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Development of Cardiac Monitoring Device Using Android Mobile Phone

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ABSTRACT

The utilisation of cardiac monitoring technology enables both medical practitioners and patients to derive advantages from the ongoing assessment of a patient's cardiac health over a period. Furthermore, these devices possess the capability to identify abnormal cardiac rhythms, which may serve as potential indicators for the existence of a cardiac ailment such as atrial fibrillation (AF). The hardware of the cardiac monitor is characterised by its minimum complexity and user-friendly operation. The primary controller of the gadget consists of the Max 30102 pulse oximeter and the ESP8266 microprocessor. The Arduino Integrated Development Environment (IDE) is utilised for the purpose of Arduino programming. The Wi-Fi module facilitates two-way wireless data communication between the mobile device and the microcontroller. The act of effectively downloading and installing the Android mobile application allows for the establishment of a wireless connection between the mobile device and the Wi-Fi network of the mobile phone. The user can employ the OLED display to monitor and track their vital signs, including heart rate, temperature, and blood oxygen saturation levels. The transmission of critical data to the cloud for subsequent analysis by medical experts or its storage on the user's mobile device for future examination is also a viable option. The ESP8266 microcontroller is responsible for managing and synchronizing the diverse tasks of the phone, while also presenting essential information to the user. After the cardiac monitor data has been successfully transmitted to the mobile device, the application is capable of computing the duration between successive heartbeats and transmitting this data to the OLED screen for visual representation.

Keywords: Heart rate, Rhythm, atrial Fibrillation, pulse oximeter, wrist band

1. INTRODUCTION

As our society gets increasingly dependent on technology, it makes sense that the number of cardiac monitoring devices will expand as well (Fernandez-Duque, 2023). The frequency and availability of real-time vital sign monitors, specifically those used for the monitoring of heart rate or blood pressure, are progressively increasing.

The utilisation of these technologies contributes to the diagnosis, treatment, and management of cardiovascular disease and hypertension, which are among the diverse medical illnesses (Raj, 2020). Nevertheless, the majority of contemporary displays are characterised by their lack of user-friendliness and their substantial physical dimensions. Manufacturers are currently engaged in efforts to develop screens that possess reduced thickness, enhanced user-friendliness, and sophisticated technological capabilities. A heart rate monitor can be worn in several locations, such as around the neck, finger, or chest. Certain products are designed to be compatible with the audio port of a mobile phone. The process of transferring information from other devices to a mobile device is facilitated by Bluetooth technology (Chow, & Yang, 2020).

The development of portable cardiac monitoring equipment offers numerous potential benefits. One of the advantages associated with this is enhanced mobility, which confers benefits to both the individual receiving care and their careers. The cost of mobile cardiac monitors may be lower in comparison to stationary cardiac monitors (Marston et al 2019). The likelihood of breakdown or maintenance requirements in smaller versions of machinery is minimized due to the decreased number of moving components. There is potential for the application of these therapeutic settings in a wider range of contexts, such as in cases when patients are confined to bed or have limited mobility (Poppe et al, 2018). Nevertheless, the development of portable cardiac monitoring devices necessitates the resolution of certain obstacles. Due to their intended utilisation beyond therapeutic environments, devices of this nature necessitate the incorporation of a rechargeable battery (Ryu et al, 2021).

Mobile cardiac monitoring systems are susceptible to the risk of data theft. It is imperative to ensure the safeguarding of patients' information to prevent unauthorized access, theft, or any sort of misuse (Keshta, & Odeh, 2021). Notwithstanding these constraints, the prospective impact of portable cardiac monitors is substantial. The potential of this technology has numerous captivating prospects for future applications. It is plausible that in the near future, advancements in technology may lead to the creation of diagnostic tools capable of detecting diverse manifestations of illness (Patra, et al 2018). The potential applications of these tools extend beyond the realms of cardiac research and patient treatment. The development of lightweight cardiac monitors is a significant breakthrough in the field of medical diagnosis (Dwivedi et al 2022). In various healthcare environments, such as hospitals and private residences, there is potential for the enhancement of patients' outcomes. If future research and development efforts prove successful, these technologies have the potential to significantly transform the practise of medicine on a global scale (Kasteren, 2018).

Despite being in its early stages, mobile cardiac monitoring exhibits significant potential in enhancing doctors' capacity to diagnose and monitor patients for heart disease beyond the confines of traditional healthcare settings (Kasteren, 2018). The utilisation of these technologies is expected to become increasingly prevalent in both medical facilities and residential settings during the forthcoming years. Scientists are currently engaged in extensive research and development efforts to explore and enhance the medical applications of mobile devices, in response to their growing ubiquity in society. This advancement holds the potential to become a highly captivating and significant development inside the realm of medicine within the twenty-first century (Rootes-Murdy, et al, 2018).

