Advances and Application of Artificial Intelligence and Machine Learning in the Field of Cardiovascular Diseases and Its Role During the Pandemic Condition

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Introduction

In this present era of digital setting, artificial intelligence (AI) has been documented as a potent device in the marketable industrial setting and a budding automation in the domain of healthcare. AI has shown a widespread potential to influence the various fields of healthcare during the COVID-19 pandemic in a positive way. In the current scenario of data explosion, the implementation of AI in the domain of cardiovascular disorders and imaging is experiencing an exemplary modification toward machine learning (ML) algorithm. Regardless of major advancement in diagnosis and treatment, cardiovascular disease (CVD) is still the chief frequent cause of malaise and death from the global aspect, accounting for roughly one-third of yearly mortalities. Prompt and precise diagnosis is the major route to improve CVD results, and it can be tackled by regular screenings. D'Costa and Zatale [1] have stated that "although screening programmes at present can be cost inefficient for niche diseases, artificial intelligence (AI) has most definitely broken the rules of what our present cardiovascular health monitoring tools can be capable of; from using ECGs for detection of left ventricular systolic dysfunction, to cardiovascular risk prediction with accuracies higher than a mammogram." These multifaceted algorithms can effortlessly evaluate various data and mechanize an array of tasks. The present book chapter explores the role of different AI implementations that includes ML and deep learning and their implementations in cardiovascular medicine. Furthermore, it aims to provide an integrative outline of the modern research in the domain of cardiovascular diseases and AI.

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AI and Its Principles

AI may be delineated as the replication of intelligence of human being by the virtue of programming in computers. The computer appears as an ideal tool for replicating interpretation processes. AI in healthcare may help in making faster diagnosis. The system gathers previously available data about the patient and the patient's medical history and current results to form a hypothesis. Another way AI is used is in online computer programs for scheduling appointments, which aids through the billing processes and gathering medical feedbacks. This technology is utilized to endow with progressive technology-based treatment in cardiovascular medicine, because it may help in facilitating the analysis and measurement of the various aspects of human heart functions.

There are various important components of AI, of which ML and DL are essentially included as a part of this book chapter. ML is a task of artificial intelligence that comprises of programs, which analyze records, gain knowledge from the information obtained, and subsequently construct notified conclusions based on the derived interpretations. A more specialized area of ML is identified as DL. DL is more similar to the thought process of humans, operating through a "neural network." In contrast to a ML script, a DL neural network generally consists of manifold stratum, every stratum comprising of a script which in its basic provisions receives an input, runs it via a numerical function, and endows with a pertinent perceptive output. Deep learning, with its capability to gain knowledge by itself, has notably produced novel opportunities in the field of AI studies. In the cardiovascular area, this automation is being employed to identify and categorize arrhythmias and murmurs availing recordings of electrocardiographic and stethoscope, respectively. In case of echocardiography (ECHO), AI image processing may assist in the mechanization of several parameter recognitions, such as ejection fraction, and also in rapid screening assessments.

The utilization of enhanced technology in medical field and diagnostics has been considered from the 1960s. In the domain of cardiovascular medicine, systems based on AI have instituted novel implementations in imaging, risk prediction, and newer drug targets related to cardiology. Prior to the incorporation of artificial intelligence systems in diverse areas of healthcare, the requirement of "training" is essential, and that can happen with the help of the data that are generated from experimental or medical researches and related work, such as screening, diagnosis, proposed mode of treatment etc., so that they can study in comparable groups of patients or volunteers. These data are obtained in various forms like medical notes, electronic recordings of various instruments, images, and so on. Particularly, in the diagnosis stage, a significant percentage of the AI review examines data from diagnosis imaging, genetic experiments, and electrodiagnostic results.

Real-time adjustments of ventilation settings and drug dosage could be done based on monitoring of patients' bodily responses and functions. A single computer can do monitoring on many patients in a unit simultaneously and provide relevant data about further course of action. Rising costs of healthcare could also benefit

from AI, since its use improves the quality of care and reduces time in making decisions about treatment prescribed and also diminishes the number of human hours required, effectively reducing the cost. Since part of AI is learning from reasoning, a routine and regular use in clinical aspects would help to better the system. Cardiovascular medicine doctors and scientists at Mayo Clinic are coalescing artificial intelligence with medical practice, viz., with electrocardiogram (ECG) machine learning, to enhance caregiving. AI is employed to recognize innovative drug therapies and ameliorate the effectiveness of the medical practitioner. Explicitly the result of the COVID-19 patient can be predicted from cardiac-based algorithms. In this pandemic scenario, this digital technology was reported to control some processes of treatments.

