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Development of an Android-Based Smart Health Monitoring Device for Heartbeat Detection

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ABSTRACT

This research presents the development of a smart health monitoring system designed to detect and monitor heartbeat patterns using Android-based technology. The increasing prevalence of cardiovascular diseases necessitates accessible and user-friendly monitoring solutions for early detection and continuous health assessment. This study aims to design and implement a portable heartbeat detection device integrated with an Android application, enabling real-time monitoring and data analysis. The system utilizes pulse sensor technology to capture heartbeat signals, which are then processed by a microcontroller and transmitted wirelessly to an Android smartphone via Bluetooth connectivity. The developed application features an intuitive user interface that displays heart rate measurements, stores historical data, and provides alert notifications when abnormal patterns are detected. System testing was conducted to evaluate accuracy, reliability, and user experience across various conditions. Results demonstrate that the device achieves accurate heartbeat detection with minimal deviation from standard medical equipment, offering a practical and cost-effective solution for personal health monitoring. This research contributes to the advancement of mobile health (mHealth) technology, providing individuals with greater autonomy in managing their cardiovascular health while facilitating early intervention opportunities. The system's portability, affordability, and ease of use make it particularly suitable for home-based health monitoring and remote patient care applications.

Keyword : Smart health monitoring, heartbeat detection, Android application, pulse sensor, mobile health, cardiovascular monitoring

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1. INTRODUCTION

Cardiovascular diseases remain one of the leading causes of mortality worldwide, accounting for millions of deaths annually according to the World Health Organization. Early detection and continuous monitoring of cardiac abnormalities play a crucial role in preventing life-threatening conditions and improving patient outcomes. Traditional methods of heart rate monitoring typically require visits to healthcare facilities and the use of expensive medical equipment, which can be both time-consuming and inaccessible for many individuals, particularly those in remote areas or with limited healthcare resources.

The rapid advancement of mobile technology and the widespread adoption of smartphones have opened new opportunities for innovative healthcare solutions. Mobile health (mHealth) applications have emerged as a promising approach to bridge the gap between patients and healthcare providers, offering convenient and cost-effective alternatives for health monitoring. Among various physiological parameters, heart rate serves as one of the most fundamental vital signs, providing valuable insights into an individual's cardiovascular health and overall well-being.

In recent years, the integration of sensor technology with mobile platforms has enabled the development of portable and user-friendly health monitoring devices. These systems allow individuals to track their health status independently, promoting proactive health management and facilitating timely medical intervention when necessary. The Android operating system, with its large user base and

flexible development environment, presents an ideal platform for deploying accessible health monitoring solutions that can reach a broad population.

Despite the availability of various commercial heart rate monitors, there remains a need for affordable, accurate, and easy-to-use devices that can seamlessly integrate with everyday mobile technology. Many existing solutions are either too expensive for widespread adoption or lack the comprehensive features needed for effective long-term monitoring and data management. Furthermore, the ability to store historical data, analyze trends, and provide intelligent alerts can significantly enhance the value of personal health monitoring systems.

This research addresses these challenges by developing an Android-based smart health monitoring device specifically designed for heartbeat detection. The system combines hardware components including a pulse sensor and microcontroller with custom-developed Android application software to create an integrated solution for real-time heart rate monitoring. The device aims to provide accurate measurements comparable to standard medical equipment while maintaining portability, affordability, and user-friendliness.

The primary objectives of this study are: (1) to design and develop a functional heartbeat detection device using pulse sensor technology and microcontroller integration; (2) to create an Android application capable of receiving, processing, and displaying heart rate data in real-time; (3) to implement features for data storage, historical trend analysis, and abnormal pattern detection; (4) to evaluate the accuracy and reliability of the developed system through comparative testing with standard medical equipment; and (5) to assess the usability and practical applicability of the device for personal health monitoring purposes.

The significance of this research lies in its potential to democratize access to cardiovascular health monitoring, empowering individuals to take a more active role in managing their health. By providing an affordable and accessible solution, this system can contribute to early detection of cardiac irregularities, support chronic disease management, and reduce the burden on healthcare systems. Additionally, the wireless connectivity and data logging capabilities enable possibilities for remote patient monitoring and telemedicine applications, which have become increasingly important in modern healthcare delivery.

