

ECG CHEST BAND FOR ARRHYTHMIA DETECTION AND BIOMETRIC EHR ACCESS

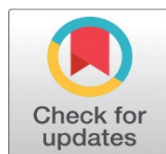
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ABSTRACT

Wearable ECG devices are valuable for heart patients monitoring systems and for fitness tracking and continuous health monitoring for individuals with no heart problems. Current devices are big, and the average person cannot afford them, which is why electronic health records need to be kept so that the ECG signal is integrated to the electronic health record. Keeping this in mind, our purpose is to make a wearable ECG device that is a lot smaller and cheaper than most devices while keeping the ECG signal intact and having smooth integration with electronic health records (EHR). Furthermore, in this case, to elicit the desired health outcome for the target population, which is all ages, we focus on health record usability, data security, and record management.

Keywords: ECG Monitoring, EHR Biometric

1. INTRODUCTION

Electronic Health Records (EHRs) are utilized in the storage, management, and sharing of patients' medical information in digital format in contemporary health care systems. Although EHRs enhance the efficiency and accessibility of health care services, major concerns regarding data security and privacy within the EHR systems. The medical field does rely on traditional security measures such as passwords, employee ID cards, and smart cards. These are not effective for securing sensitive medical information as they are easily stolen, shared, or otherwise misused. As such, access systems for sensitive data that rely on biometric verification are becoming more common in medical centers [2].

Health monitoring systems that are worn on the body allow for the ongoing capture of various physiological indicators. The electrocardiogram (ECG) is one of the MOST important among these sensors. ECG signals are used for clinical diagnoses and monitoring, and they reflect the electrical activity of the heart. These signals are also important for individual and personal identification. ECG signals, in addition to clinical application, contain characteristics that are different for every individual, owing to variations in the anatomy and physiology of the heart. This makes ECG a highly effective biometric for personal identification [1].

wearing an ecg device that authenticates your identity and ties into your electronic health records (EHR) system gives you the peace of mind that your ecg is monitoring your health and verifying your identity simultaneously always. ecg is one of the main signals that is generated by internal physiological processes and is extremely difficult to forge or duplicate. as such, ecg-based biometric systems provide spontaneous \liveness detection\ and decrease the chances of an unauthorized person accessing a system and impersonation attacks [1][2].

it is, however, challenging to build an ecg biometric system because of the ecg biosignal noise, motion artifacts, and the changes in heart rate due to a person's physical or emotional state. therefore, ecg wearable devices need to have good signal preprocessing and artifact detection and removal strategies. recent developments in wearable devices processing ecg signals have shown that real-time analysis is possible, lending ecg biometric systems an ideal application in secure intelligent ehr systems [3].

2. LITERATURE SURVEY

Secure and continuous health monitoring systems are becoming more crucial as the healthcare system advances. Traditional hospital ECG monitoring systems are cumbersome and can only monitor patients for short periods of time. These systems are unfit for the detection of intermittent cardiac anomalies such as arrhythmias. Therefore, the need for patient-friendly, long-term ECG monitoring, wearable devices, is essential. Securing Electronic Health Records (EHRs) is also of utmost importance because of the concerns of cyber threats. Literature suggests integrating biometric authentication and ECG wearable monitoring as a potential solution for the clinical and security issues [2][4].

For many years, ECG signals have proven to be reliable physiologic biometrics because they are unique and originate internally. ECG signals, unlike fingerprints or facial features, result from the heart's electrical activity. Additionally, ECG signals are not the same from person to person. Many researchers have proven that unique features exist in ECG waveforms to facilitate individual identification. These crucial characteristics of traditional biometrics make them a perfect fit for the healthcare system because of the importance of security and liveness detection.

New developments in sensor technology and low-power electronics have helped develop ECG devices, especially promising Chest-band ECG devices, which have been noted for their potential to record high-fidelity signals from the heart. Research indicates that chest-mounted ECG detectors provide more stable signals than wrist-mounted ones. This increases their effectiveness in the detection of certain heart disorders such as arrhythmia. Research also notes that ECG chest bands take the opportunity for remote cardiac monitoring a step further by allowing users to move freely with the bands and thereby enhance the discovery of heart rhythm disorders and lessen the need for in-house patient monitoring [4].

The detection of arrhythmia in wearable ECG systems has been a popular field of study over recent years, with many studies showing that the continuous monitoring of ECG increases the chances of identifying heart rhythm irregularities that would not have been found in short clinical tests. Some of the most common methods of signal processing that are used to analyze ECG signals are filtering, peak detection, and waveform analysis. ECG systems are able to provide reliable R-R intervals, which are

essential components for the detection of arrhythmia, especially at wearable chest band level. These systems provide continuous remote cardiac monitoring and are able to provide timely medical interventions.

