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Sensor-Based Smart Wireless Emergency Pendant

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ABSTRACT:
Smart wireless emergency pendants represent a technological advancement in personal safety devices, offering an innovative solution for rapid access to emergency assistance. This paper explores the evolution, functionalities, applications, benefits, and challenges associated with these wearable devices. Through an extensive review of existing literature and technological developments, this research elucidates the pivotal role played by smart and wireless emergency pendants in revolutionizing emergency response systems, particularly in healthcare settings. The analysis encompasses the technological components, such as sensors and connectivity, highlighting their capabilities in detecting emergencies, triggering alerts, and facilitating prompt communication with emergency services or designated contacts. Moreover, this paper discusses the broader implications of these devices, including their impact on emergency response times, user safety, and the challenges related to adoption and implementation. Future trends and potential societal implications are also deliberated upon, laying the groundwork for further advancements and applications of these devices in diverse contexts. This research underscores the significance of smart and wireless emergency pendants in augmenting personal safety and enhancing emergency preparedness in an increasingly interconnected and technology-driven world.

Keywords: ESP32, Sensors, Fall detection, Emergency Button, Wireless emergency pendant,
GPS-enabled wearable pendant, GSM Module.

I. INTRODUCTION

In recent years, technological advancements have revolutionized the way we approach personal safety and emergency response systems. Among these innovations, smart and wireless emergency pendants have emerged as crucial tools designed to provide immediate assistance and peace of mind, particularly for seniors, individuals with medical conditions, or those living alone. These devices, often compact and wearable, offer a seamless connection to emergency services or designated contacts, leveraging cutting-edge technology such as GPS tracking, fall detection, and real-time communication capabilities. This introduction explores the significance, functionalities, and benefits of these modern emergency pendants in ensuring swift and effective responses during critical situations. These are innovative devices designed to enhance personal safety and provide immediate assistance in emergency situations. These devices are often worn as accessories allowing individuals to call for help or notify their emergency contacts with a simple activation button. These devices are equipped with various sensors such as the fall detection sensor, GPS-tracking, sweat sensor, temperature sensor, heart rate and oxygen sensor. The primary objective of the intelligent, smart and wireless emergency pendant is to enhance personal safety and security, ensuring immediate help in emergency situations, allowing individuals to lead an independent life with the assurance that support so easily accessible whenever needed.

II. LITERATURE SURVEY

Kommey, B., Kotey, S. D., & Opoku, D. (2018). The paper titled “Patient Medical Emergency Alert System” focuses on the development of a system that provides timely alerts for medical emergencies in hospitals. The system uses a structured early warning score (EWS) tool to detect patient deterioration and trigger appropriate responses, which is facilitated by the afferent arm of the rapid response system (RRS). The RRS consists of three interrelated components: an afferent arm, an efferent arm, and a governance and audit process. The afferent arm is responsible for crisis detection and response triggering, while the efferent arm provides competent and skilled personnel and resources at the bedside to initiate an appropriate response. The governance and audit process coordinates human and financial resources, evaluates and prevents future adverse events, and ensures the sustainability of the RRS.[1]

Xueyi Wang, Joshua Ellui and George Azzopardi. (2020). The paper titled " Elderly fall detection systems", provides a comprehensive literature survey on the topic of elderly fall detection using sensor networks and IoT. The paper delves into various aspects related to fall detection systems, including the types of falls, hardware and software components used, fall detection methods, security and privacy issues, projects and applications, current trends, challenges, and future directions. It also highlights the importance of addressing the urgent need for the development of fall detection systems, especially with the growing aging population. [2].

Lee, S., Lee, S., & Park, S. (2020). The paper titled "Development of Smart Emergency Pendant with Voice Recognition and Fall Detection", presents a comprehensive exploration of the design and development of a smart emergency pendant equipped with voice recognition and fall detection capabilities. The main focus of the paper revolves around the creation and integration of technological features within the emergency pendant. These features include voice recognition, which likely enables users to trigger alerts or communicate with the pendant through voice commands. Additionally, the paper discusses fall detection technology, a critical aspect for identifying potential emergencies, particularly in scenarios where the user may not be able to manually activate the pendant [3].