The primary objective of this study was to design and implement a cardiac monitoring system that operates on the Android platform. This article provides an overview of the development process involved in conceiving, constructing, and launching a cardiac monitoring application specifically designed for the Android operating system (Raj, 2020).

The technique employed in this study enables the detection of aberrant heart rhythms by the continuous monitoring of electrical signals, which are then wirelessly transmitted to a receiver worn on the patient's fingertip. The system that has been built has the capability to capture and store electrocardiographic (ECG) data, making it suitable for use in the realm of remote heart disease detection.

Regardless of the approach, the technology has the capability to acquire the patient's electrocardiogram (ECG) and transmit it to the physician for subsequent analysis (Larkai, 2015). The suggested technique has potential applications in the field of healthcare, specifically in telemedicine and remote patient monitoring. This technology proves to be particularly advantageous in rural areas and other regions characterised by a limited availability of cardiologists (Kirkland et al, 2019). The implementation of remote heart disease diagnosis is very straightforward for patients residing in metropolitan regions (Wang et al, 2021). This diagnostic method exhibits remarkable potential in the early detection of heart illness, enabling identification even in patients who do not display any symptoms (power et al, 2018). Through the reduction or elimination of routine medical appointments, this approach possesses the capacity to substantially mitigate healthcare expenditures. Enhances the likelihood of survival by facilitating early detection of cardiac ailments. In addition, this technological advancement has the potential to enhance public health through facilitating the timely detection of life-threatening cardiac conditions (Latimer et al, 2018).

There exist several compelling justifications for monitoring one's cardiovascular well-being. Given the cardiovascular nature of the subject matter, it is advisable to closely monitor one's progress in mitigating risk factors (Tchicaya et al, 2017). Regardless, it is imperative to eliminate the motor. In this study, the authors employ a pulse oximeter and an ESP-8266 Wi-Fi module to exemplify the application of remote health monitoring. Elevating an individual's heart rate through physical activity is a fundamental determinant of one's health status. Furthermore, it is crucial to monitor one's weight, resting metabolic rate, and blood pressure (Chooruang & Mangkalakeeree, 2016). In order to maintain feasibility, our focus will be directed towards an affordable and straightforward method for monitoring heart rate. This will involve utilising an ESP-8266 module in conjunction with a pulse oximeter sensor.

The continuous monitoring of cardiac activity is a fundamental component of both preventive and therapeutic healthcare. Accurate heart rate monitoring necessitates the use of a reliable device. While there is a large availability of cardiac monitoring equipment, it is important to note that not all of these devices can be considered reliable or capable of reliably detecting irregular heart rhythms (Wang et al, 2021). The ECG signal will be subjected to digital filtering utilising the analogue capabilities of the esp8266 microcontroller in order to ensure precise visualisation of the cardiac rhythm.

The electrocardiogram (ECG) signal will be subjected to digital filtering using on-board C code, followed by its reconversion into the digital domain. Subsequently, the altered electrocardiogram (ECG) signal is transmitted wirelessly and subjected to monitoring through an Android application specifically developed for this purpose (Chandra, & Singh, 2020).. In order to optimise patient care, it is imperative for the cardiologist to diligently monitor the patient's heart rate and conduct a comprehensive analysis of this metric in conjunction with other pertinent indicators. Instead of being dependent on a wireless connection, the transmission of a real-time electrocardiogram (ECG) signal to the cardiologist's smartphone can be facilitated by the utilisation of a Bluetooth module.

The use of real-time remote analysis of patient data by cardiologists has the potential to enhance the reliability of the project and potentially result in improved treatment outcomes. Individuals working in the field of cardiology who encounter difficulties in attending routine check-up appointments may find a remote monitoring equipment advantageous (Penmatsa & Reddy, 2016). The efficiency of healthcare systems will be enhanced by reduced time allocation for the processes of diagnosis and treatment.

2. LITERATURE REVIEW

The esp8266 microcontroller is frequently employed in low-power IoT devices due to its cost-effectiveness and extensive range of practical functionalities. The ESP8266 is a widely utilized microcontroller that is frequently employed in modern cardiac monitoring equipment. This article aims to critically examine the fundamental characteristics of the microcontroller under study and draw comparisons with other commonly utilized microcontrollers. This analysis will investigate the stated issues pertaining to the esp8266 and discuss the ongoing initiatives undertaken to address these concerns.

