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MONITORING ELDERLY HEART RATE BASED ON OXIMETER SENSORS

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Abstract— *Heart rate check is an important step in preventing heart attacks that is often not realized by the elderly. However, independent heart rate checks by the elderly have not utilized technology, especially Android. This study design a heart rate detector using the Max30102 Oximeter Sensor integrated with Android device from the elderly aged 60 to 75 years and displays the results of the heart rate per minute (BPM) along with normal or abnormal status on the Android application. The prototype method involves the stages of development, testing, and evaluation of the tool. The results of the study showed that this heart rate detector was able to provide data on heart rate per minute (BPM) that was accurate and easily accessible to the elderly, so that the elderly could check their health independently. The test results indicate a detection accuracy of 97% with a standard deviation of 1.19 BPM, which is higher compared to studies using the Max30100. Thus, this tool is expected to help increase the independence of the elderly in monitoring heart health and reduce the risk of heart attack through routine monitoring.*

Keywords*: android , elderly, heart rate, max30102, sensor.*

Intisari—*Pemeriksaan detak jantung merupakan langkah penting dalam pencegahan serangan jantung yang sering tidak disadari oleh lanjut usia. Namun, pemeriksaan detak jantung secara mandiri lanjut usia belum memanfaatkan teknologi khususnya Android. Penelitian ini untuk merancang alat pendeteksi detak jantung menggunakan Sensor Oximeter Max30102 yang diintegrasikan dengan perangkat Android dari lanjut usia berusia 60 hingga 75 tahun dan menampilkan hasil detak jantung per menit (BPM) beserta status normal atau tidak pada aplikasi Android. Metode prototype melibatkan tahap-tahap pengembangan, pengujian, dan evaluasi alat. Hasil penelitian menunjukkan bahwa alat pendeteksi detak jantung ini mampu memberikan data mengenai detak jantung per menit (BPM) yang akurat dan mudah diakses oleh lanjut usia, sehingga lanjut usia dapat melakukan pengecekan kesehatan secara mandiri. Hasil uji coba menunjukkan tingkat akurasi deteksi sebesar 97% dengan standar deviasi 1,19 BPM, yang lebih tinggi dibandingkan penelitian terdahulu menggunakan sensor Max30100.Dengan demikian, alat ini diharapkan dapat membantu meningkatkan kemandirian lanjut usia dalam memantau kesehatan jantung dan mengurangi risiko serangan jantung melalui pemantauan rutin.*

Kata Kunci*: android, detak jantung, orang tua, max30102, sensor.*

INTRODUCTION

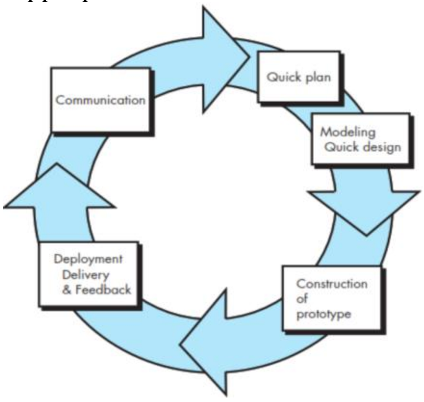
Elderly people experience physical changes from a strong body to a very weak one. Heart rate changes beyond normal are one of the most common heart problems. The normal adult heart rate is between 60 and 100 beats per minute [1], [2]. The decline in conditions experienced by the elderly tends to cause physical health problems [3], [4]. Heart attacks and heart disease are one of the deadly diseases in the world, for elderly people with hypertension, increased blood flow is more dangerous because it interferes with organ function causing heart disease and stroke [5], [6]. Heart rate monitoring is an important step [7] in efforts to prevent other diseases. Common examinations that are done independently place the palm of the hand on the chest or neck to feel the pulse, but are less accurate because they do not use special tools [8], [9] . Resulting in elderly people not knowing if they are having a heart attack.