Aaron Smith, Rui Li, and Zion Tsz. (2023). The paper titled "Reshaping healthcare with wearable biosensors". discusses the potential of wearable biosensors to revolutionize healthcare and improve patient outcomes. Wearable biosensors are devices that incorporate biometric aspects into sensor operations, such as enzymes, antibodies, cell receptors, or organelles, and can monitor various vital signs and conditions related to a patient's wellbeing, including heartbeat, blood pressure, motion, and body temperature. The authors highlight the potential of wearable biosensors to revolutionize healthcare by enabling continuous monitoring and feedback to users, leading to improved healthcare outcomes and personalized medicine. It discusses how wearable biosensors can monitor patients' health status in real-time, remotely, and provide measurements of biochemical markers in biofluids, such as sweat, tears, saliva, and interstitial fluid [4].

Gambhir, S.S, Ge, T.J, Vermesh, Spitler, R, Gold, G.E. (2021). The paper titled "Continuous Health Monitoring: An Opportunity for Precision Health", discusses the potential of continuous health monitoring using wearable devices and integrated diagnostic devices to identify and prevent early manifestations of diseases. It highlights the challenges that lie ahead in validating new health monitoring technologies and optimizing data analytics to extract actionable conclusions from continuously obtained health data. It emphasizes the potential of continuous health monitoring to enable precision health, which involves the use of data-driven approaches to prevent, diagnose, and treat diseases. Continuous health monitoring can provide real-time, actionable insights into an individual's health status, enabling personalized interventions to manage health conditions. [5].

Jingjing Lou, Fan Yang, and Changsheng Lv. (2022). The paper titled "Detection and Application of Wearable Devices Based on Internet of Things in Human Physical Health", discusses the potential of wearable devices based on the Internet of Things (IoT) in monitoring and improving human physical health. The paper highlights the growing market for wearable devices and their ability to track various health-related metrics, such as heart rate, calories burned, step counts, blood pressure, and biochemical release. It emphasizes the importance of wearable devices in healthcare, particularly in the context of the ongoing COVID-19 pandemic, which has accelerated the adoption of wearable technology in healthcare. Wearable devices can enable self-monitoring and preventive medicine, particularly for elderly people. The paper also discusses the potential of wearable systems that monitor muscle activity, store data, and deliver feedback therapy as the next frontier in personalized medicine and healthcare. [6].

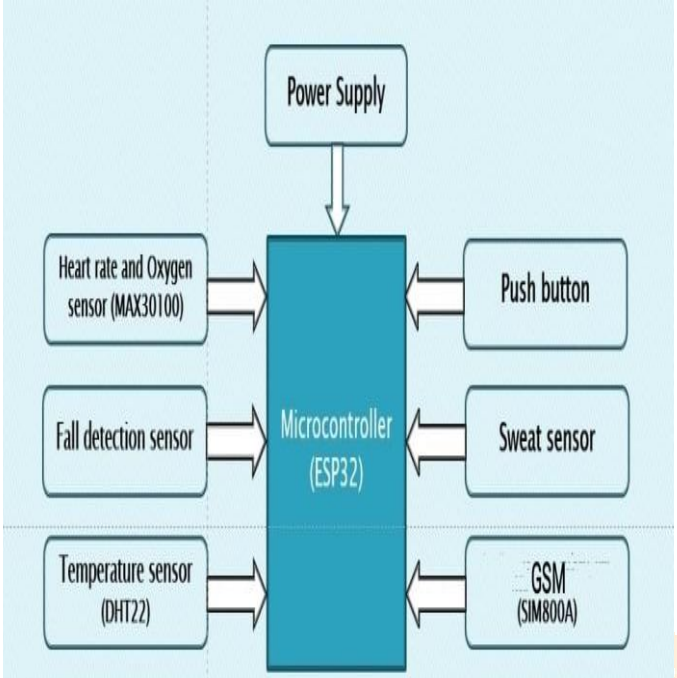
Ju-Yu-Wu, Yuhling Wang, and David Wang. (2023). The paper titled "IOT Based wearable health monitoring device", presents a wearable health monitoring device that utilizes the Internet of Things (IoT) to remotely monitor the exact locations and health status of individuals. The device is designed to be worn on the body and can measure various health parameters, including heart rate, blood pressure, and oxygen saturation, among others. The data collected by the device is transmitted to a cloud-based platform, where it can be accessed by healthcare professionals and family members in real-time. The advantages of the IoT-based wearable health monitoring device include its ability to provide continuous monitoring of health status, which can help in early detection of health issues and preventive care. The device is also designed to be user-friendly, with a simple interface that allows users to easily access and understand their health data. Additionally, the device can be customized to meet the specific needs of individual users, such as those with chronic health conditions or those who require regular monitoring for medical reasons. [7].