Apart from clinical monitoring, ECG signals are used for biometric verification. Research indicates that specific-to-individual ECG patterns are stable enough for continued identification. Also, contrary to passwords or security tokens, ECG-based authentication is frictionless for users, and is very difficult to share or lose. Research suggests that the ECG biometric and EHR systems that are integrated improve access control by making certain that users are authorized to access sensitive information about a patient's records. The combined use of ECG for clinical monitoring coupled with the security of information systems is a twofold benefit and increases efficiency and enhances patient confidence [1][2].

from physical activity. Some studies suggest that chest-band ECG devices mitigate these issues owing to improved electrode stability, though sophisticated preprocessing techniques remain necessary. Some researchers propose feature normalisation, for example, to enhance reliability. Other studies have suggested that, in practical applications, combining robust signal processing and machine learning (ML) can improve real-time biometric authentication and arrhythmia detection [1][4].

The development of ECG-based systems heavily relies on machine learning and pattern recognition. Support vector machines, k-nearest neighbors, and neural networks are some of the classifiers used in prior studies for individual identification and arrhythmia detection. Studies have shown that the choice of ECG features can substantially affect the system's overall accuracy. These techniques can be applied to wearable ECG chest-band systems to provide the users with real-time automated analysis. Studies suggest that lightweight algorithms for wearable devices ensure lower power consumption and faster processing while maintaining accuracy [3][4].

Current research shows a great promise for ECG chest-band wearable systems in both arrhythmia detection and secure access to electronic health records (EHR). Research shows ECG signals as a dependable biometric characteristic and permits persistent monitoring of the heart. Moreover, the combination of wearable ECG devices and EHR systems improves the security of healthcare, integrity of data, and safety of patients. However, more research is needed to enhance robustness under different physiological situations and in the real world. This project advances the existing works by concentrating on a single system that integrates arrhythmia detection with ECG-based biometric access for secure EHR access. [1][2][4].

Secure and continuous health monitoring systems are becoming more crucial as the healthcare system advances. Traditional hospital ECG monitoring systems are cumbersome and can only monitor patients for short periods of time. These systems are unfit for the detection of intermittent cardiac anomalies such as arrhythmias. Therefore, the need for patient-friendly, long-term ECG monitoring, wearable devices, is essential. Securing Electronic Health Records (EHRs) is also of utmost importance because of the concerns of cyber threats. Literature suggests integrating biometric authentication and ECG wearable monitoring as a potential solution for the clinical and security issues [2][4].

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3. PROPOSED METHODOLOGY

1) Data Acquisition and ECG Chest Band

An ECG chest band is a type of wearable device that provides continuous ECG monitoring by capturing the cardiac electrical signals of the user. ECG monitoring at the chest level enables the band to secure the electrodes and capture high quality signals. Additionally, the user is free to engage in most daily activities while ECG monitoring is in progress.

2) ECG Data Acquisition and Transmission

ECG signals are acquired and conditionally transmitted via a low power communication module from the chest band to the processing unit. Users are free to move from one place to another while the ECG monitoring and activity processing system continues to capture and transmit raw activity ECG signals.

3) ECG Signal Processing

Before the ECG signal is subjected to further processing, it is first filtered, for example, through the removal of Power-line noise, baseline wander, and motion artifacts, so that only the glitch free signals are processed. It is then that the signal is processed using digital filters and normalization techniques to enhance its quality for further analysis.

4) Detecting Arrhythmia through ECG and Signal Feature Extraction

Some of the important features of a pre-processed ECG signal that are used to identify and detect the presence of arrhythmia are the P Waves, QRS Complex, T Waves, and the morphologies of the signals. Continuous monitoring and comparison of the morbid rhythms with the normal rhythm is vital for preventing the occurrence of dangerous abnormalities.

5) Biometric Enrollment Using Fingerprint Scanners

Fingerprint scanners allow for the biometric enrollment of authorized users in the proposed system. In the enrollment process, the users' fingerprints are captured and saved as a biometric template that is tied to the users' identities and EHR profiles. Fingerprint biometrics are reliable and ensure that only admitted users can access sensitive ECG and health information.