The use of Android smart device technology for the elderly to monitor health is considered a positive step because technology can facilitate independent health monitoring [10], [11], [12], [13]. Independent heart rate checks for the elderly have not utilized Android technology and at Chandra Indah Housing the elderly do not rely on help from others in carrying out daily activities. The elderly need an automatic tool that displays heart rate results based on the results of the sensor's work in real time [14], [15], [16], [17] .The principle of Photoplethysmography implement to the Max30102 Oximeter Sensor works, Photoplethysmography is a non-invasive method for measuring heart rate and oxygen saturation by detecting the volume of blood flow in the veins that are very close to the skin [15], [18]. The sensor works based on the principle that the light source and detector are located on the same side, allowing measurements to be taken on different parts of the body, biological signal sensors are designed to detect and measure biological signals in the human 20, 21 [19], [20]. In an IoT-based health monitoring system, data can be viewed in real time via the dashboard, the cloud system allows data to be stored and analyzed for long-term tracking or integration with a larger health system [13], [17]. Previous studies have mostly focused on athletes or younger patients [13], [15], while very few developed Android-based devices specifically for elderly users.

This study aims to design a heart rate per minute (BPM) detector using the Max30102 Android-based Oximeter Sensor using the Blynk application, which is expected to be a solution for the elderly to help increase the independence of the elderly in monitoring heart health and reducing the risk of heart attacks through routine monitoring. The Max30102 Oximeter Sensor can detect temperature and heart rate at the same time with a near photodetector and infrared light and red LED with low noise levels and is easy to adjust [21], [22], [23]. This research gap emphasizes the novelty of this study, which focuses on designing a simple and independent monitoring tool tailored for elderly users.

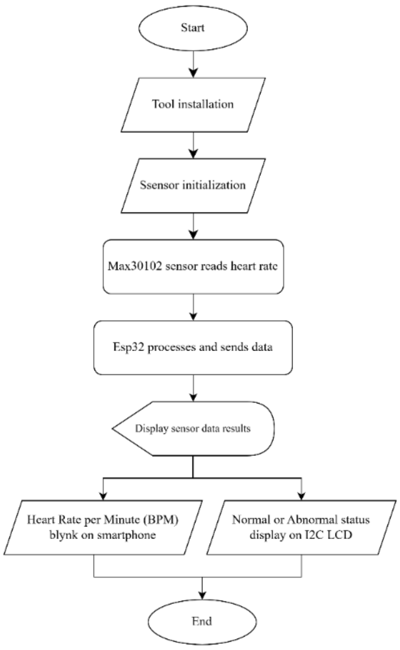
MATERIALS AND METHODS

Prototyping system design (Figure 1) follows the steps of software creation modeling [23], [24]. First communication to listen to the needs, users together determine the concept of the system to be developed. The second stage Quick Plan planning to make a prototype is done quickly. The third stage Quick Design Modeling is modeled with several tools that are in accordance with user needs. The fourth stage Construction of prototype to design a prototype that represents user needs and create applications according to user needs analysis. The fifth stage is deployment, delivery, and feedback, a feasibility test of the tool designed for users, namely elderly people, is carried out so that it provides input on the system being used and user needs that are less appropriate can be fixed.



Source: (Subianto et al, 2023)
Figure 1. Prototyping Model

System schematic (Figure 2) is a flowchart of the heart rate detection system which describes the process starting with the installation of the Max30102 Oximeter Sensor and ESP32 Nodemcu.