Applications of AI in the Medical Field Settings

AI has multiple applications in the field of medicine. First of all, AI can help health professional in the analysis and evaluation of the disease and also to delineate an effective treatment protocol. The Application of AI in various medical approaches can diminish the frequency of misdiagnosis and thereby ameliorate diagnostic effectiveness. Secondly, the identification and application of deep learning has augmented the skill of AI to identify healthcare imaging and offer healthcare professionals with additional dependable imaging diagnostic data. Another important application of AI is that by utilizing big data analysis, the algorithms may frequently give additional precise outcomes for patient prediction. AI may also provide assistance for investigations in pharmaceutical industry, which can ameliorate the efficacy of novel drug development. Lastly, the amalgamation of AI and robot-assisted surgery may ameliorate the precision of numerous difficult and complicated procedures. Amidst the advancement of AI, big data analysis, and cloud computing technologies, AI may be capable of offering patients with elevated quality medical services. Furthermore, artificial intelligence will help to lessen patient's time of waiting and charge and get secure, suitable, and elevated standard of therapeutic services. Hence, the accomplishment of DL of AI will be of an added advantage to the field of cardiology.

Application of AI in Cardiovascular Diseases

Presently, AI technologies have been practiced in the area of cardiovascular medicine, which includes "precision medicine, clinical prediction, cardiac imaging analysis and intelligent robots." There are positive promises of the application of AI in the domain of cardiology.

Precision Medicine

At the outset, from the perspective of the patient, AI can be primarily utilized for distant pursuing of the patient, medicine remembrance, real-time ailment analysis, and prior cautions of various signs of diseases. Simultaneously, from the viewpoint of medical professionals, AI can facilitate collection of voice data (e.g., case history), attach electronic health checkup data arrangements, and condense the burden of doctors. It has been reported by researchers that in the subsequent times to come, cognitive computers, which are instruments that are upskilled via ML or DL programming, can decipher certain complications without healthcare professionals support, will assist medical professionals formulate precise assessments, and forecast patient results. Scientists have suggested that there is almost no probability that AI will substitute medical professionals. On the contrary, healthcare professionals should be acquainted with the utilization of AI technology and procure skill in this form of practice through the application of AI for the betterment of CVD diagnosis and management by evaluating the big data.

Clinical Prognosis

By the assistance of ML and analysis of the big data, artificial intelligence can facilitate medical professionals to provide precise prognosis for the patients. It was reported by Dawes et al. [2] that AI may forecast probable time phases of mortality for patients with heart-related disorders. Furthermore, it was also reported by the researchers that AI application documented the reports of cardiac MRI scans and tests of various related blood parameters of 256 patients suffering from heart disorder by various mechanisms. It was observed that AI could guess the possible abnormal circumstances that my lead to the death of the patient. Furthermore, the abovementioned application was capable of estimating the survival rates of patients for the subsequent 5 years, and the precision of the prediction of the succeeding year easily reached 80%. Motwani et al. [3] instituted a predictive model through the lens of DL and evaluated the threat of fatality for the subsequent 5 years for 10,030 patients suspected with coronary heart disease (CHD). The results obtained from their research specified that "the risk assessment based on AI is superior to traditional clinical judgement and coronary computed tomographic angiography."

Cardiac Imaging Analysis

In the current era, for the initiation of DL, cardiac imaging investigations have revealed an immense progress. Deep learning can facilitate the analysis of coronary angiography, ECHO, and ECG. Scientists have predicted that in the near times to

come, by using DL, artificial intelligence can recognize coronary atherosclerotic plaques more perfectly than the medical practitioners. Additionally, AI can also be employed for examining the echocardiographic images, encompassing automated evaluation of each chamber dimension and evaluation of left-side ventricular function. Additionally, it can also be utilized to evaluate diseases related to structural aspects, viz., valvular disease, for helping in determining various aspects of the disease. A study by Samad et al. [4] revealed that DL can predict the survival rate of patients with elevated precision after evaluating ECHO of several patients. There are various additional purposes of the application of AI in cardiovascular imaging examination (which is regarded as one of the major important standards for the diagnosis of cardiovascular diseases), such as intravascular ultrasound and optical coherence tomography MRI, to name a few. In the coming days, DL will construct imaging analytics more dependable, simpler, and quicker to achieve results.

