International Journal of Informatics and Computation (IJICOM)
Vol.7, No.1, 2025
ISSN: 2685-8711, E-ISSN: 2714-5263 DOI: 10.35842/ijicom

Building Employee Health Monitoring Tool Using IoT Oximeter in Palm Industry

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Abstract

Ensuring employee health and safety is a critical concern in the palm oil industry, where physically demanding environments can pose significant risks. Traditional health monitoring methods often lack real-time data collection and prompt intervention capabilities, creating gaps in maintaining occupational health standards. This paper addresses these challenges by presenting the design and implementation of an Internet of Things (IoT)--based oximeter prototype tailored to the needs of the palm oil industry. The system leverages the Blynk IoT platform to enable continuous monitoring of employees' oxygen saturation levels (SpO2) and heart rates in real time. By integrating sensor-based data collection with a user-friendly interface, the prototype facilitates immediate access to vital health metrics and sends alerts for abnormalities. A simulated palm oil plantation environment was used to evaluate the system, demonstrating its effectiveness in delivering accurate health measurements and timely notifications. Results indicate that the IoT-based oximeter significantly enhances employee health monitoring by addressing the limitations of traditional methods, promoting proactive health management, and enabling timely interventions. This innovation not only improves workplace safety but also fosters a culture of health awareness among employees and is a valuable tool for occupational health monitoring in the palm oil industry.

***Keywords*:**
Internet of Things (IoT), Health Monitoring, Wireless Data Transmission

1. Introduction

The Internet of Things (IoT) has become an increasingly popular solution to tackle this challenge. Health monitoring is important for living creatures. Many things are important factors in the health of living creatures, especially humans, including heart rate, body temperature, and oxygen saturation. IoT technology is very helpful in the development of health technology so that it becomes possible to monitor patient health in real-time and patient emergency information can be accessed easily [1]. In modern workplaces, maintaining employee health and safety is vital for ensuring organizational productivity and a supportive work environment. Traditional health monitoring methods often rely on periodic checkups, manual reporting, or post-incident responses, which are insufficient to address real-time health concerns. Employees, especially in high-risk or high-stress industries, may experience sudden health anomalies like cardiac irregularities, elevated stress levels, or exposure to hazardous conditions, which require immediate attention. Unfortunately, the absence of continuous monitoring tools delays intervention, putting employees at significant risk [2].

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The integration of the Internet of Things (IoT) into employee health monitoring systems offers a promising solution to these challenges. IoT-based health monitoring tools leverage wearable devices such as smartwatches, fitness bands, or IoT-enabled biosensors to track vital health parameters, including heart rate, oxygen saturation, body temperature, and even stress levels. These devices continuously collect real-time data, which is transmitted to centralized systems for analysis and alert generation. In cases of health anomalies, automated alerts can notify supervisors, medical personnel, or emergency services, ensuring prompt intervention [3].

In addition to real-time monitoring, IoT systems also enhance workplace safety by integrating environmental monitoring. For example, IoT sensors can assess air quality, temperature, noise levels, or hazardous gas concentrations in real time, ensuring that employees are not exposed to harmful working conditions. This is particularly beneficial in industries like construction, manufacturing, and mining, where environmental hazards are common. Such systems can not only prevent accidents but also help organizations comply with occupational health and safety regulations effectively [4]. Moreover, the vast amount of data generated by IoT health monitoring systems can be analyzed using advanced algorithms to identify health trends and predict potential risks. This proactive approach enables organizations to implement tailored wellness programs, reduce absenteeism, and enhance overall employee well-being. For instance, early detection of high stress levels or signs of fatigue can allow employers to provide mental health support or adjust work schedules to prevent burnout [5].

A heartbeat monitoring system application integrated with Blynk Apps, OLED, and pulse sensors is proposed in this paper. Counting the heartbeat in beats per minute (BPM) in a manual way would be time-consuming, especially for a large group of patients and when in an emergency condition. A study proposed heartbeat monitoring system is designed to reduce the effort and improve the performance of the current heartbeat monitoring system. The system can capture the pulse rate and use the application to track down every heartbeat condition, with the aid of an IoT system and sensors. The hardware-based Internet of Things (IoT) platform is termed ‘Blynk’ which is an amalgamation of machine learning, analytics, private device management, and white-labeled mobile applications. The microcontroller used system in this project would beESP8266 NodeMCU with a built-in Wi-Fi module. The proposed e-health monitoring system can be used for high-intensity workout competitions and training purposes to capture the participants of the heartbeat condition to avoid unprofessional acts that can endanger one's health. Furthermore, the proposed attendance system can save time from queueing up at the clinic or hospital to check heartbeat conditions and wait for consultation, patients can directly use the monitoring system at home and the apps to capture the results [14].