6) EHR Access using Fingerprint Biometric Authentication

When users want to gain access to the web-based Electronic Health Records (EHR), Fingerprint verification is performed. The system captures a live fingerprint using the sensor, and compares it with the saved templates. If a match is found, the user is granted access to the EHR, and otherwise, the system denies access. This step minimizes the privacy risks and protects sensitive data from falling into the wrong hands.

7) Web Integration and Storage of ECG data

The results of the ECG signal processing and arrhythmia detection are saved as CSV files. Using NodeMCU and UART communication the CSV files are sent to a web application. This enables healthcare providers to have a secure, web-based access to the ECG records of their patients where they can view, track, and download the records.

8) Alert Generation and Communication System

When there are abnormal patterns in the ECG or arrhythmia, there is an instant alert to the patient using the buzzer. In addition, an alert message is sent using the GSM module to emergency contacts and or healthcare providers. This gives them the opportunity to attend to the patient in case of an emergency.

Figure 1

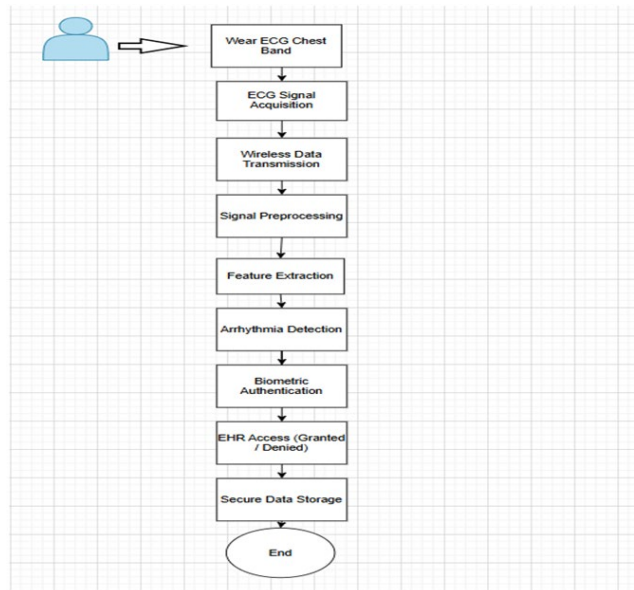


Figure 1 Flowchart of ECG Chest Band for Arrhythmia Detection and ECG-Audio Biometric EHR Access

4. SYSTEM ARCHITECTURE

Figure 2

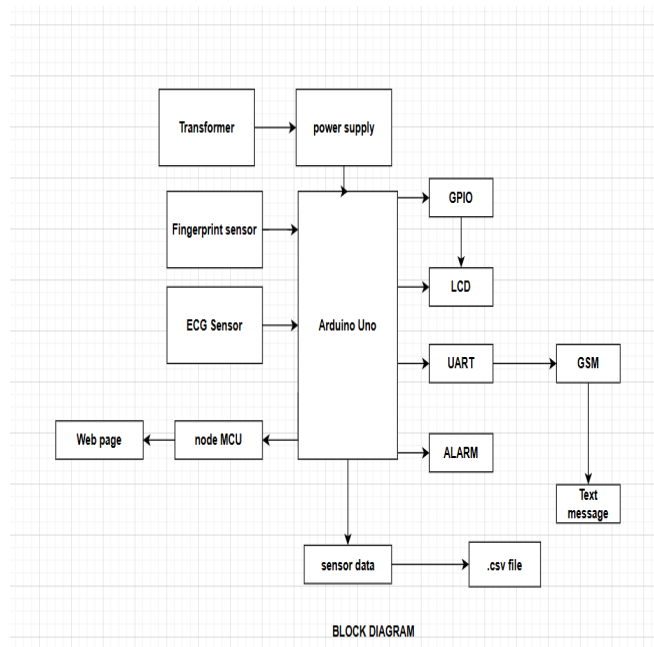


Figure 2 Block Diagram of ECG-Based Arrhythmia Detection and Secure EHR System

The system architecture proposed for the project ECG Chest Band for Arrhythmia Detection and ECG-Audio Biometric EHR Access using Deep Learning describes how the system continuously monitors the heart, detects arrhythmia, and provides EHR access. The system starts with the ECG chest band; it records the heart's electrical activity as it occurs. Due to the chest positioning of the electrodes, it provides optimal signal acquisition and reduces the possibility of motion artifacts; as such, it allows the user to perform their daily activities while the system runs.

ECG signals are digitized and sent to a signal processing unit. The communication module is Bluetooth or Wi-Fi, and the ECG signal Acquisition is done wirelessly. Because the system is mobile and the user is not tethered to any wires, there are no barriers to the user moving. The first step after signal acquisition is Preprocessing. This step involves removing artifacts, so the system doesn't confuse signal artifacts with the signal. This is done to improve the signal for the analysis step in later stages.