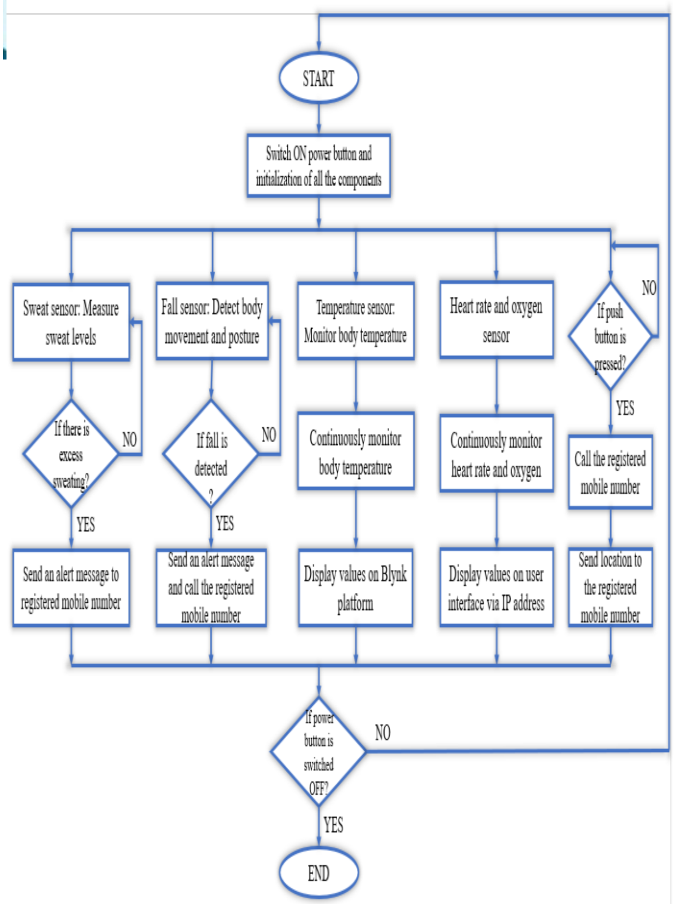
Wei-Hsun Wang and Wen-Shin Hsu. (2023). The paper titled "Integrating Artificial Intelligence and Wearable IoT System in Long-Term Care Environments", discusses the integration of artificial intelligence and wearable IoT systems in long-term care environments. The paper highlights the potential of wearable IoT care systems in providing real-time communication and location functions, as well as supporting the development of portable physiological signal detection devices and electronic fences. The paper also discusses the challenges and limitations of integrating artificial intelligence and wearable IoT systems in long-term care environments, including issues related to data privacy and security, as well as the need for robust and reliable infrastructure to support the integration of these technologies. [8].

III. BLOCK DIAGRAM AND FLOWCHART

Fig.1. System block diagram

Fig. 2. Flowchart





IV. METHODOLOGY

A smart wireless emergency pendant typically functions as a wearable device equipped with various sensors, communication modules, to assist in emergency situations. The pendant includes sensors that detect fall, heart rate and oxygen levels, sweat and also temperature of the user. It has a GSM module to provide communication between the user and the registered mobile number. All the sensors, and GSM module are interfaced to the ESP32. Analog output signals (changes in voltage if occurs) are received by the ESP32. Then the ESP32 reads analog signals from the sensors at regular intervals. ESP32 processes these signals into digital values and computes the physical conditions (Ex. Heart rate, Oxygen levels of blood, temperature, humidity, sweat etc.,).

In case of an emergency, the user can get assistance by pressing the push button. It is also known as an emergency button because of its functionality, as it helps the user in immediately calling the registered mobile number in case of any critical situation. For instance, pressing a push button on the pendant or the device detecting an unusual event like a fall can trigger the emergency response process and sends a quick pop-up message to the Blynk IOT application and immediately calls the registered mobile number via the GSM Module.