Intellectual Robots

The introduction of robots programmed for performing surgeries has helped medical professionals execute surgery for bladder replacement and hysteromyoma resection. In subsequent times to come, the blend of artificial intelligence and modestly invasive surgery technology, such as the Da Vinci Surgical Robot, may formulate the utilization of programmed surgery more pragmatic. This may diminish distress and suffering of the patient, enhance surgical protection, and curtail postsurgical stay in the hospital. It has been suggested by a group of researchers that "with this kind of combination, instead of clinicians, AI can perform cardiac interventional operations, such as percutaneous coronary intervention (PCI) operations and catheter ablations of atrial fibrillation, on patients; which will reduce the radiation exposure for the clinicians from the use of digital subtraction angiography." Therefore, it can be suggested that the integrated use of artificial intelligence and robotic surgeries may encourage the insurgence of conventional medication.

Clinical Decision Support System and Preventive Cardiology: The Application of AI

Yan et al. [5] suggested a fascinating idea by proposing that wherein the conventional model engaged a health professional diagnosing and providing "instructions" to a patient in a straight way, a newer advancement might be relatively that a medical professional will be providing directives to a solution-based AI, thereby acting as a linkage. The programmed application of AI would explore for errors, if any, in the practitioner's analysis and would then ask for assistance from a senior healthcare practitioner prior to ultimately passing the exacted recommendation on to the

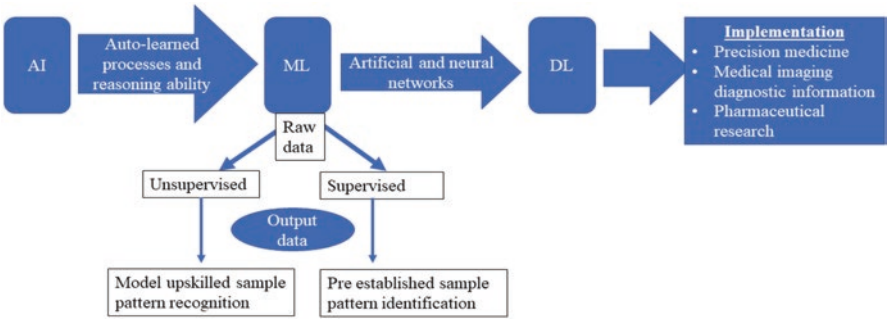

Fig. 1 AI, ML and DL-relationship and its Implementation

patient. These advancements would most certainly aid in declining mistakes in clinical practice, acting as a "redundancy tool." The instance of Google is very apt in this regard, where it has been capable of determining factors leading to cardiovascular risk from retinal fundic images, age, sex, smoking, blood pressure, and key unfavorable measures. This activity allowed the researchers to utilize these records to assess the patient's threat of various cardiovascular diseases, with a precision of 70% (Fig. 1).

Applications of AI During the COVID-19 Pandemic in the Domain of Cardiology

From the above data, we can delineate that digital application can be employed as supervising instruments to construct a considerable quantity of records in cardiology. AI is a smart method that can get accomplishment in the pandemic situation of COVID-19. For these instances, ML is also entailed to build up a smart system as required. This expertise will be able to forecast and treat multifaceted cardiovascular issues of the patient of COVID-19.

AI constructs an affirmative effect on prediction and evaluation of CVDs. A clinician speculates many aspects of a patient suffering from CVD from the provided electronic patient data. AI has been utilized for the evaluation of COVID-19 patients suffering from congenital heart disease. Haleem et al. [6] observed that this tool is helpful in relieving the overload of a cardiologist. The use of AI assists in scrutinizing the collected data and also helps in the decision-making process of the physicians, thus can prove to be beneficial for the patient in certain instances. Therefore, during the pandemic situation, it can be utilized to resolve complex difficulties by using technology-based clinical assessment systems. It assists physicians to give a precise prediction and at the same time also may lead to the enhancement of the human thinking process and cognition. The major noteworthy prospective of this system is to advance the healthcare quality provided to the

patients of COVID-19. The physician can virtually verify the information of a patient even without travelling to the hospitals and therefore in the process may circumvent this infection. Expert advice of the cardiologist can be taken by the patient via an application, reducing time by preventing unessential hospital visits during the pandemic scenario.

