospital that are time-consuming, monotonous and could potentially lead to burnout, automation can be a solution. Billing, scheduling appointments, general enquiries and updating the medical records of patients are all essential tasks that unfortunately take up too much time. Using chatbots and AI-assisted software systems to automate these tasks will result in minimal human intervention and human error. Recently, Baptist Health, a hospital in Florida, has started making use of an automatic transcribing system [7]. This application records the conversation between the doctor and the patient and transcribes it into notes that get transformed to a formal clinical summary. This is then automatically updated to the patient's electronic health record. This is just one instance, amongst a myriad of examples, where the use of AI has increased the efficiency of consultation provided at hospitals.

2.5. Remote monitoring:

The constant supervision of patients at the hospital might be feasible given the number of available staff members. However, the same supervision is not always possible since the patient cannot be expected to be in the hospital at all times during the recovery process. There are also situations where a patient might be at the risk of falling sick anytime, for instance, sudden cardiac arrests, fall risks and so on. In such cases, having a small, portable medical device on the patient at all times to monitor their health in real-time may be the best option. This device would ideally be able to relay real-time information on the patient's health to their doctors. Such a device would consist of a combination of both hardware and AI-assisted software systems. They enable a doctor to have full-time access to information about a patient's current health at all times. Such systems could also come equipped with alert systems that could immediately inform the concerned doctor should anything abnormal occur, for example, a sudden drop in the patient's blood pressure or

heart rate, erratic patterns in the patient's pulse or movement and so on. A detailed review was recently published in the PubMed journal about the various ways in which AI can be used for monitoring patients from a remote location [8]. This review found that the remote monitoring of heart health was a favorite amongst medical device manufacturers with 74% belonging to that category. After cardiac health, the constant monitoring of the general vital signs of the body was seen to be popular. Further research in these areas could expand the use of remote monitoring systems to post-operative care, gerontological support and sports physiotherapy.

2.6. ChatGPT and its idea of Personalized Medicine using AI:

ChatGPT, the online chatbot, provided additional insights on how AI can also be used to tailor medical support and advice to suit one's personal requirements. A deeper dive into this idea shows that it is indeed necessary to have personalized medical care in some cases. A great amount of biomedical research in today's world is data-intensive: medical records, medical images, DNA sequences and data collected from remote monitoring devices. These are all massive amounts of data that are very useful when leveraged efficiently. These datasets also provide information on the different types of physiological, biological and behavioral information on diagnoses, treatments and the results of treatments. A recent study in the PubMed journal elaborates on the same by giving a step-by-step description of how we can tailor medical advice to suit a patient's personal needs and also make it available to the public by publishing the data in a warehouse/repository [9]. This database can be queried later as part of an Open Source platform for other patients.

3. An exploration of AI in the early diagnosis of cancer: Review

This section is a detailed review of a research article published in the PubMed Central journal that talks about the use of AI in the early detection of cancer [10].

Cancer is a condition in which there is a rapid multiplication of abnormal cells that have the ability to destroy normal tissues leading to a formation of masses of cells called tumors. If the tumor is benign, it is easier to detect and remove. However, if metastasis occurs (malignant tumors that develop in various other parts of the body by spreading from the initial location), it is difficult to detect and treat since the location of tumors remains unknown for the most part. When cancer starts to develop, it is easier to cure than when it's allowed to develop. Early intervention is the most crucial in the treatment of cancer. People go to the doctor only when they start developing symptoms that do not gradually subside on their own. When it comes to cancer, by the time people go to the doctors for a consultation, it might already be too late, and the cancer may have spread.

This is where AI comes in. This study analyzes the use of AI in the early detection of cancer. What makes it special is that it focuses on screening asymptomatic patients who are at-risk of developing cancer. This is done by analyzing medical images, blood tests, biopsy results, and so on. ML algorithms were used to incorporate this data to make predictions about the likelihood of a person being diagnosed with cancer. There is a discussion on how Convolutional Neural Networks (CNNs) and Artificial Neural Networks were made use of in the early detection of pancreatic cancer. Natural Language Processing (NLP) of data warehouses containing public health data and cancer data on patients can be carried out to analyze data and arrive at a possible prognosis of cancer. The use of DL-based analysis of medical images, particularly radiological images such as scans, MRIs and X-rays is based on the detection of abnormalities in the forms of tumors in the target region. These models are capable of differentiating between benign or malignant tumors, cancerous or non-cancerous tumors and so on. The detection of any cyst-like mass in the target region triggers a response in the model that makes it learn deeper to make a differentiation. Such methods have been used in the detection of lung, throat, brain, breast, skin and ovarian cancers, to name a few. While radiological images may be useful in detecting some types of cancer, pathological images may be useful in detecting other types such as pancreatic and prostate cancers. Microscopic analysis of pathological images and biomarker analysis of sample smears can be done using complex DL architectures like CNN. Tumors are complex and their biology and composition even more so. As a result, limiting focus to just images of possible tumors or pathological slides or biomarker analysis of sample smear may not be sufficient enough to accurately predict cancer, since it is missing out on other possible factors. This type of analytics required much more data, for instance, genomic data, nucleotide mutation data (SNP), gene methylation data, and mRNA transcriptome abnormalities, to name a few. Unsupervised ML clustering techniques and autoencoder DL techniques were seen to be useful in identifying possibilities of cancer.