2. RESEARCH METHOD/MATERIAL AND METHOD/LETERATURE REVIEW

A. Heart Rate Monitoring

Heart rate monitoring has evolved significantly over the past decades, transitioning from purely clinical applications to consumer-oriented devices. Traditional electrocardiography (ECG) remains the gold standard for cardiac monitoring in medical settings, providing detailed electrical activity patterns of the heart. However, ECG devices typically require multiple electrodes and specialized equipment, making them impractical for continuous daily monitoring. Photoplethysmography (PPG) has emerged as an alternative technology that offers a non-invasive, simpler approach to heart rate detection by measuring blood volume changes in microvascular tissue using optical sensors.

Recent studies have demonstrated the effectiveness of PPG-based sensors in various applications, from fitness tracking to clinical monitoring. Research by Allen (2007) established the fundamental principles of photoplethysmography and its applications in physiological measurement, confirming its reliability for heart rate detection when properly calibrated. Subsequent investigations have explored the integration of PPG sensors with microcontroller systems, demonstrating feasibility for portable monitoring solutions.

B. Mobile Health (mHealth) Applications

The proliferation of smartphones has catalyzed a paradigm shift in healthcare delivery through mobile health applications. According to research by Free et al. (2013), mHealth interventions have shown promise in improving health outcomes across various domains, including cardiovascular disease management, medication adherence, and health behavior modification. The Android platform, commanding a significant market share globally, has become a preferred development environment for health monitoring applications due to its open-source nature and extensive hardware compatibility.

Studies by Kumar et al. (2013) highlighted the potential of smartphone-based health monitoring systems to provide continuous, real-time data collection while maintaining user engagement through intuitive interfaces. The integration of wireless communication protocols, particularly Bluetooth technology, has facilitated seamless data transmission between external sensors and mobile devices, enabling the development of comprehensive monitoring ecosystems.

C. Wireless Sensor Networks in Healthcare

Wireless body area networks (WBANs) and Internet of Things (IoT) technologies have revolutionized personal health monitoring by enabling continuous data collection without constraining user mobility. Research by Movassaghi et al. (2014) examined various wireless technologies suitable for medical applications, identifying Bluetooth Low Energy (BLE) as particularly advantageous for wearable health devices due to its low power consumption and adequate data transmission rates.

The integration of microcontroller units such as Arduino and ESP-based systems with physiological sensors has been extensively documented in literature. These platforms offer cost-effective solutions for prototyping and implementing custom health monitoring devices while maintaining sufficient processing capabilities for real-time data acquisition and preliminary signal processing.

D. System Architectura

The proposed system consists of three main components: (1) a hardware module comprising pulse sensor and microcontroller unit, (2) wireless communication interface using Bluetooth technology, and (3) an Android application for data reception, processing, visualization, and storage. The system architecture follows a client-server model where the hardware device acts as a data acquisition server, and the Android application functions as the client interface.

3. RESULTS AND DISCUSSION

A. Tool Assembly

This section discusses the detailed assembly steps for a heart rate detector using an Arduino Uno R3 as the main microcontroller. This system is equipped with a pulse sensor to detect heart rate and a Bluetooth HC 05 to connect to the Oximeterku application. For power, a power bank is used to provide sufficient power to support the operation of all components. This sub-chapter will cover the physical assembly of these components, setup, and initial testing to ensure proper system functionality before proceeding to implementation and field testing.