The ESP8266 is a contemporary microcontroller that utilizes the prevalent 32-bit ARM architecture. The facilitation of sensor and circuit connectivity is enhanced by the inclusion of 54 GPIO (general-purpose input/output) pins on this board. The USB connector facilitates the processes of debugging and programming, while further providing support for wireless data transfer through Bluetooth and Wi-Fi technologies. The ESP8266 is equipped with typical features such as a temperature sensor, a timer module, and a flash memory module.

The esp8266 distinguishes itself from other microcontrollers by virtue of its integrated transceiver, hence obviating the necessity for a distinct RF module in wireless connectivity endeavors. Two key benefits of this technology include decreased power consumption and a smaller form factor. Nevertheless, it is important to acknowledge that there are certain constraints associated with these capabilities, notably the potential for interference stemming from neighboring wireless transmitters, a factor that necessitates caution and awareness. When the device is employed within a medical setting, where patients may encounter many types of electromagnetic interference, the scenario becomes further exacerbated. The potential difficulty arises when the functionality of the device is contingent upon maintaining a constant online connection. The maintenance of a continuous internet connection is of significant significance inside healthcare environments, as it plays a crucial role in ensuring the safety of patients.

The performance of the esp8266 is constrained by its maximum clock speed of 80 MHz. It seems plausible that this constraint is sufficient, considering that the primary function of a microcontroller is not to do intricate computations. At first view, this appears to be a significant drawback.
The typical repertoire of this system comprises prompt reactions to the surroundings and straightforward execution of instructions. The ability to function at high velocities is sometimes regarded as a characteristic rather than a necessity for the aforementioned equipment. In order to provide an exact cost estimate for the esp8266, it is imperative to first determine the needs of the application. When compared to other products, the microprocessors utilized in these devices exhibit a higher degree of cost-effectiveness. Academic scholars engage in a critical examination of the scholarly endeavors undertaken by their colleagues in order to uncover potential areas for enhancement in their own research endeavors.

Singh et al. (2021) have introduced a wireless smart device that utilizes the Android platform to measure SpO2, heart rate, and skin temperature in an integrated manner. The microcontroller platform is responsible for the processing of data within the device, while Bluetooth technology is utilized for establishing wireless connectivity. The developed system possesses characteristics of being wearable, compact, and cost-effective, while also demonstrating therapeutic efficacy and user-friendliness. Following surgical procedures, this technology has the potential to be utilized in various healthcare settings, including home health care, community health care, and even sports training within medical facilities.

The method proposed by Sihombing et al. (2020) involves the utilization of an Android smartphone, an Arduino microcontroller, and a pulse sensor. The device utilizes a light source and sensors to detect and assess fluctuations in blood volume. In addition to employing an electrocardiogram (ECG) waveform for the purpose of ascertaining a patient's heart rate, it is also possible to utilize the pulse sensor as a standalone method. The sensor is comprised of an infrared light-emitting diode (LED) and a photodiode. In the context of infrared light transmission, it can be observed that the aforementioned electromagnetic radiation has the ability to traverse a human fingertip and then undergo reflection when encountering the arteries located at the distal portion of such digit.

This device has the capability to identify an Android phone that is presenting heart rate information. The sensor is capable of rapidly acquiring a precise measurement of an individual's heart rate within a time frame of around 10 seconds. The SMS alert will present the heart rate in the conventional format of 100 beats per minute (BPM).

The study conducted by Latiff et al (2013) involved the development of an Android application designed for the purpose of recording cycling sessions. In the present arrangement, information originating from wireless sensor nodes is collected, encompassing data pertaining to a cyclist's heart rate and pedaling cadence. The data is transferred to the cyclist's mobile device using wireless technology. The data is first stored in the memory of the device prior to being transmitted to the server. The utilization of the Eclipse Juno Android Software Development Kit (SDK) in conjunction with the SQLite database is employed for hardware programming purposes. The graphical user interface (GUI) implemented in Java is specifically designed to cater to the needs of touchscreen mobile devices.

Due to the extensive implementation of healthcare information technology (IT), individuals are able to access medical services at their convenience and from any location. Furthermore, there is a significant discourse surrounding the potential benefits of physical exercise and the utilization of mobile cellular devices in enhancing overall health. In order to facilitate the real-time monitoring and analysis of electrocardiogram (ECG) waveforms obtained from wearable ECG devices, a portable monitoring terminal will be implemented using an AndroidTM smart phone, as proposed by Li et al. (2017). Wireless sensor networks (WSNs) are progressively supplanting labor-intensive wired technologies in order to cater to a diverse range of healthcare establishments.