AI and Cardiology Treatment During the Pandemic Situation

In the exigent circumstances of the pandemic, a critical challenging issue for the cardiologists was to suggest well-timed and suitable advice to the patients. The widened extend of the virus all through the pandemic has provided various obstacles for the patients visiting the healthcare centers, such as clinics, hospitals, medical centers, etc. To provide assistance to both the cardiologists and the patients, specific solicitations of AI have been used, viz., telemedicine, wearable sensors, monitoring devices, robotic implants, intelligent robots, etc. These abovementioned methods also provided aid for patients suffering from angina, fibrillation, strokes, etc., which are regarded to be very difficult conditions to handle with conventional medical care perceptions.

COVID-19 Pandemic and Artificial Intelligence: The Challenges

The distress derived from the devastating impacts of the pandemic is global and it has severely influenced the healthcare system and its correlated areas. In this scenario, it's a necessity to successfully investigate the huge quantity of records obtained at the time of this global emergency, and AI can perform it efficiently. AI processes the unrefined data and then, by the process of data mining, obtains an important conclusion. Further, it utilizes a variety of algorithms for automated data analysis. It has been reported by various studies that it is a useful tool for monitoring the COVID-19 virus and preventing its universal spread. Consequently, AI may also aid in developing a complete perception of certain aspects of COVID-19. The noteworthy proficiencies of artificial intelligence for the pandemic may be enlisted as follows:

- Examining various data related to transport systems in the nation during the spread of the virus
- Tracking and predicting a social evaluation of diverse areas
- Aiding measures in evaluating the effect of the worldwide pandemic
- Investigating the advancement of the enduring COVID-19 condition
- Providing an enhanced resolution for the healthcare management structure during crisis at the universal level

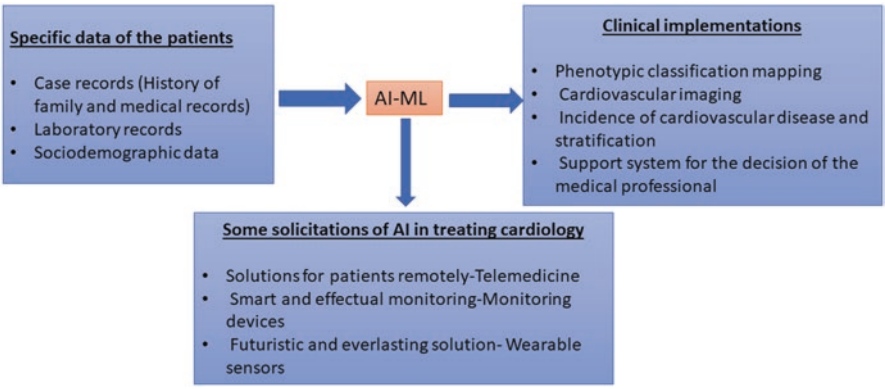

Fig. 2 Application of AI in cardiovascular research and Covid-19 pandemic

- Computing the constant impact by COVID-19
- Suitable supervision of the patient affected by COVID-19
- Automatic and regular tracking of physical condition of the population
- Appropriate investigation of the medical records obtained during the global crisis
- Proficient evaluation of the infection (Fig. 2)

The Future Scope of Artificial Intelligence

The era when AI will substitute a cardiologist is not yet in the future sight. Even though not conventional yet, we are unquestionably in the epoch where artificial intelligence is aiding cardiologists globally routinely in the rapid and enhanced evaluation and image understandings. The prospect rests in utilizing this technology in domains that have not been endeavored owing to some expenditure limitations. Moreover, incorporation of automated evaluation and cardiovascular risk assessment methods into already available electronic medical documentation application would help in developing a comprehensive treatment protocol and also will assist in counseling of patients about amendable risk factors, thus providing a positive impact on morbidity and mortality. In conclusion, AI is a metamorphic technology and has mammoth prospective in the healthcare settings.

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