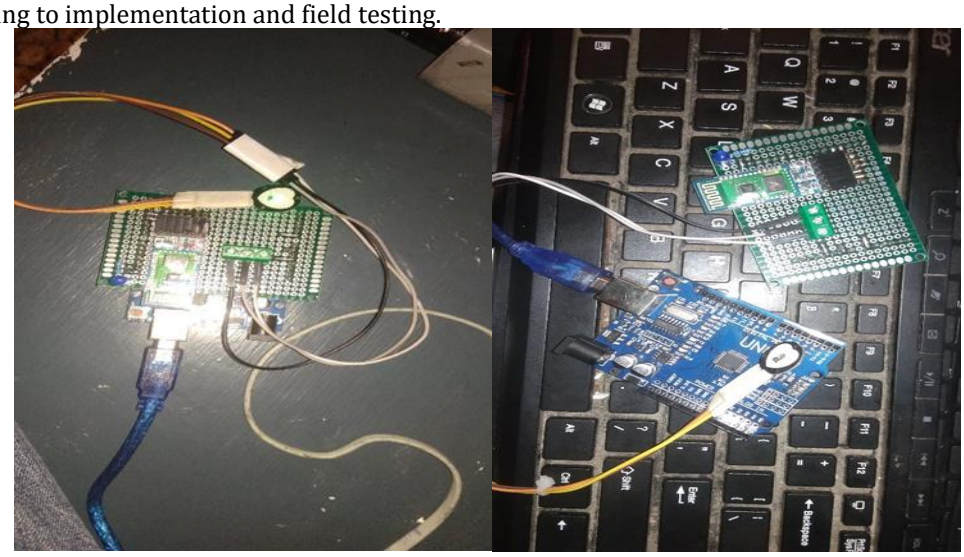

Fig 1. Tool Set

Figure 1 shows several jumper cable connections from the Pulse Sensor and Bluetooth HC 05 to the Arduino Uno R3, which is already connected to the Arduino IDE. The pins are used as reference for connecting the Pulse Sensor to the Arduino Uno R3.

B. Equipment Testing

Equipment testing was conducted over a one-day period. Starting on August 12, 2024, testing was conducted in several residential homes.

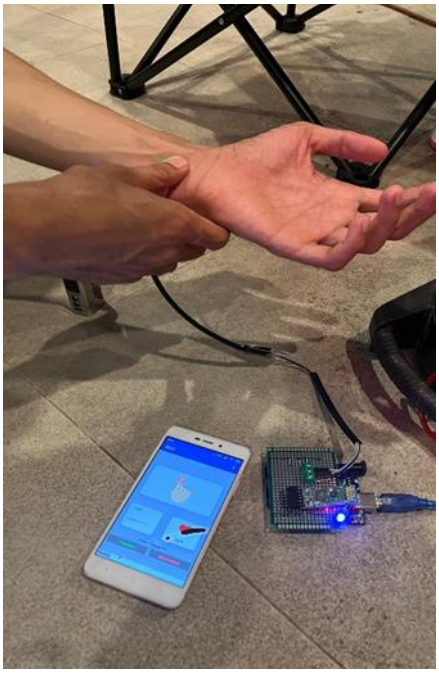

Fig 2. Equipment Testing

The error is calculated by subtracting the prototype result from the pulse sensor result, dividing by the pulse sensor result, and multiplying by 100.

For example, if the prototype result is 81 and the pulse sensor result is 82, the result is 1. Then, divided by 82, the pulse sensor result is 0.012. Multiplying by 100 gives the result of 1.2. Therefore, the error percentage is 1.2.

Tabel 1. Comparison Test Results

No	Name	JK	PO (Bpm)	Prototipe (Bpm)	Error (%)
1	Abdul Syawaluddin	Man	74	71	4,05
2	Hani	Women	95	95	0
3	Zidan	Man	87	87	0
4	Adnan	Man	92	93	1,08
5	Luis	Man	81	82	1,23
6	Wagiran	Man	78	78	0
7	Siti	Women	87	87	0

Based on the test results by comparing the results between the Pulse Sensor and the prototype in table 4.3, it can be seen that the percentage error between the Pulse Sensor and the heart rate monitoring system prototype is more than 5%.

4. CONCLUSION

After designing, implementing, testing, and analyzing the design of a human heart rate detector using a pulse sensor and a modular application based on the Arduino Uno R3, the following conclusions can be drawn: Based on the program created, the maximum BPM limit displayed is 240 BPM with no lower limit. Testing was conducted by placing the thumb and arm with a pulse on the Pulse Sensor. Based on the test results, comparing the results between the Pulse Sensor and the prototype in Table 4.3, it can be seen that the error percentage between the Pulse Sensor and the Prototype for heart rate detection is more than 5%.

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