Source: (Research Result, 2024)
Figure 2. System Schematic

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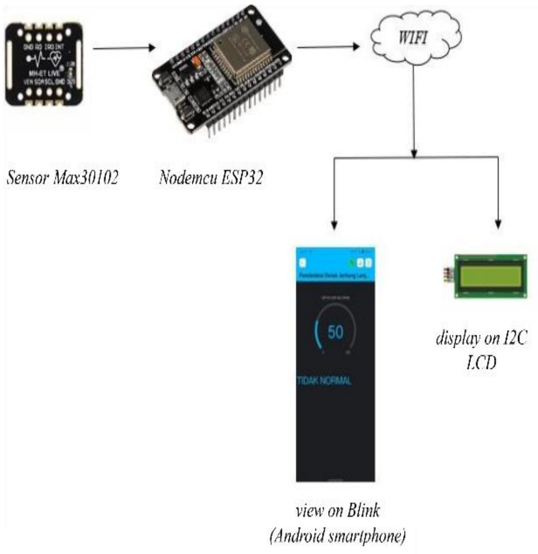
The system will wait for the user's finger to touch the Max30102 Oximeter Sensor. If no finger touches the sensor, the I2C LCD will display the message "No Finger" and the message "Status: - " When the finger touches the sensor, the Max30102 Oximeter Sensor will start reading the heart rate using infrared light to detect blood flow in the finger. The data obtained from the sensor is then sent to the ESP32 Nodemcu for processing. The ESP32 Nodemcu processes the data and sends it to the Android device via a Wi-Fi connection.

The Max30102 sensor was selected because it offers higher accuracy and stability compared to the Max30100, with lower noise levels and the ability to simultaneously detect temperature and heart rate [2], [18], [21], [22]. In this study, testing was conducted on three elderly respondents aged 60–75 years, with each measurement repeated three times to ensure consistency and validation of the data.



Source : (Research Result, 2024)
Figure 3. System Architecture

RESULTS AND DISCUSSION

The architecture of the heart rate detector (Figure 3) starts from the Max30102 Oximeter Sensor which is responsible for detecting the heart rate sending raw data to the Nodemcu ESP32 microcontroller via a cable connection. While the Nodemcu ESP32 acts as the main processor that receives data from the sensor, processes the data and determines the BPM (Beats Per Minute). After the data is processed by the Nodemcu ESP32, the data is sent via the same WiFi network to two destinations, namely the Blynk application and the I2C LCD screen. The display results on the Blynk application and the I2C LCD have similarities, namely displaying the heart rate per minute (BPM) and the status "Normal" and "Not Normal" in the normal BPM range set between 60 to 100 BPM. However, the I2C LCD display can display "No Finger" and the status "-" which indicates that there are no fingers attached to the Max30102 Oximeter Sensor so that the heart rate data per minute (BPM) obtained is 0. In addition, the system was tested for its accuracy by comparing the detected BPM values with manual stopwatch measurements. The results showed that the detection accuracy reached 97% with a standard deviation of 1.19 BPM, which is higher compared to previous studies using the Max30100 sensor [2], and consistent with other research that tested the Max30102 under similar conditions [18], [21], [22].

Android-based heart rate detector with Max30102 Oximeter Sensor input, detects heart rate through elderly fingers can be processed by Nodemcu ESP32 so that it can produce information about the number of heart beats and normal status or not in real-time. Max30102 Oximeter Sensor as a heart rate detector sensor by emitting infrared light to the skin, then measuring the amount of light reflected back so that the sensor can calculate the number of heart beats per minute (BPM) [13], [19], [25]. Nodemcu ESP32 as a microcontroller tasked with processing data from the Max30102 Oximeter Sensor which is programmed using Android software [26], [27], [28]. The implementation of the Android application was carried out using Blynk, supported by ESP32 source code. The application interface successfully displayed BPM values and condition status (Normal/Not Normal) in real time. The code snippet used in the implementation is shown in Figure X, divided into initialization, BPM calculation, finger detection, and data transmission.