The incorporation of a barcode decoding application into a mobile phone enhances the existing monitoring system by introducing an additional level of security. The purpose of this tool is to monitor and provide support to patients undergoing therapy inside the community setting. This enhances and enhances the standard of medical care that patients receive. Alvaro et al. (2013) have developed applications for both Android and iOS platforms, enabling users to conveniently monitor their electrocardiograms (ECGs) during mobile activities.

The software facilitates the creation and storage of two distinct configurations through the utilization of its many interface elements, such as buttons, switches, sliders, and spinning panels. The live trace and historical data are observable in all modes. With the advancement of its capabilities and the reduction of its complexity, the tool has emerged as an indispensable asset inside healthcare settings. Islam et al. (2019) proved that the "Heart Monitor" health station has the capability to monitor many physiological data, including heart rate, body temperature, and blood pressure, among others. Cloud services have facilitated the ability of clinicians to remotely monitor the health conditions of their patients at any given time and from any location. In the event that it identifies any deviations from the norm in your heart rate, it will transmit a text alert to you. In the event that the system identifies five atypical readings, an instant alarm will be sent to a designated healthcare professional or someone of your choice. The procedure of conducting a comparison and evaluation of electrocardiogram (ECG) devices is undertaken. Hence, it may be inferred that 97.4% of the outcomes can be deemed reliable.

Kakria et al. (2015) developed these systems by the integration of cutting-edge wireless communication and wearable sensor technology. The continuous development of new technologies has led to the increased sophistication of remote health monitoring systems. This study aims to evaluate multiple aspects of a real-time cardiac monitoring system, including its cost, usability, accuracy, and data security. Effective communication between healthcare providers and patients is a reciprocal process. The objective of this research endeavor is to enhance the availability of healthcare services for individuals with heart conditions residing in underprivileged communities characterized by a limited doctor-to-population ratio. A total of forty individuals, with ages spanning from 18 to 66, were selected as volunteers for this study. These individuals were equipped with sensors and provided with an Android smartphone, which they utilized under controlled experimental conditions. Throughout the duration of the study, these people were closely observed and watched by a team of experts. The performance evaluation provides evidence that the suggested system demonstrates efficiency and practicality.

Reza et al. (2017) conducted research on the development of a real-time cardiac monitoring system that prioritizes user convenience, accuracy, and privacy. The program facilitates the connection between patients and their doctors, serving as a medium for the exchange of information. The primary objective of this study is to provide non-traditional clinical monitoring methods for the management of cardiovascular disease. The monitoring of an individual's vital signs is facilitated by the utilization of an Android device, a web interface, and a pulse rate sensor. The proposed system has demonstrated efficacy and reliability in performance evaluation due to its capacity for continuous monitoring. Based on the results obtained, it can be concluded that the suggested technology is both viable and secure. The implementation of the new system will facilitate effective communication between physicians and their patients.

In this study conducted by Majumder et al. (2019), a low-power communication module and an embedded sensing system were employed to covertly capture electrocardiograms and body accelerations utilizing cellphones inside a public setting. The electrocardiogram (ECG) is observed by utilizing the internal sensors of the smartphone, namely the accelerometer and the Global Positioning System (GPS), as well as external sensors such as the heart rate monitor. In order to conduct experiments and validate hypotheses, a diverse set of test participants are employed across various test scenarios, encompassing activities such as sitting, walking, jogging, and running. In this study, we demonstrate the feasibility of developing a multimodal system that utilizes signal classification and machine learning techniques to achieve accurate classification and dependable prediction of heart rate quality.

According to Gregoski et al. (2012), the inclusion of video cameras in contemporary smartphones enables the acquisition of photoplethysmographic (PPG) data, hence facilitating the measurement of heart rate (HR). In this study, we conducted a comparison between the heart rates (HRs) obtained using an Android application on a Motorola Droid device and those obtained through the utilization of an electrocardiogram (ECG) and a Nonin 9560BT pulse oximeter (PO). The measurements were taken during a state of rest among the participants. This section provides a detailed breakdown of the materials and methods that were utilized in the study. Simultaneous recordings were made of the resting, observed, and monitored heart rates of a sample consisting of 14 individuals, comprising both healthy and clinical volunteers, with ages ranging from 20 to 58 years.

Bland-Altman plots were employed to assess the degree of concordance among the three instruments across all conceivable scenarios. The results of the study indicate. Irrespective of the prevailing circumstances, we have observed robust correlations between any given pair of electronic devices. The study conducted by Blond-Altman demonstrated that the Droid serves as a reliable measure of heart rate. The results indicate that a significant majority, specifically 95% of the data points, exhibited a level of consistency within the margin of error when comparing the Droid and the ECG across various situations.