The next step is to extract relevant features from the ECG signal. These features include R peaks, and the morphology of the wave in addition to the time intervals between R peaks. These features are important in determining the pattern of heart activity to find irregularities.

Basic preprocessing is done to remove noise like power line interference and baseline drift after the ECG signal is acquired. From the cleaned signal, important ECG features like heart rate, R-R intervals, and waveform are patterns. These features are analyzed for detecting the presence of abnormal heart rhythms and potential arrhythmia.

When it comes to ECG records, the processed ECG data and arrhythmia results are kept in CSV format and stored for reference. Data is transferred using UART communication from the Arduino Uno to the NodeMCU and then to a web application. This enables users to remotely monitor and access ECG records through the web interface.

When there are abnormal patterns in the ECG, the patient is alerted immediately using a buzzer. Then, the GSM module sends messages to the emergency contacts. This enables access to the Electronic Health Records.

Table 1

Table 1 Hardware Components and Their Function Specifications used in the Proposed System.

Component Name	Model / Type Used	Function
ECG Sensor Module	AD8232 ECG Sensor	Acquires and amplifies ECG signals from chest electrodes
ECG Chest Electrodes	Ag/AgCl Electrodes	Captures cardiac electrical activity from the chest
Microcontroller Unit	Arduino Uno	Acquires ECG data, performs basic processing, controls system operation
Wireless Communication Module	Node MCU (Wi-Fi)	Transmits ECG data to the web application
GSM Module	GSM Module (SIM800/900)	Sends alert messages during abnormal ECG conditions
Signal Processing Module	Software (Digital)	Removes noise and artefacts from ECG signals
Arrhythmia Detection Module	Algorithm-based	Detects abnormal heart rhythm patterns
Biometric Authentication Module	Fingerprint Sensor	Provides secure biometric access to EHR
Data Storage	CSV File Format	Stores ECG signals and arrhythmia results
User Interface	Web Application	Displays ECG records and patient information
Alert Unit	Buzzer	Provides immediate alert during critical conditions
Power Supply Unit	Transformer + Power Supply	Supplies regulated power to the system

5. RESULTS

An ECG chest band with an AD8232 ECG sensor and Arduino Uno was successfully used to develop the proposed system. ECG signals were obtained and processed from chest electrodes in real time. Noise and motion artifacts were removed using basic preprocessing techniques so that ECG waveforms suitable for analysis could be displayed. This system monitored the heart rate without interruptions and analyzed R-R intervals to identify and detect the abnormal rhythm patterns associated with arrhythmias. ECG data and detection results were processed and stored in CSV format, and then sent to the web application using NodeMCU. The buzzer and GSM module were activated for emergency conditions. Users were authenticated to access the Electronic Health Records using fingerprint biometrics to guarantee access control to sensitive ECG data.

6. CONCLUSION

The project developed a wearable health care technology that provides real time monitoring of ECG signals, detection of heart rate abnormalities, and secure access to electronic health records by implementing biometric authentication. The system by using an ECG chest band, provides real time monitoring of the heart and the audio signal representation of the ECG provides an avenue for the application of deep learning techniques along with robust biometric authentication.

7. FUTURE WORK

Improved Deep Learning Models

Advanced Deep Learning Architectures are being explored. Models such as hybrid CNN-LSTM or transformer-based structures may improve both the accuracy of arrhythmia detection and the authentication of a user's biometrics. The system may further improve real-world adaptability if the model is trained using varied and extensive datasets of ECG recordings.

Multi-Signal Health Monitoring

The system may be expanded - especially if additional physiological signals such as PPG, blood oxygen level (SpO₂), and body temperature data are integrated. The fusion of multiple signals may enhance the reliability of health monitoring and may facilitate a deeper level of medical analysis.

Mobile and Cloud Integration

The system may also be developed further by incorporating mobile applications to provide real-time ECG data and alerts. A cloud-based approach may facilitate remote patient monitoring by physicians, and health records may be accessed and saved securely from remote locations.

Energy Optimization and Battery Life

The use of power-efficient hardware components together with energy-optimized algorithms will be less resource-intensive, improve battery life and may prolong the period of continuous use for the wearable device.

Enhanced Security and Privacy

More integrated security mechanisms, such as EHR storage on a blockchain, or multi-factor authentication, may further strengthen the integrated system in terms of increasing security.

CONFLICT OF INTERESTS

None.

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