The initialization of hardware and network connection. The ESP32 is connected to the Max30102 sensor, I2C LCD, and Blynk platform through WiFi. This stage ensures the device is ready to acquire heart rate signals and display them in real time (Figure 4).

```
#include <elapsedMillis.h>
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include "heartRate.h"
#include <Wire.h>
#include "MAX30105.h"
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);
elapsedMillis PengirimanMillis;
char ssid[] = "Rifa Arofah";
char pass[] = "rifa2502";
MAX30105 particleSensor;
const byte RATE_SIZE = 4;
byte rates[RATE_SIZE];
byte rateSpot = 0;
long lastBeat = 0;
float beatsPerMinute;
int beatAvg;
String kondisi = "      NORMAL      ";
String kondisi_ = "NORMAL";

void setup() {
  Serial.begin(115200);
  if (!particleSensor.begin(Wire, I2C_SPEED_FAST)) {
    while (1);
  }
  particleSensor.setup();
  particleSensor.setPulseAmplitudeRed(0x0A);
  particleSensor.setPulseAmplitudeGreen(0);
  WiFi.begin(ssid, pass);
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
  }
  lcd.begin();
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("    WELCOME    ");
  delay(500);
  lcd.clear();
}
```

Source : (Research Result, 2024)
Figure 4. Source Code Initialization and Setup

Presents the algorithm for calculating BPM (beats per minute) based on the infrared signals acquired from the Max30102 sensor. The calculation is performed by measuring the time intervals between heartbeats, then averaging the results to obtain a more stable BPM value (Figure 5).

```
void loop() {
  long irValue = particleSensor.getIR();
  if (checkForBeat(irValue) == true) {
    long delta = millis() - lastBeat;
    lastBeat = millis();
    beatsPerMinute = 60 / (delta / 1000.0);
    if (beatsPerMinute < 255 && beatsPerMinute > 20) {
      rates[rateSpot++] = (byte)beatsPerMinute;
      rateSpot %= RATE_SIZE;
      beatAvg = 0;
      for (byte x = 0; x < RATE_SIZE; x++)
        beatAvg += rates[x];
      beatAvg /= RATE_SIZE;
    }
  }
  Serial.print("BPM = ");
  Serial.println(beatAvg);
```

Source : (Research Result, 2024)
Figure 5. Source code BPM Reading Algorithm

Detects the presence of the user's finger. If no finger is detected, the system displays a "No Finger" message. When a finger is detected, the system shows the BPM value and the heart rate status (normal or abnormal) on the LCD (Figure 6).

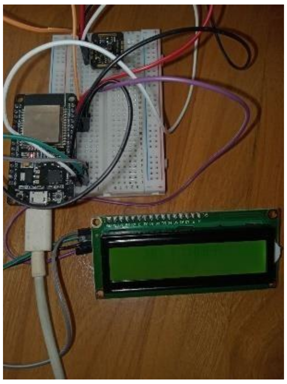
```
if (irValue < 50000) {
  beatAvg = 0;
  beatsPerMinute = 0;
  kondisi_ = "-";
  lcd.setCursor(0, 0);
  lcd.print("   NO FINGER    ");
  lcd.setCursor(0, 1);
  lcd.print("       -        ");
}
else {
  if (beatAvg >= 60 && beatAvg <= 100) {
    kondisi = "      NORMAL      ";
    kondisi_ = "NORMAL";
  }
  else {
    kondisi = "  TIDAK NORMAL  ";
    kondisi_ = "TIDAK NORMAL";
  }
  lcd.setCursor(0, 0);
  lcd.print("BPM : " + String(beatAvg) + "       ");
  lcd.setCursor(0, 1);
  lcd.print(kondisi);
}
```

Source : (Research Result, 2024)
Figure 6. Finger Detection and LCD Display Source Code

Illustrates the data transmission mechanism to the Blynk application every 3 seconds. The BPM values and condition status are sent via virtual pins so they can be displayed on the user's Android device (Figure 7).

```
  if (PengirimanMillis >= 3000) {
    Blynk.virtualWrite(V0, kondisi_);
    Blynk.virtualWrite(V1, beatAvg);
    Blynk.run();
    PengirimanMillis = 0;
  }
}
```

