Recent Advancements in Artificial Intelligence Assisted Monitoring of Heart Abnormalities and Cardiovascular Diseases: A Review

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Abstract: Smart sensors integrated with artificial intelligence (AI) have brought pragmatic solutions to many networking sectors, enterprises, and as well as government organizations around the world. This review highlights linking Internet of Things (IoT) technology coupled with artificial intelligence with heart monitoring to make it more personalized and timelier by allowing devices to communicate with one another. Most heart attacks result in the death of a patient much prior patient seeking treatment. The conventional and established treatment strategy is passive, in which patients initiate contact with healthcare providers. As a result, if the patient is not in a state to contact healthcare professionals while facing critical symptoms of cardiovascular disorders, they are unlikely to call for help. The potential prospective of AI in learning information contained in human heart rate monitoring for boosting an individual’s performance is briefly outlined in this research.

Keywords: artificial intelligence; machine learning; cardiovascular diseases; smart wearables.

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1. Introduction

Heart disorders currently account for more than 3 million fatalities in India each year, being this country’s biggest cause of death. Patients with cardiac disorders are unaware of various internal physiological changes and seek medical help only when the symptoms worsen, or they become critically sick [1]. However, disease-related symptoms are not frequent; they appear when the disease has progressed to a stage that has caused irreversible changes. Consequently, most patients with heart disease die before they receive any medical attention and optimum therapy. Thus, transforming old passive treatment options into an extensive approach is essential to improve patients’ performance in cardiovascular diseases and lower disease death rates. Healthcare professionals should keep an eye on patients’ health status and can provide their services depending on the patients' real-time health-related data. It is possible to monitor key processes of humans using Machine learning (ML) and deep learning (DL) with the aid of designed algorithms. The data collected through AI can be supplied to remote physicians at a cheap cost with the help of IoT, ensuring that these specialists are always aware of their patients’ physical status [2]. Some researchers presented an IoT-integrated monitoring system to treat widespread cardiac disease in their work. This system continually monitors the patient's vital signs, like routine blood pressure, pulse rate, ECG, and SpO₂, as well as pertinent variables. These systems also provide well-defined data transmission essential to balance the
demand of health-related sectors, communication with associated professionals, and processing of available resources [3, 4]. The usage of ubiquitous mobile devices and the evolution of novel portable sensors with seamless wireless connectivity and machine learning algorithms that can deliver a specialist-level diagnosis in near real-time have the potential to provide more individualized treatment. Devices for assessing hemodynamics have been invented, which help in the detection of disease-related symptoms prior to worsening of disease; they act as an indicator for cardiovascular diseases [5-7].

![Image of AI integrated Smart Wearables](https://nanobioletters.com/)

**Figure 1.** AI-assisted and IoT-based smart wearables for monitoring cardiovascular diseases.

2. **IoT-Based Heart Disease Monitory**

IoT-assisted wearable sensor systems technology in healthcare is a thriving and blossoming industry [8]. As the healthcare industry grows, we will require on-site diagnostics and data monitoring and control. Smart sensing devices and the Internet are used in IoT technology to provide an effective solution to the difficulties that networks, public and private sector enterprises, and government organizations confront worldwide (Figure 1). The treatment of most heart-related disorders nowadays necessitates long-term monitoring as well as ongoing monitoring [9]. In this sense, IoT is highly valuable because it replaces traditional monitoring systems with a more efficient method by giving important information about the patient's status to the doctor. Furthermore, the nurses or duty doctors on duty at the hospital can use the real-time monitoring system to check the patient's heart rate on the serial monitor [10].

3. **The General Architecture of IoT Medical Applications**

Architectural models of IoT-based medical appliances generally consist of basic three-layered design. The sensing layer is made up of well-worn appliances and carried by heart patients. The second transport layer of the device is made up of connectors that help to connect with various layers. The third application layer is made up of a remote server. These main levels make up the constructing blocks of IoT integrated medical appliances. Received data is sent to a distant server, stored in a database, or applied in real-time by physicians [11, 12]. When IoT tools are integrated with real-time analytical algorithms, they can be used to provide early warning of potential assaults.
4. Data Acquisition

Data obtained from sensing devices has to be transmitted directly to the remote side, but the constraints are the high cost of long-distance wireless communication technology. Consequently, the data transmission procedure is divided into two steps; the connectors are used to transmit data to remote locations at a comparable price [13]. Smartphones, Personal Digital Assistants (PDAs), and laptops work as connectors. The public frequently uses these gadgets because they have the capability of wireless connection over short and long distances, as they may be linked with computational software. The received set of data will be transferred to the distant areas by another technique that is low in price for long-distance communication [14].

5. AI Integrated Techniques for Management of Heart Diseases

5.1. Photoplethysmography.

Photoplethysmography (PPG) is used to obtain a plethysmograph optically. It detects any change in blood volume flowing through blood capillaries and other microvascular areas after it reaches the skin surface. This is a comparatively one of the optical economic techniques that patients could use cost-effectively. It was invented by scientists to record human blood flow with the help of the light bulb. PPG's can now be used to easily analyze blood pressure as the technique could be employed in wearables [15, 16]. The results of these wearable sensors are generally computed and analyzed with the help of one of the peripheral devices. Smartphones have mostly supplanted those auxiliary devices to deliver data to users user-friendly [17, 18]. Bluetooth technology is used to connect to smartphones. Consumer-grade wearable devices have made continuous monitoring of heart rhythm practical, allowing for advanced and well-organized diagnostic and patient management tools. Analysis through these techniques is achievable thanks to the widespread use of economic, easy-to-handle optical sensors as comfortable wearables. These sensors employ PPG to record blood volume variations by analyzing data from blood veins, arteries, and many small capillaries. These data are used to predict heart rate and other crucial information about the user's activity, fitness, sleep, and health [19, 20].