This paper introduces a system designed for the purpose of continuous monitoring, which enables the transmission of patients' vital signs readings to remote healthcare databases in real-time. The system comprises two fundamental components, namely the data gathering module and the data transmission module. The development of the monitoring plan, including the determination of parameters to be examined and the frequency of monitoring for each parameter, was facilitated through expert interviews. Continuous monitoring is performed on many physiological parameters of the patient, including posture, heart rate, blood sugar levels, lipid profile, and electrocardiogram (ECG). This study introduces four discrete channels by which data may be conveyed. The development of these methods has taken into account the potential risks to patients, the necessity for medical analysis, and the demand for communication and processing resources. Empirical evidence demonstrates the efficacy of the system's paradigm in practical applications.

3. METHODOLOGY

The advancement of cardiac monitoring has encountered obstacles due to varied practices in heart rate monitoring and a dearth of research that assess the comparative efficacy of various devices across diverse individuals. This poses a challenge in the development of a sensor that is both dependable and efficient. An ideal monitoring device would acquire an individual's electrocardiogram (ECG) by means of electrodes affixed to their thoracic region, and thereafter exhibit the collected data on an Android smartphone. This feature would enable the customization of the display for individual users with minimal exertion.

Before the production of such a device can be realized, several technical problems still need to be addressed. The assessment of ECG recording sensor performance, the convenience of capturing the ECG signal on a mobile device, and the clarity of the displayed data are all significant factors to be taken into account. Devices used to measure the electrical activity of the heart are commonly referred to as cardiac monitoring instruments. Many cardiac monitoring devices are now available as apps for mobile phones. A cost-effective and energy-efficient cardiac monitoring device has been created, which can be seamlessly integrated with a mobile phone.

The MAX30102 and TP4056 sensors constitute the fundamental components of the developed system. The microcontroller receives the sensor data and subsequently transmits it to the phone through Wi-Fi. The electrocardiogram (ECG), blood oxygen saturation (SpO2), core body temperature, and heart rate (as shown in Figure 3.4) are all illustrative instances. The real-time display of the patient's vital signs is facilitated by the Wi-Fi connection established between the medical gadget and the mobile phone. The data can be stored on the mobile device and accessed remotely by medical professionals. The system has undergone rigorous testing and consistently fulfills its intended functionality. This technology has the potential to facilitate the monitoring of a patient's condition during the intervals between scheduled office visits. Moreover, it can function as a diagnostic instrument for the purpose of monitoring a patient's well-being during their hospitalization. The devised device is cost-effective and readily producible in significant volumes. The low power consumption of the device makes it well-suited for continuous operation. Additionally, it has the potential to be condensed into a portable device that can be worn on the wrist or forearm.

Components

1) ESP 8266 microcontroller.
2) Max 30102 pulse oximeter.
3) SSD 1306 OLED Screen.
4) TP 4056 (Li-ion) Battery charger.
5) 18650 Li-ion battery.
6) Double side perf board.
7) Slide switch (DDT).
8) Voltage regulator (Mic 29150-3.3WT).

Design Implementation

The sensor unit is equipped with an integrated circuit module, such as the Max 30102 pulse oximeter sensor, located at the forefront. The integrated circuit operates using a direct current (DC) supply with a voltage of 3.7 volts. Upon receiving a signal, the microcontroller executes actions based on the instructions stored in its memory.