This study also highlights the use of blood-based biomarkers to detect cancer. CancerSEEK is a test that can detect 8 types of common cancers by analyzing cell-free DNA. It works based on a Random Forest model that takes into account 9 proteins and 1933 gene positions. It was seen to work best with ovarian and liver cancers. Using genomic data combined with a patient's medical history is a useful way to detect cancer in asymptomatic individuals.

Model bias, data privacy, limits to data size and varying standards were seen to be the biggest challenges in this study.

The biggest takeaway from this study is that there is no one size fits all approach to the early detection of cancer. While radiological images suited some cancers, pathological images suited some others. While images suited some types, cellular and genomic data seemed to suit the others. Both these types of analyses were complemented by the

enormous amount of data pertaining to public health in general and the patient's individual health history. To aim for a more balanced approach, it would be wise to incorporate all these factors in the early detection of every type of cancer. This way, we would not be guessing the usefulness of each factor in predicting cancer as we would be quantitatively establishing its influence. By weighing out the results from image analysis, biomarker analysis, genomic and cellular data analysis and health records, doctors could make an informed decision about the next steps to be taken in the patient's treatment. This would also ensure that no important factors are missed out while trying to detect cancer early.

4. Pros and cons of AI in healthcare:

It is now imperative that the advantages and disadvantages of the use of AI in healthcare are discussed. If we were to begin with the pros of AI, it is wise to start by discussing the highly accurate manner in which AI produces results with minimal human intervention and human error, given that diagnostic accuracy is the most important factor to consider in a field like healthcare. The use of AI in the early detection of potentially deadly conditions like cancer could change the way cancer is thought of today. When used in a hospital setting, AI makes for a very efficient substitute to manpower with respect to administrative tasks such as billing, record maintenance and management, query management and so on. It would also result in a reduction of costs incurred. Furthermore, the predictive capabilities of AI could potentially decide when and how medical intervention is necessary and this could in turn help avoid unnecessary medical procedures, save man hours and time. Drug discovery and testing is one of the areas that depends on a lot of factors such as clinical trials, human trials, government approval and so on. The use of AI can be useful in fast tracking every step of the long-drawn process needed to get a drug into the market. Advancements in the area of remote patient monitoring will change the way medical institutions administer emergency care and post-operative care. With the possibility of using AI to predict possible disease outbreaks, it might be possible to prevent another pandemic like COVID-19.

Now that the advantages of AI in healthcare have been discussed, it would be wise to discuss some of its cons as well. The most important issues with AI in general are ethical concerns. AI makes use of a vast amount of data. This type of data is highly confidential because it contains private health information about people. Furthermore, this type of data also contains valuable information about drug research, treatments and so on. Should this data fall into the wrong hands, it would be almost impossible to prevent its misuse. Utmost care must be taken when dealing with such highly valuable and confidential data. When data is being processed and modeled in such large quantities, it is possible that the

results obtained from the data could be skewed in a direction that does not provide reliable results. Avoiding this type of bias may not always be possible. In addition to that, it is also a very challenging task to integrate AI with the existing systems of practice, since the use of newer technology, regardless of the setting, takes a while to get used to. This transition may not necessarily be as smooth as one would expect. While using AI for diagnoses, it can be expected that not many people would be as welcoming of the idea as one would like. The underlying fact is that AI is still a piece of programmed machine that cannot possibly outperform the experience of humans. It still needs the occasional human intervention to function as expected. There is also the growing concern that AI would replace humans at their jobs. AI is faster, more efficient and is less prone to error when compared with humans, and so, lately there have been situations where humans have unfortunately lost their jobs to AI, particularly those in the administrative sections of hospitals.

5. Conclusion:

Artificial intelligence is a wonderful example of the extent to which humans have advanced in the field of technology. When harnessed ethically and applied within appropriate limits, AI can be a revolutionary concept that could change the way healthcare is viewed today. However, there is also the downside to the excessive use of AI, wherein the limits of privacy are not respected or where there is an overreliance on its abilities. One must always remember that AI must only be used to complement the intelligence of humans and not replace it. Healthcare is one of the industries where the use of AI can potentially save millions of lives when used correctly. The future of AI in healthcare gives one a lot of hope and a boom in its development is inevitable.

6. References:

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