Despite these benefits, the adoption of IoT in employee health monitoring raises concerns about data privacy and security. Employees may hesitate to participate if they fear their sensitive health information could be misused or leaked. To address this, organizations must implement robust data encryption, access control, and compliance with data protection regulations to build trust among employees. Balancing technological advancements with ethical considerations is key to the successful implementation of IoT-based health monitoring systems [6].

Using IoT for employee health monitoring can address these challenges by leveraging smart devices, wearable technology, and real-time data processing. IoT-enabled systems can continuously monitor vital signs (e.g., heart rate, oxygen levels, body temperature) and environmental factors (e.g., air quality, noise levels) to ensure a safe and healthy work environment. Alerts can be sent to supervisors or medical personnel in case of abnormalities, enabling immediate intervention. Moreover, data collected through IoT can be analyzed to improve workplace wellness programs, identify high-risk employees, and meet regulatory compliance. Ensuring robust data security and privacy protocols can help alleviate employee concerns, fostering trust and wider adoption of such systems [7].

In this paper, we proposed an IoT Oximeter Starter Prototype that serves as an innovative employee health monitoring tool in the palm industry, leveraging the capabilities of the Internet of Things (IoT) to enhance health surveillance. This prototype aims to address the challenges of routine health monitoring faced by workers, facilitating early detection of health issues and timely medical responses. The integration with the Blynk application allows for real-time data monitoring, which is crucial for maintaining employee health. A starter prototype of an IoT-based oximeter is one implementation of IoT technology that can be used to monitor employee health in real time by measuring oxygen saturation and heart rate. The oximeter measures blood oxygen levels, and integration with the Blynk platform enables remote monitoring via mobile devices or computers. This research was initiated to develop a starter prototype of an IoT-based oximeter as a health monitoring tool for employees in the palm oil industry. The use of this technology is expected to enhance employee health resilience, enable early detection of potential health issues, and provide rapid responses to health conditions requiring medical attention.

2. Related Works

The IoT Oximeter Starter Prototype serves as an employee health monitoring tool in the palm oil industry, enhancing routine health monitoring efficiency, increasing health resilience, and enabling early detection of potential health issues for timely medical responses. This study develops an IoT oximeter starter prototype as an employee health monitoring tool in the palm industry, leveraging Blynk integration to enhance efficiency, detect health problems early, and improve employee health resilience [8].

With the recent COVID-19 pandemic break, people are becoming more conscious of checking their SpO2 (Percentage of Oxygen in our blood) and heart rate levels. The pulse oximeter is a widely used clinical instrument for performing effortless testing via a non-intrusive method. The proposed system is a smart device that has been used to monitor the health vitals and monitoring these vitals can help us to track the SpO2 and heart rate. The proposed device comprises simple components such as an MAX30100 pulse oximeter sensor and an ESP8266 Node MCU. This device can be connected to the Blythe nk App to monitor the regularly updated data through the web by connecting to Wi-Fi. In addition to this, the SpO2 percentage and heart rate can also be observed on the OLED Display. The proposed system can assist in detecting the health abnormalities like pneumonia, asthma, and many other respiratory diseases. The proposed system can assist in detecting health abnormalities like pneumonia, asthma, and many other respiratory diseases and can be connected to the App to monitor the regularly updated data through the web by connecting to Wi-Fi [9].

Smart healthcare uses technology such as wearable devices and the Internet of Things to dynamically retrieve/access information, which is important for people who require continuous monitoring, that cannot be provided outside of medical facilities. The paper presents a smart health monitoring wristband that uses Arduino Nano 33 IoT with a built-in gyroscope and accelerometer module as the microcontroller, biomedical sensors like temperature sensor, pulse oximeter, heart rate sensor, and GSM/GPRS module. This prototype is developed for all age communities but can be especially useful to the elderly, people with special needs, and those with chronic illnesses. The hardware system is connected to the Blynk application using the microcontroller's built-in WiFi module. The biomedical sensors measure the readings, and the data are uploaded onto the Blynk application interface for viewing. The Smart Health Monitoring Wristband enables real-time health monitoring to be done remotely and helps with emergency response time. The paper presents a smart health monitoring wristband that uses Arduino Nano 33 IoT with a built-in gyroscope and accelerometer module as the microcontroller, biome and medical sensors like temperature sensor, pulse oximeter, heart rate sensor, and GSM/GPRS module [10].