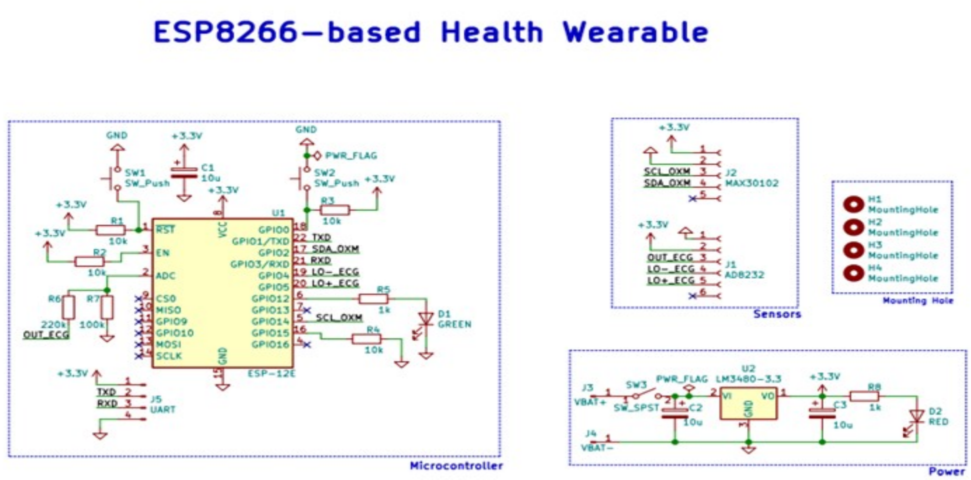

Figure 3.1 Circuitry connection of the Esp8266 Health wearable

Consequently, we shall proceed with the programming of the microcontroller. A battery with a voltage of 3.70 volts provided the electrical energy. To accommodate the microcontroller and other digital integrated circuits, a voltage regulator was employed to decrease the 9-volt power supply to 5 volts. The circuit utilized in the design is illustrated in Figure 3.1.

ESP 8266 microcontroller.

The ESP8266, an affordable microprocessor with Wi-Fi capabilities, comes preloaded with TCP/IP networking software. The ESP8266 Wi-Fi Module, a system-on-chip (SOC) with a built-in TCP/IP protocol stack, enables connectivity of any microcontroller to a wireless network. The ESP8266 possesses the capability to function as a host for many applications and effectively manage Wi-Fi networks. The ESP8266 Wi-Fi Module facilitates the implementation of Internet of Things (IoT) by enabling the transmission and reception of data when connected to nearby Wi-Fi networks. Figure 3.2 displays an image depicting an ESP8266 microcontroller.

Features of ESP 8266 microcontroller.

i. Processor: L106 32-bit RISC microprocessor core based on the ten silica Diamond.
ii. Standard 106Micro running at 80 or 160 MHz
iii. Memory: External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included).
iv. Serial Peripheral Interface Bus (SPI).

Specification of ESP 8266 microcontroller.

i. 32-bitmicrocontroller.
ii. CPU ---Ten silica Diamond Standard 106Micro (aka. L106) @ 80 MHz (default) or160 MHz iii. Memory ---32 KiB instruction, 80 KiB user data.

Fig 3.2 ESP 8266 microcontroller.

Max 30102 pulse oximeter.

The MAX30102 biosensor module monitors an individual's pulse and blood oxygen levels. In the realm of electronic devices, there exist several technologies designed to minimize noise, including low-noise electronics, optical components, photodetectors, light-emitting diodes (LEDs), and electronics specifically engineered to mitigate the influence of ambient light. The utilization of the MAX30102 system-in-package facilitates the development of mobile and wearable devices. A single infrared LED and a single monochromatic LED are integrated in the MAX30100. The MAX30100 pulse oximeter is capable of measuring heart rate and blood oxygen saturation levels. The detection of heart rate is accomplished through the utilization of red lights. Both of the light-emitting diodes (LEDs) serve as oxygen meters. The images of the Max30102 pulse oximeter are presented in Figure 3.

Features and specifications.

i. Heart-Rate Monitor and Pulse Oximeter Biosensor in LED Reflective Solution.
ii. Tiny5.6mm x 3.3mm x 1.55mm 14-Pin Optical Module.
iii. Ultra-Low Power Operation for Mobile Devices.
iv. Fast Data Output Capability.
v. Robust Motion Artifact Resilience.
vi. 40°C to + 85°C Operating Temperature Range.

Figure 3.3: Max 30102 pulse oximeter.

TP 4056 (Li-ion) Battery charger.

The TP 4056 integrated circuit, commonly found in lithium-ion battery chargers, serves the purpose of safeguarding single-cell batteries from potential harm resulting from high current flow and inadequate voltage levels. The device exhibits two distinct status outputs, indicating whether the charging process is now ongoing or has been successfully completed, as depicted in Figure 3.5. Additionally, it has the capability to charge at a rate of 1A. Lithium-ion battery chargers that incorporate the TP 4056 chip are designed to prevent both overcharging and undercharging of individual cells. Two distinct outcomes indicate the current state of the charging process: ongoing and finished.

The charging current has the capability to be adjusted to a value of 1A. The potential exists to enhance the capacity of a single-cell battery by employing a parallel connection of two lithium-ion battery cells. This module should not have more than two cells attached to it.

The features include:

i. The current monitor,
ii. Under-voltage lock out,
iii. Automatic recharge and two status pin to indicate charge termination and the presence of an input voltage.

Specifications are:

i. Specific energy---100–265W·h/kg (0.36–0.875MJ/kg)
ii. Self-discharge rate--- 0.35% to 2.5% per month depending on state of charge
iii. Cycle durability---400–1,200 cycles.
iv. Nominal cell voltage--- 3.6/ 3.7 / 3.8 / 3.85 V, LiFePO4 3.2 V, Li4Ti5O12 2.3 V.