Source : (Research Result, 2024)
Figure 7. Source Code for Sending Data to Blynk


8a


8b

Source : (Research Result, 2024)
Figure 8. Hardware Design Results of the Proposed System

Accredited Rank 2 (Sinta 2) based on the Decree of the Dirjen Penguatan RisBang Kemenristekdikti No.225/E/KPT/2022, December 07, 2022. Published by LPPM Universitas Nusa Mandiri

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In the hardware arrangement (Figure 8a) Oximeter Sensor Max30102, Nodemcu ESP32 and LCD IC installed on the breadboard and connected using jumper cables. After all components are connected correctly (Figure 8b) the Nodemcu ESP32 that has been programmed will receive data from the Oximeter Sensor Max30102 every second which is processed to calculate the heart rate and can be displayed on the Android screen and on the I2C LCD screen to further monitor the measurement results in a way that can be understood by the elderly [21], [29], [30]

Prototype Testing

Heart rate calculation is usually done manually by counting the pulse for 1 minute [21]. So for heart rate data collection in the trial, it was done in 1 minute or 60 seconds using a stopwatch on an Android device. The trial was conducted on 3 people in the elderly category with the profile.

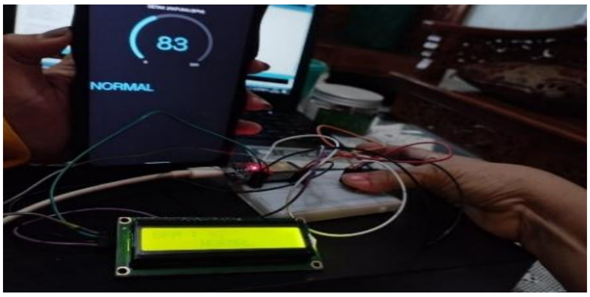
Table 1 presents the profiles of the elderly respondents involved in the system testing. This data supports the validity of the research results since the respondents represent different health conditions (healthy, hypertension, and heart attack history), which allows the system performance to be evaluated under varied medical scenarios. These differences in health status directly influenced the detected heart rate variations, enabling comparisons with the medical standard range (60–100 BPM). The tool's ability to correctly display "Normal" and "Not Normal" status for each respondent demonstrates its effectiveness in reflecting real health conditions. This also reinforces the accuracy results of 97% with a standard deviation of 1.19 BPM, showing that despite the limited sample size, the system consistently provided reliable measurements.

Table 1. Elderly Data

No	Age	Gender	Medical history	Drug Consumption
1	64 years old	Female	Have no history of illness or do not suffer from any illness.	Do not take any medication
2	60 years old	Female	Suffering from hypertension	Take hypertension medication once a day
3	64 years old	Male	Suffering from heart attack disease	Take heart medication 3 times a day

Source : (Research Result, 2024)

The trial was conducted on three elderly people in Chandra Indah Housing with different medical histories (Table 1). The purpose of this trial was to measure the effectiveness of the heart rate detection system using the Max30102 Oximeter Sensor and the Android-based Nodemcu ESP32 microcontroller with the Blynk application. The trial results (Figure 9a, 9b, 9c), it has been conducted on three elderly people in Chandra Indah Housing. The trial results are differentiated based on each individual's health history and analyzed.



9a

9b 9c

Source : (Research Result, 2024)
Figure 9. Trial Results on the Elderly (9a)(9b)(9c)

Elderly 1 (Female, 64 years old, No history of disease). The first trial stage was carried out using the Max30102 Oximeter Sensor connected to the ESP32 Nodemcu on an elderly woman who did not have any disease who successfully displayed the Heart Rate Per Minute results of "83 BPM" with "Normal" status (Figure 9a). The trial results showed that the elderly's heart rate was within the normal range (67-83 BPM). The detected BPM range reflects healthy heart activity and no indication of cardiovascular disorders.