Before the COVID-19 pandemic, pulse oximeters were commonly used in clinics, hospitals, medical centers, and homes of individuals requiring a prescription. As a result of the health crisis caused by COVID-19, their use has been normalized and they can now be found in the first aid kit of many homes along with the thermometer. This article shows the design and experimental implementation of a pulse oximeter using an ESP32 microcontroller that allows through its Bluetooth and WiFi modules to perform an IoT (Internet of Things) application in conjunction with the online platform ThingSpeak and the Android application Blynk, generating remote and real-time monitoring of the information generated by a sensor that can measure blood oxygen concentration and heart rate reference MAX30102. The design and experimental implementation of a pulse oximeter using an ESP32 microcontroller that allows through its Bluetooth and WiFi modules to perform an IoT application in conjunction with the online platform ThingSpeak and the Android application Blynk, generating remote and real-time monitoring of the information generated by a sensor that can measure blood oxygen concentration and heart rate reference MAX30102 [11].

This research also aims to design an Android-based heart rate monitoring system using ESP8266 as a microcontroller. The sensor used is Max30102. The research method used is applied research, with experimental research methods. The research stages carried out were literature study, software design, hardware design, system testing, and analysis. The results of the research are the design of a patient health monitoring tool with three measured indicators, namely the patient's heart rate, body temperature,ure, and oxygen levels. The system can monitor in real-time based on the Internet of Things and can be accessed by Android and iOS. From the study results, it was found that the Android-based health monitoring system has an accuracy rate of 97.63% and it can be said that the system can be used for patient measurements. With details, 96.71% is the accuracy level for measuring heart rate, 96.45% accuracy level for measuring oxygen levels in the patient's body, and 99.75% accuracy level for measuring patient temperature [12].

A paper constructed of a heart rate device has been carried out using the PPG method. This tool uses the MAX30102 sensor as input. The measurement results are displayed on the smartphone. This tool can calculate the heart rate by sticking the surface of the fingertips for ten seconds. The light waves emitted by the sensor source will hit the surface of the finger. Changes in blood volume cause changes in light intensity according to what is received by the sensor. Based on the test results, the average standard deviation of this tool's heart rate measurement is 1.176. If considered the data from the pulse oximeter is correct, then this tool has an accuracy of 98.804% [13].

Differences from traditional standalone devices, this paper establishes a prototype to connect to the Blynk platform, enabling remote monitoring and notifications. The use of the NodeMCU and ESP8266 modules provides a low-cost solution with minimal hardware requirements. This prototype can display SpO2 and BPM locally on an LCD and remotely through the Blynk app, offering dual access points for employees and supervisors. It can increase scalability and flexibility as modular design allows future upgrades, such as adding more sensors for monitoring additional health parameters. By leveraging IoT technology and integration with the Blynk platform, this prototype is anticipated to be an initial step toward more effective and efficient health monitoring within the palm oil industry, ultimately improving employee quality of life and productivity.

3. Proposed Method

This phase focuses on the design and development of a starter IoT-based oximeter prototype for health monitoring in the palm oil industry. It begins with gathering data and references from online sources, such as scientific journals, to ensure the system aligns with current best practices and technological standards. The proposed system leverages an integration of hardware and IoT platforms to provide a comprehensive, real-time health monitoring solution.

3.1 Tools

a. NodeMCU V3: Serves as the microcontroller, enabling data processing and connectivity with other components.
b. ESP8266 Module: Acts as the processing unit and connector to the Blynk IoT application for real-time data monitoring.
c. Max30100 Oximeter Sensor: Measures heart rate and oxygen saturation (SpO2) with high accuracy.
d. 16x2 LCD Display: Displays real-time data locally on the device.
e. Jumper Cables: Facilitates connections between components.
f. Smartphone: Used as the medium for accessing the Blynk IoT application for remote data visualization.