The registered mobile number receive the message and takes appropriate action. This could involve dispatching emergency services to the user's location, contacting a registered mobile number, or providing instructions for assistance. After the alert is resolved, the system may continue to monitor the user's status, ensuring the situation is under control and providing ongoing support if needed.

With the help of this module the patient's physical health condition is monitored continuously and if there is any change in the condition of the health (if a fall is detected or if the user is profusely sweating) then it immediately sends a message through Blynk IOT application. In this we check the patient's health condition by continuously monitoring the vitals of the person. The heart condition and oxygen level in blood are monitored with the heart rate and oxygen sensor. And the same can be monitored continuously via an IP address. It also monitors the temperature and humidity of the body with a temperature sensor, and the data can be continuously monitored on the Blynk platform. The device is also equipped with a tilt sensor which detects changes in movement or body posture and any movement above 90 degree is taken as changed value and immediately an alert message is received as a notification on the blynk console application and a call is initiated to the registered mobile number. The location of the person is continuously monitored in real time. The pendant is also equipped with rechargeable batteries, provided with a charging circuitry, to charge the batteries if they're drained. The device also has a power button, switching it on activates the pendant followed by continuous monitoring of the vitals of the user.

The Smart Wireless Emergency Pendant is a wearable device designed to enhance personal safety and well-being by monitoring the user's health parameters and facilitating quick communication for emergency assistance. The functionality of the pendant includes:

1. Health Monitoring: The pendant is equipped with sensors to detect falls, monitor heart rate, oxygen levels, body temperature, and sweat composition.
2. Emergency Button: Users can activate the device through a push button in case of emergencies, triggering immediate communication with registered mobile numbers via the GSM module.
3.Real-time Data Processing: Sensor data is continuously processed and analyzed in real-time to check for abnormal readings or events like sudden changes in vital signs or falls.

4. Emergency Detection: The system determines if an emergency situation is detected based on the analyzed sensor data, such as fall detection or abnormal vital signs.
5. Alert Generation: In case of an emergency, the system generates an alert containing relevant information like location coordinates, sensor readings, and device ID.
6.Communication: The pendant establishes communication using the GSM module to send emergency alerts to predefined contacts or services via SMS or call.
7. Emergency Response: Upon receiving the alert, designated contacts or services take appropriate action, which may include dispatching emergency services, notifying caregivers, or activating emergency protocols.
8. User Interaction: The user can interact with the pendant by activating the emergency button, interpreting alerts and notifications, and communicating with emergency services or contacts.
9. Location Tracking: The pendant utilizes GPS technology to track the user's location in real-time, aiding in emergency response and assistance.
10. Monitoring and Follow-Up: After the emergency alert is resolved, the system may continue to monitor the user's status or implement follow-up actions to ensure ongoing support and control of the situation.

Overall, the Smart Wireless Emergency Pendant provides a comprehensive solution for monitoring health parameters, detecting emergencies, triggering alerts, and facilitating prompt communication with emergency services or designated contacts in times of need.

V. HARDWARE IMPLEMENTATION:

This health device is made up of numerous different types of sensors, including the GPS for live location tracking, with a GSM Module for communication purpose, and the ESP32 microcontroller is the heart of the device. ESP32 is a microcontroller that is linked to all the other components. The different hardware components included in this health device are as follows:

1) ESP32 microcontroller: The ESP32 integrates all the sensors, and is responsible for all the data processing, wireless communications, and the alert mechanisms.

2) Fall detection sensor [Tilt sensor]: If the person has any hard-fall, the fall detection sensor senses it and it will be notified to the user by a buzzer. The buzzer gets switched ON and a message will be sent to the registered mobile number with the live location of the person.

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3) Temperature sensor [DHT22]: The temperature of the body is monitored with the temperature sensor and any changes in the normal conditions of the temperature will be notified to the user by a buzzer. The buzzer gets switched ON and a message will be sent to the registered mobile number.

4) Heart rate and oxygen sensor [MAX30100]: The heart rate and the oxygen rate of the body is monitored with the heart rate and the oxygen sensor and any changes in the normal conditions of the heart and oxygen level will be notified to the user by a buzzer. The buzzer gets switched ON and a message will be sent to the registered mobile number.

5) Sweat sensor: If the person sweats profusely or if there is excess of sweating, then the buzzer gets switched ON and a message will be sent to the registered mobile number.