Elderly 2 (Female, 60 years old, Has a history of hypertension). The last trial stage was carried out using the Max30102 Oximeter Sensor connected to the ESP32 Nodemcu on an elderly woman who suffered from hypertension who successfully displayed the Heart Rate Per Minute results of "91 BPM" with "Normal" status (Figure 9b). Hypertension is often correlated with increased heart rate. The results of this test indicate that the elderly's BPM is in the increased range (70-91), which can indicate high blood pressure that affects heart activity.

Elderly 3 (Male, 64 years old, Suffering from heart attack). The second trial phase was carried out using the Max30102 Oximeter Sensor connected to the ESP32 Nodemcu on an elderly man suffering from heart attack who successfully displayed the Heart Rate Per Minute results of "55 BPM" with the Status "Not Normal " (Figure 9c). The test results showed that the individual's heart rate was below the normal range (49-60 BPM), which indicates significant cardiovascular disorders. This low heart rate is in accordance with the condition of the heart attack suffered by the elderly.

Table 2 shows the results of the heart rate detector test conducted on three elderly people, with each test result assessed based on the assessment criteria, namely the limit for a normal heart beat within the range of 60-100 BPM.

Table 2. Results of the Heart Rate Detector Trial

No	Age	Gender	Medical history	Heart Rate (BPM) Results	Status
1	64 years old	Female	Have no history of illness or do not suffer from any illness.	67 – 83 BPM	Normal
2	60 years old	Female	Suffering from hypertension	68 – 91 BPM	Normal
3	64 years old	Male	Suffering from heart attack disease	49 – 60 BPM	Not Normal

Source : (Research Result, 2024)

The data sending process received from the Max30102 Oximeter Sensor is processed by the Nodemcu ESP32 microcontroller. After being processed, the heart rate data (BPM) is first sent to the I2C LCD screen to be displayed directly. After the display on the LCD, the data is then sent to the Blynk application to be displayed in real-time via an Android device. The data sending process has a delay of about 3 seconds between the display on the LCD and the display in the Blynk application. This delay is caused by the time required for data processing and transmission over the internet network.

To evaluate the accuracy of the prototype, the BPM values obtained from the system were compared with manual pulse measurements using a stopwatch. The results showed that the system achieved an accuracy of 97% with a standard deviation of 1.19 BPM. This finding confirms that the Android-based detection system using the Max30102 sensor is reliable for elderly users. However, since the prototype testing involved only three elderly participants, further trials with a larger sample size are needed to strengthen the generalization of the results.

However, the results of the trial on the three elderly people showed that the heart rate detection system built using the Max30102 Oximeter Sensor and Nodemcu ESP32, with the display of results in the Blynk application, was able to detect heart rate accurately and provide health status based on the measured BPM. The accuracy of the system in displaying BPM and detected health status can help in making better medical decisions.

CONCLUSION

The design of a Heart Rate Detector using the Max30102 Oximeter Sensor connected to an Android-based NodeMCU ESP32 microcontroller for the elderly can produce a display that can be understood by the elderly, heart rate per minute (BPM) and normal status or not successfully displayed using the Android-based Blynk application on a smartphone. Heart rate data is sent from the NodeMCU ESP32 to the I2C LCD screen and the Blynk application with a delay of about 3 seconds. Independent heart rate checks with real-time results make it easy to monitor health without relying on others.

The trial results showed that the proposed system achieved an accuracy of 97% with a standard deviation of 1.19 BPM, indicating high reliability when compared to manual pulse measurements and previous studies using the Max30100 sensor. Further development of the currently designed system works on a local network with ESP32 as an IoT server. However, this system is only effective in environments with local Wi-Fi access. This limits the use of the device if in a truly remote area without network infrastructure. Another limitation of this study is the small number of elderly participants (three respondents), so future work should involve larger and more diverse populations to validate the system performance across different health conditions. Wider trials can be conducted on a wider and more diverse elderly population to ensure that this tool is effective and can be used by various groups with different health conditions.

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