3.2 Hardware Design

a. The hardware consists of several interconnected components:
   Max30100 Oximeter Sensor: A digital sensor chosen for its ease of calibration and accurate measurement of heart rate and SpO2.
b. NodeMCU V3 Board: Functions as the base microcontroller for processing data from the Max30100 sensor and transmitting it to the Blynk application.
c. ESP8266 Module: Enables wireless data transfer, allowing seamless communication between the hardware prototype and the smartphone application.
d. 16x2 LCD Display: Displays real-time data values locally, including SpO2 and BPM (beats per minute).

3.3 Implementation Scheme

a. Sensor Connection: The Max30100 sensor is connected to the NodeMCU V3 via jumper cables for data transfer.
b. Data Processing: The ESP8266 module processes the sensor data and prepares it for display on the LCD and transmission to the Blynk platform.
c. Real-Time Monitoring: The NodeMCU sends the processed data wirelessly to the Blynk application, where it is displayed in real-time on a smartphone interface.
d. Visualization: The LCDs' SpO2 and BPM values on the prototype itself, allow employees to access health data immediately.

3.4 Formula and Data Flow

The formula for oxygen saturation (SpO_2) in pulse oximeters, written in standard mathematical notation as follows:

$$SpO_2(\%) = \frac{HbO_2}{HbO_2 + Hb} \times 100 \quad (1)$$

Where:

- HbO_2 = Concentration of oxygenated hemoglobin
- Hb = Concentration of deoxygenated hemoglobin

The proposed IoT-based oximeter prototype introduces a novel and practical solution for monitoring employee health in the palm oil industry. The hardware design for the SpO2 and BPM monitoring device consists of several basic components, including the Max30100 sensor, Node MCU V3 board, ESP8266 module, and a 16x2 LCD. The Node MCU will then send the sensor data to be displayed on the LCD. Additionally, the Node MCU acts as a supporting unit, connecting the device prototype to the Blynk application for real-time monitoring. Fig 1 depicts the elements of the Starter Prototype of the IoT Oximeter.

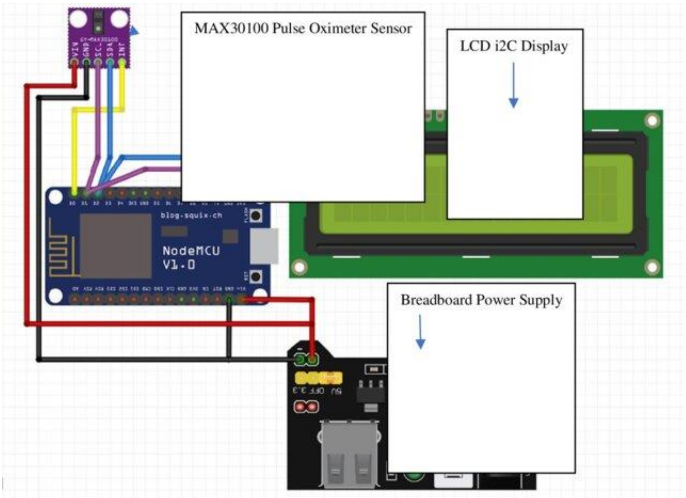

Fig 1 Architecture of Starter Prototype of IoT Oximeter.

In this paper, system functionality can develop system functions effectively, with the MAX30100 sensor demonstrating high accuracy in detecting oxygen saturation (SpO2) and heart rate (BPM). The sensor consistently provided measurements within the normal range for arterial blood oxygen saturation in humans (95%-100%). Levels below 90% were correctly identified as low, highlighting the system's reliability for health monitoring. To measure device performance, the voltage measurements during testing confirmed that the pulse oximeter device operated consistently without performance degradation. This indicates the robustness of the hardware components and system design, ensuring long-term usability in the field.

Integration with the Blynk application enhanced the usability of the system by enabling real-time data visualization on a smartphone connected to a Wi-Fi network.

This feature supports the immediate monitoring of health parameters, allowing timely detection of abnormalities. The system's functionality and ease of use make it suitable for monitoring the health of employees in the palm oil industry. This industry requires workers to maintain good physical health due to demanding and remote working environments, making the IoT oximeter a valuable tool for ensuring employee welfare and productivity.