6) GSM Module [Sim800A]: The GSM Module is responsible for communication purpose between the user and the registered mobile number.

7) **Push button:** In case of any emergency situation, the user presses the button (emergency button) and a call is initiated to the registered mobile number and the live location of the person is sent.

8) **Power Supply:** To ensure continuous operation, the Arduino Nano would require a reliable power source, such as a rechargeable battery.

VI. SOFTWARE IMPLEMENTATION:

1) Arduino Sketch Development:
   a. A code is written in the Arduino IDE, incorporating libraries and functions as needed for the project (e.g., sensors, actuators, and also the communication protocols).
   b. The code is compiled in the Arduino IDE to check for errors.
   c. The compiled code is then uploaded into ESP32 development board via USB.

2) Blynk Project Configuration:
   a. A new project is created in the Blynk app.
   b. Widgets and other virtual pins are added to the project interface to control or monitor the ESP32 device remotely.
   c. The authentication token is copied and included in the Arduino IDE code for the project.
3) Integration:
   a. The Blynk library with all the other necessary and required libraries are included in the Arduino Sketch.
   b. The code is configured to establish a connection with the Blynk server using the authentication token.
   c. The code logic is implemented to handle incoming commands from the Blynk app and send data back to the app for display.

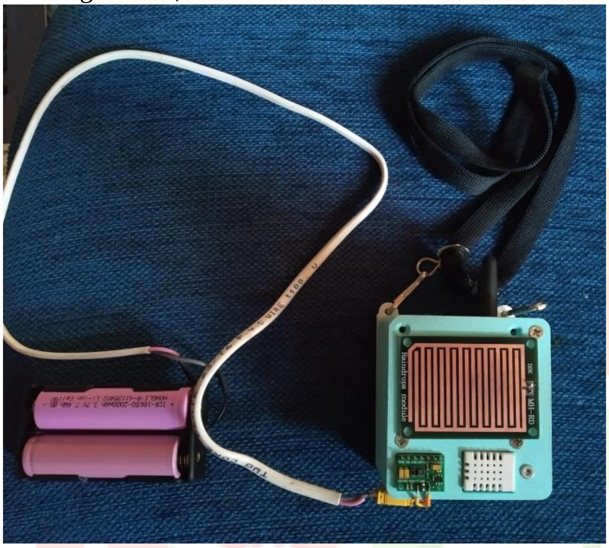
4) Testing and Deployment:
   a. The setup is tested by running the ESP32 development board with the uploaded Sketch and interacting with the Blynk app.
   b. Necessary adjustments are made to the code or project configuration based on testing results and other requirements.
5) The finalized setup is deployed and the working model is demonstrated for our intended application.

VII. CONCLUSION

In conclusion, the evolution of smart wireless emergency pendants has revolutionized the landscape of personal safety, especially for vulnerable populations and individuals with medical conditions. These devices have transcended traditional emergency alert systems by incorporating advanced technologies, such as IoT, GPS, and two-way communication capabilities, into compact and wearable forms.

Throughout this research paper, it becomes evident that the benefits offered by these pendants are multifaceted. They not only provide a sense of security and independence for users but also significantly improve emergency response times, ultimately saving lives. The integration of location tracking and real-time communication empowers users to swiftly and effectively signal for help, enhancing their overall safety and well-being.

Looking ahead, the future of smart and wireless emergency pendants appears promising. Advancements in sensor technologies, AI integration, and design improvements offer vast opportunities for innovation. These advancements hold the potential to further enhance the functionality, reliability, and user experience of these devices, thus solidifying their role as indispensable tools for personal safety and emergency response.



In conclusion, while challenges persist, the continuous evolution and integration of smart and wireless emergency pendants into our daily lives have and will continue to significantly impact safety and independence for individuals in need. Further research, technological innovation, and collaborative efforts are crucial to realizing the full potential of these devices, ultimately creating safer and more secure environments for everyone.