Figure 3.4: TP 4056 (Li-ion) Battery Charger

4. RESULTS

When the MAX30102 sensor is powered on, the OLED display and red LED are illuminated, as depicted in Figure 4.0a. The OLED display is utilized to present the formal launch of the item by displaying its name (see picture 4.0a). Subsequently, the device initiates the activation of its access point, which is visually presented on the OLED screen, enabling the user to establish a connection (see to Figure 4.0 b). Upon successfully establishing a connection to the access point (AP), the user will be presented with the local IP address of their device, which will be shown on the OLED panel. The desired website can be accessed by typing the provided URL into a web browser. Upon establishing a connection to the device via the designated IP address, the webserver logic of the device is triggered, resulting in the presentation of measured vitals on a visually appealing and user-friendly web interface.

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It is important to observe that in figures 4.C and 4.D, the recorded physiological measurements are substituted with "---" on both the OLED panel and web user interface when the user's finger is not in contact with the MAX30102 sensor. Upon utilization and subsequent power-off of the device, the activation of a red Light Emitting Diode (LED) serves as an indicator that the USB port is prepared for the charging process (see to Figure 4.0e). Upon completion of the charging process, the red indicator light will be substituted with a blue indicator light.

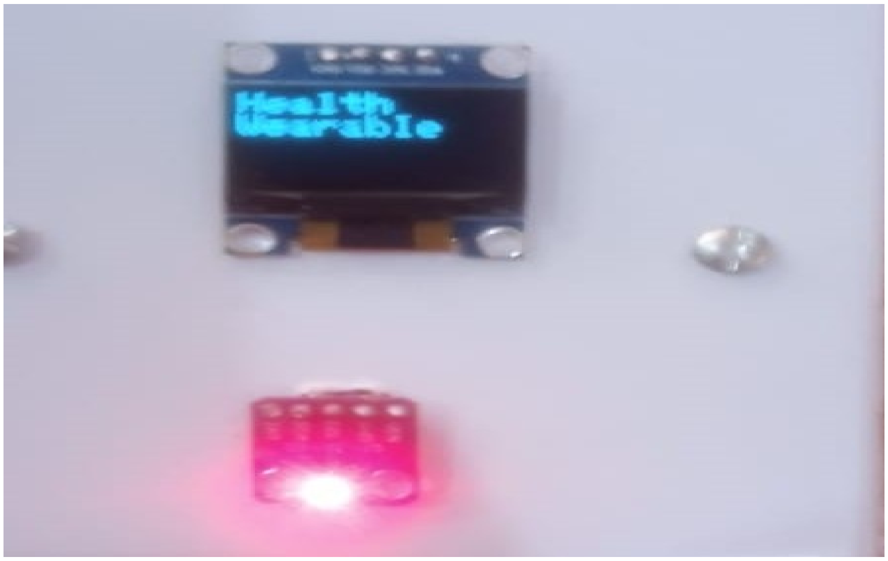

Fig.4.0a: Introductory Screen Display

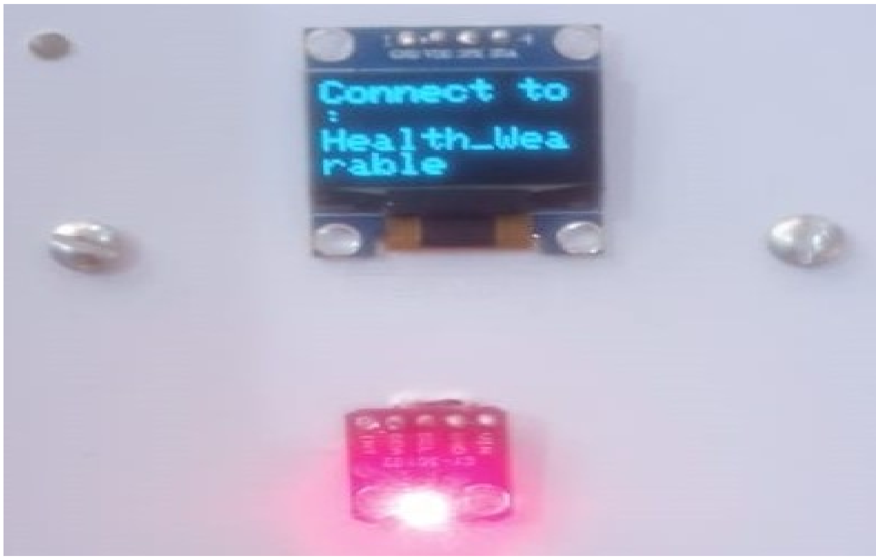

Fig.4.0b: Request Connection to the Access point (AP) named "Health Wearable".