The prototype device is built as a system assembled on an acrylic platform, where the ESP8266 Module on the NodeMCU V3 acts as the processing unit, connected to the LCD and the MAX30100 sensor using jumper cables. The sensor data will be processed by the NodeMCU into digital data, which will be displayed on the LCD and sent to the Blynk application. Fig. 2 depicts the communication model of the IoT Oximeter Prototype for health monitoring.

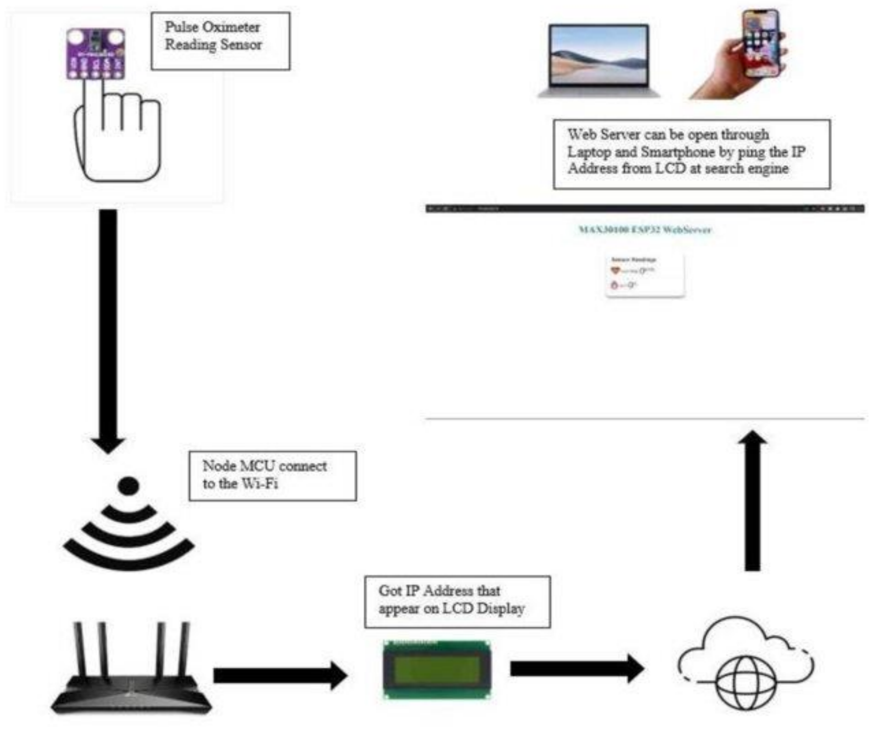

Fig. 2 Communication model of IoT Oximeter Prototype for health monitoring.

4. Result and Analysis

4.1 Sensor Testing

This test is conducted to assess the accuracy of the MAX30100 sensor in measuring BPM and SpO2. During the test, participants are asked to place their finger on the MAX30100 sensor for one minute on the prototype device, which is connected to a laptop via a USB port to read heart rate (BPM) and blood oxygen levels (SpO2) data. During testing, it must be ensured that both the prototype device and the smartphone with the Blynk application installed are connected to the internet so that data can be displayed through the Blynk application. Table 1 displays the testing of the MAX30100 Sensor for Heart Rate (BPM).

Table 1. Testing of the MAX30100 Sensor for Heart Rate (BPM)

No	Respondent	Age	Heart Rate (BPM)					Average (bpm)
			1	2	3	4	5	
1	Abud	18	90	92	89	92	95	91,6
2	Fajar	19	87	90	90	89	92	89,6
3	Isma	19	89	90	92	90	92	90
4	Maudy	19	92	90	90	93	91	91,2
5	Farodis	23	87	85	90	92	89	88,6

This test is conducted to assess the accuracy of the MAX30100 sensor in measuring BPM and SpO2. During the test, participants are asked to place their finger on the MAX30100 sensor for one minute on the prototype device, which is connected to a laptop via a USB port to read heart rate (BPM) and blood oxygen levels (SpO2) data. During testing, it must be ensured that both the prototype device and the smartphone with the Blynk application installed are connected to the internet so that data can be displayed through the Blynk application. Table 2 shows the MAX30100 sensor analysis results for heart rate (BPM).

Table 2. MAX30100 sensor analysis results for heart rate (BPM)

No	Respondent	Age	Note
1	Abud	18	Normal
2	Fajar	19	Normal
3	Isma	19	Normal
4	Maudy	19	Normal
5	Farodis	23	Normal

In Table 2, the analysis results for each respondent's heart rate data testing indicate that all measurements are within the normal range. This is because the normal resting heart rate for adults is typically between 60–100 BPM. Table 3 displays MAX30100 sensor testing for oxygen saturation (SpO2).