VIII. RESULTS

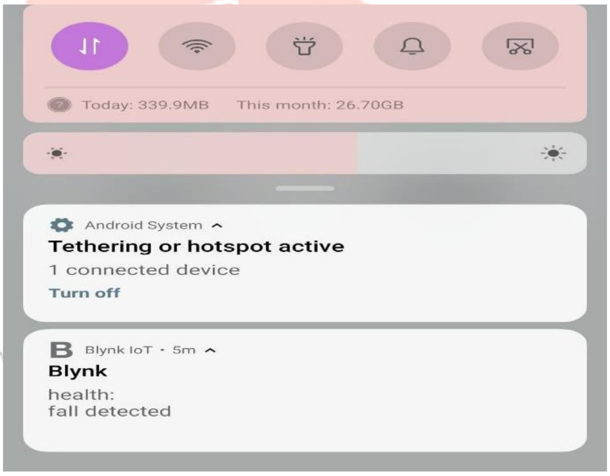
This study develops a smart wireless emergency pendant that integrates multiple functional physiological signal measurement technologies into a device, including detection of heart rate, body temperature, blood oxygen, blood pressure and also fall detection with location tracking technologies. It also combines wireless transmission technology to transmit physiological signals and location information back to the monitoring center in real time. Additionally, in response to the needs of long-term care or day care facilities, due to various activities, some areas being more dangerous that need to be avoided by care recipients alone, and the fact that care recipients may also leave the park area, the system also includes location tracking functions. Finally, a software application is established to collect and establish various physiological information as a data source for monitoring data in real time and for subsequent research analysis.

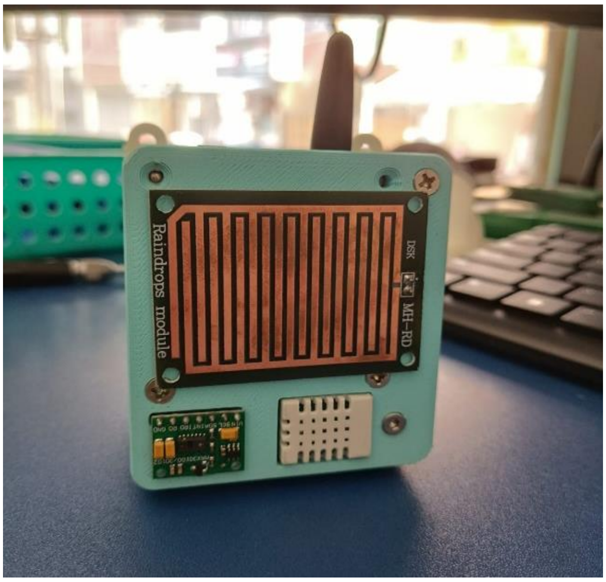
Figure: Proposed system of smart wireless emergency pendant.

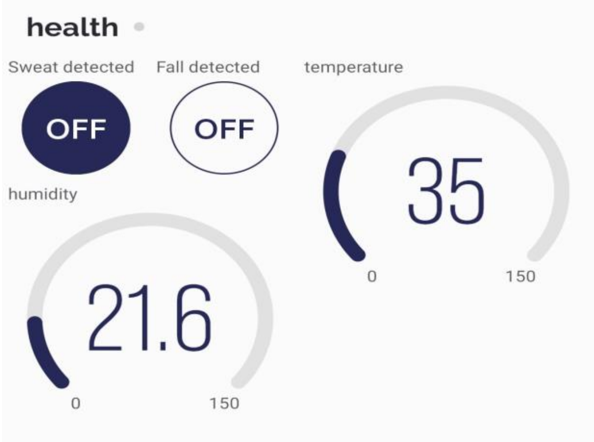
Figure: A comprehensive view of the collected and analysed data from the blynk console application.
Figure: The figure shows a smart wireless emergency pendant whose rechargeable batteries and power button are outside the case in order to make it more compact.

Figure: The notifications are received from Blynk Console application.

IX. FUTURE SCOPE







The future of smart wireless emergency pendants looks promising. Advancements in technology may lead to smaller, more discreet designs with enhanced features like accurate GPS tracking, measuring variations in fall detection, integration with smart home systems, and quicker emergency response systems. Moreover, these devices might become more accessible and affordable, catering to a wider demographic, including seniors, individuals with disabilities, and anyone needing immediate assistance in emergencies. Additionally, improvements in connectivity, battery life, and artificial intelligence could further enhance the functionality and reliability of these devices, making them an indispensable tool for ensuring personal safety and well-being. By using more accurate technologies the device can be integrated with the nearest hospitals for emergency assistance and immediate help and care. Other biosensors can also be included to enhance the features of the wearable device.

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