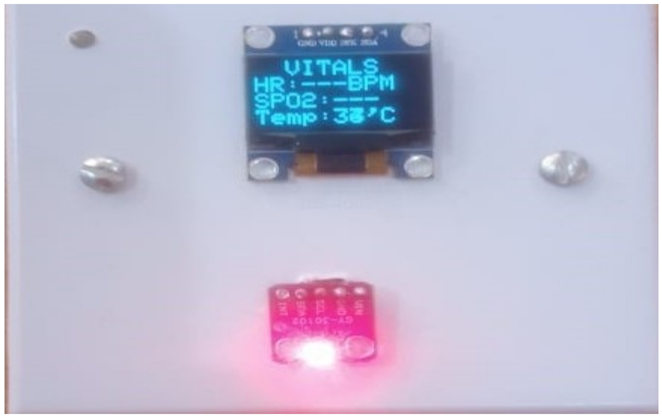

Fig.4.0c: OLED Display Prior To Finger Placement On Sensor.

Fig.4.0d: Touching the OLED screen displays the user's vitals.

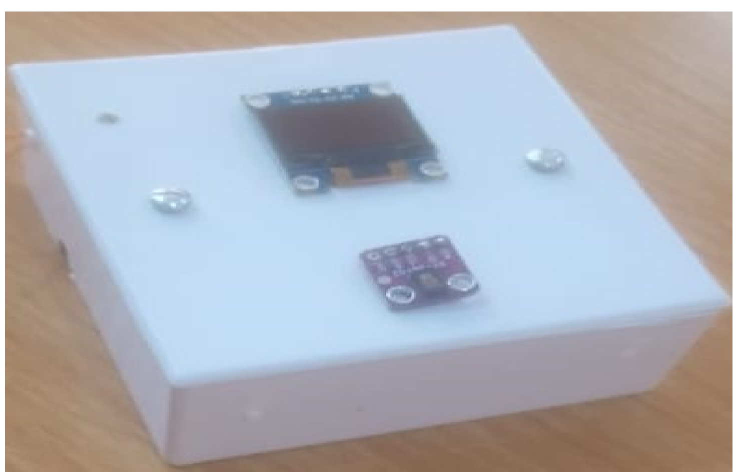

Fig.4.0e: Device When Powered Off.

5. CONCLUSION AND RECOMMENDATIONS

This article presents a concise summary of the conducted study and proposed recommendations pertaining to a cardiac monitoring system implemented on an Android-based mobile phone platform. The primary aim of this study was to develop a self-contained cardiac monitoring system utilizing a mobile phone platform, with the capability to autonomously identify and classify arrhythmias. The development, testing, and subsequent distribution of a portable cardiac monitoring gadget involved the utilization of a Techno Pova Dual SIM phone. This study additionally provides a comprehensive account of the methodologies employed during the design and fabrication of the cardiac device, as well as the subsequent implementation of mobile phone monitoring. As proven by the test results, the automatic cardiac monitoring system is capable of diagnosing the most prevalent cardiac arrhythmias. Future development efforts will target on the system's detection accuracy and overall functionality.

The study recommended that:

a) In order to facilitate patient autonomy and enable result monitoring, it is imperative to develop a graphical user interface. This feature enables the system to be customized based on the individual requirements of the patient, hence enhancing the accuracy of the system.
b) A web-based application can be designed to enable healthcare providers to remotely access their patients' vital signs data stored on the cloud. This will assist in the analysis of E findings and enable remote diagnosis of cardiovascular problems.
c) One potential avenue for the development of a cloud-based solution is the storage of data derived by the patient's device. Implementing this solution will effectively mitigate the risk of data loss in the event of device failure, while also promoting seamless collaboration among medical personnel for the purpose of diagnosis and data analysis.
d) The system can be enhanced by incorporating supplementary monitoring and control modalities, hence increasing its adaptability and versatility. Examples of these modalities include vibration detection via a piezoelectric sensor and blood pressure detection, among others. In addition, it is possible to utilize a video monitor in tandem with the device to monitor and record the patient's body and head position throughout the monitoring process. This serves the purpose of ensuring that the sensor remains stationary on the device and does not experience any displacement while the patient is wearing the sensors. The proposed enhancements will enhance the reliability and user-friendliness of the system, hence augmenting the overall efficacy of the monitoring system.
e) The enhancement of the system might be achieved through the integration of artificial intelligence algorithms, which would facilitate the analysis of gathered data and the identification of preliminary indicators that may indicate the presence of cardiac disorders prior to their progression into critical medical situations.

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