5.2. Mobile health.

Mobile health is an eHealth area of the healthcare system that focuses on using mobile and wireless technology to advance and improve the healthcare sector [21, 22].

Mobile gadgets, particularly nutritional self-monitoring applications, physical activity monitors, and blood pressure monitors, hold significant potential in preventing CVD. These apps can assist patients in achieving a healthy weight, increasing physical activity, quitting smoking, controlling blood sugar, and manage blood pressure and cholesterol to attain target values. Apple completed a research study [23] in partnership with Stanford Medicine to see if the Apple heart Study App (a mobile medical app that analyses pulse rate data) might use data acquired on the Apple Watch to identify abnormal heart rhythms (atrial fibrillation and other arrhythmias). This research set the path for a new large-scale pragmatic study in which user-owned devices can be used to analyze outcomes and findings [24].
The use of echocardiography in the diagnosis and treatment of cardiovascular illness is critical. However, interpretation is still heavily based on the operator's subjective expertise. Quantitative analysis may not be feasible in busy clinical settings, such as acute emergency rooms, due to the additional time necessary for manual tracing [25, 26]. As a result, it is widely recognized that optical computation is the gold standard in various fields of clinical practice, even though this takes extensive echocardiography experience. ML and its subpart DL optimize ECG interpretation by undertaking patient stratification as recent findings. The data sets are divided into training, validation, and test sets throughout the development of AI techniques. The training set frequently contains most of all accessible data, and it is used with a smaller validation set to construct the AI approach [27, 28]. Automated view classification can make it easier for standardized processes and various analytical techniques in echocardiography examinations. Furthermore, automatic view at various grades can assist non-professionals in learning, using, and predicting echocardiography [29, 30].

5.4. AI in cardiac magnetic resonance imaging.

Deep learning technologies for image capture, remodeling, investigation, and clinical resolution support are reorganized in the field of medical imaging, particularly Cardiovascular Magnetic Resonance (CMR). Several approaches for improving and expediting CMR data accession, image reconstruction, data-processing, computation, and the discovery of potential AI-linked bio-sensitive markers for cardiovascular diseases have been created in recent years [31, 32]. Because of the exponential increase in the quantity and complexity of CMR data, various AI models have been developed. However, integration into clinical practice in a meaningful sense continues to be difficult. Image capture and processing have been greatly accelerated thanks to AI applications in CMR. Data from rapidly captured undersampled MRI images have been reconstructed using neural networks across distinct sequences. Low-resolution data can now be reconstructed using a deep-learning-based super-resolution CMR Angiography framework in a limited time [33]. AI has the ability to speed up MRI scanning, image post-processing, and reporting, as well as introduce novel biomarkers and incorporate them into decision-making and prognostication models. Patients with claustrophobia, anxiety, or difficulty obeying breath-holding directions may benefit from faster picture capture [34].
Furthermore, current data show discrepancies in the availability of CMR services around the world. Scan and post-processing speeding and AI-assisted analysis can help expand the availability of long-term, faster, and less expensive CMR, resulting in better patient care in underserved areas [35].

5.5. Cardiac computed tomography.

In the recent decade, the probabilities of AI in heart CT have grown dramatically [36]. Many researchers and doctors have begun investigating the application of AI in the clinical work progress as a result of the emergence of overtly accessible datasets and various ML and DL-linked algorithms [37]. AI-assisted in cardiac CT includes Image refinement & creation, diagnosis-based classification, Object detection, and disease prognosis with outcome prediction [38]. Different AI algorithms are being evaluated for a number of applications based on distinct neural network topologies and prepared for different types of functions. AI can accomplish tasks such as classification, segmentation, prognosis and outcome prediction, and image optimization, which are all of the great interest in radiology, particularly in the field of heart CT [39].

6. Possible Future Advantages

AI integrated smart devices help people who ever had a heart stroke monitor the cardiovascular system's vital functions. Patients get a CT scan report when they come in with emergency heart stroke or intracerebral hemorrhage. That report is accessed by an AI-linked computer device to analyze and predict data in an amplified manner, thereby reducing the time to diagnose disease and thus reducing tissue damage [40, 41].

Preventing heart disease is one of the most important things you can do. By using artificial intelligence to analyze ECGs, researchers have created a low-price test to find out the presence of a weaker pumping function of the heart, which may cause heart failure if not managed in a proper way at the earliest. Because it has a database of more than 7 million ECGs, Mayo Clinic is well-positioned to advance this use of AI. To safeguard privacy, all identifiable patient information is deleted first. Then, using this information noninvasively, affordably, and in seconds, precisely predicting cardiac failure may be done [42].

Early detection of atrial fibrillation (a-fib) ECGs assisted by artificial intelligence is also used to detect abnormal cardiac rhythms (atrial fibrillation) before symptoms appear [43].

7. Conclusions

One of AI's goals is to do jobs with equivalent or with better accuracy than humans while also decreasing the amount of time it takes to do it [44]. The initial process that AI scientists and inventors do is make perfect algorithms clinically implementable to achieve accuracy comparable to or greater than that of human observers. The thorough testing and validation of AI algorithms is the second step that must be completed before being used in therapeutic settings [45, 46]. The progress in AI integrated cardiac CT is encouraging, and it is not easy to predict how far specific algorithms are from clinical use. Because of internet platforms, where publications can be openly released before being published in a peer-reviewed journal, and GitHub, where databases and algorithms can be shared, the area of AI is fast-evolving [47]. These platforms simplify sharing algorithms and discoveries, but they lack peer-
review's quality guarantee. Important examination and validation of these algorithms are critical for widespread clinical application, since judgments based on these AI algorithms may affect and effect patient care and results.

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**Conflicts of Interest**

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**References**