Table 3. MAX30100 sensor testing for oxygen saturation (SpO2)

No	Respondent	Age)	oxygen saturation (SpO2)					Average (SpO2)
			1	2	3	4	5	
1	Abud	18	90	95	96	97	98	95,2
2	Fajar	19	95	94	97	98	97	96,2
3	Isma	19	93	96	96	97	98	96
4	Maudy	19	94	96	98	96	97	96,2
5	Farodis	23	96	94	96	95	98	95,8

In Table 3 it is shown that each respondent has 5 data (changes in values) for the calculation of oxygen saturation (SpO2) which is carried out in 1 minute. The average value obtained will be calculated. Table 4 displays MAX30100 sensor analysis results for oxygen saturation (SpO2).

Table 4. MAX30100 sensor analysis results for oxygen saturation (SpO2)

No	Respondent	Age	Note
1	Abud	18	Normal
2	Fajar	19	Normal
3	Isma	19	Normal
4	Maudy	19	Normal
5	Farodis	23	Normal

In Table 4 it can be seen that the analysis results of each respondent for testing oxygen saturation (SpO2) data are normal. Because the normal arterial blood oxygen saturation level in humans is 95% -100%. If the level is below 90%, it is considered low.

4.2 Blynk Application Appearance

The Blynk application provides an innovative solution for health monitoring by integrating IoT-based oximeters to measure and track vital signs like oxygen saturation (SpO_2) and heart rate in real time. Through a user-friendly dashboard, it visualizes health data using intuitive widgets such as gauges, graphs, and value displays. The IoT oximeter collects data using sensors and transmits it to the Blynk cloud via Wi-Fi or Bluetooth, enabling remote monitoring capabilities. Users can set thresholds to receive alerts and notifications if abnormal readings are detected, ensuring immediate action can be taken when necessary.

This real-time data visualization and alert mechanism make it ideal for both personal health management and professional medical monitoring. In addition to real-time monitoring, the Blynk application also supports data logging, allowing users to track historical trends and generate reports that can be shared with healthcare providers. Customizable profiles make it possible to monitor multiple individuals, making the application suitable for families or healthcare facilities. Features like remote monitoring, notifications, and the ability to analyze historical data enhance its usability and effectiveness. With its seamless integration of IoT technology, the Blynk application represents a cost-effective and scalable solution for proactive healthcare management, ensuring improved health outcomes for users. This application will later be installed on the cellphone of the supervisor or officer. Fig.3 depicts the Blynk application interface in health monitoring using IoT Oximeter.

Fig.3 Blynk application interface in health monitoring using IoT Oximeter.

The application can display the heart rate (BPM) and blood oxygen levels (SpO2), LED to display the normal or abnormal status of BPM and SpO2 values, Chart to display graphs and store data on BPM and SpO2 values, Event to display routine equipment conditions, and Notification to create messages/warnings when there are abnormal values in BPM and SpO2 measurements. The user interface that is built can communicate with devices using WiFi (personal hotspot) media on cell phones. The Blynk platform is an excellent choice for creating a user-friendly, real-time health monitoring application powered by IoT devices such as an oximeter. By leveraging IoT sensors and Blynk's cloud and mobile interface, a health monitoring system can be implemented effectively to measure and track vital signs

5. Conclusion

In this paper, the IoT-based oximeter prototype represents a significant step forward in utilizing technology to improve occupational health monitoring. By addressing both immediate and long-term challenges, this study paves the way for innovative approaches to health resilience in the palm oil industry and other sectors requiring robust health management solutions. By integrating accurate sensors with IoT technology and a user-friendly interface, the system ensures real-time data access, early detection of abnormalities, and improved workplace safety. Future work will focus on expanding the system's capabilities and refining its functionality to meet industry needs.

Future directions could integrate additional sensors to monitor other vital signs, such as body temperature, blood pressure, and stress levels, for a more comprehensive health assessment. Incorporating machine learning algorithms could provide predictive analytics, enabling early detection of potential health risks and trends based on historical data. Developing offline capabilities would allow the system to operate effectively in areas with limited or intermittent internet connectivity, which is common in palm oil plantation environments.

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