



## SOS WRISTBAND: ARDUINO-BASED EMERGENCY SIGNALING SYSTEM PROTOTYPE

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### ABSTRACT

This study focused on the development and assessment of an Arduino-based wristband emergency signaling system designed specifically to support elderly individuals and persons with disabilities who live alone or independently. The project aimed to address risks associated with social isolation, heightened vulnerability, and delayed access to emergency services by creating a wearable device equipped with pulse detection, fall detection, GPS location tracking, and manual alert activation. The system processes physiological and motion data and transmits emergency alerts through email to designated recipients. Utilizing a developmental research design, the study involved the construction of a functional prototype and performance evaluation under controlled conditions. Findings demonstrated acceptable pulse detection accuracy, high fall detection reliability, precise GPS tracking, and timely alert transmission. The results indicate that the device is feasible, functional, and capable of supporting rapid emergency response for at-risk populations.

**Keywords:** *Emergency signaling system, wearable technology, fall detection, pulse monitoring, GPS tracking*

### INTRODUCTION

#### Background of the Study

The natural process of aging or living with a disability should not equate to social isolation. Yet in the Philippines where family and intergenerational care used to be cultural cornerstones, more and more older adults now find themselves living alone (Russel et al., 2024).

One of the reasons is the shift from mostly egalitarian households where the elderly co-reside with their adult children to nuclearized families with family members scattered around the globe in search of better job opportunities. While options such as hiring caregivers exist for persons with disabilities and for older individuals who are not healthy or mobile, many Filipinos cannot afford this kind of care.

In most cases where all family members are employed and a caregiver is financially out of reach, they are left with no choice but to live alone despite the risks. A study from the Philippines reveals that despite the availability of emergency services, social isolation remains a critical barrier hindering timely care and health service utilization (Buan et al., 2024). Another concerning factor is the lack of specialized Emergency Medical Services (EMS) in the country for those in the minority, such as the deaf community, making emergency response inaccessible (Tannenbaum et al., 2025).

Several modern approaches have emerged, such as wearable devices that gained popularity as personal safety and health technologies. The compact and portable design made them well-suited for daily use, especially for individuals who need continuous monitoring or immediate access to emergency alerts. These were typically in the form of smartwatches such as the well-known Apple Watch with fall-detection and Emergency SOS feature; however, they face inaccuracy

and usability concerns.

The Apple Watch fall detection feature showed a sensitivity of 4.7% and false negative rate of 95.3%. The user's height, impact force, lower limb functioning were some of the factors that played a role in the accuracy of fall detection which are parameters that may influence the ability of Apple Watch to detect falls from wheelchair users (Abou et al., 2021). Wearable devices also come in wristbands; Manasa et al. (2024) investigated an IoT-based smart wristband designed for women's safety through real-time communication and alert functions.

Similarly, Mitro et al. (2023) introduced an AI-enabled wristband that monitors vital signs and stress levels, showing how wrist-worn devices can serve as health monitors and safety tools. These studies highlight the potential of wearable wristbands instead of smartwatches that can integrate personal safety features with real-time physiological and environmental monitoring.

Correlated with social isolation, falls represent a leading cause of fatal unintentional injuries worldwide. For the elderly, it is an increased vulnerability that comes as they age due to the natural decline in muscle strength, proprioception, vision, and vestibular function, making them lose their balance and control. When isolated individuals fall and undergo a long-lying, where a period of more than an hour is spent on the floor after a fall because they are unable to get up or call for help, a 50% increase in mortality rates within six months of the event prevails even if the initial fall was not fatal. (Vellas et al., 1987, as cited in Kubitzka et al., 2023)."

Consequently, older people stand to benefit from non-complex wearable devices as safety innovations, particularly for those living independently who are more prone to delayed medical emergency

response. Wearable devices have been shown to improve older people's lives by continuous health monitoring and rapid emergency response.

Research published in PubMed (2024) emphasizes the importance of devices in providing immediate assistance during emergencies. While studies in MDPI (2022) support that these devices help maintain elderly independence, mitigating risks associated with accidents or sudden health events.

Previous studies have explored many approaches, programs, and tools in creating a security gadget to assist vulnerable individuals during emergencies. Despite this, some limitations in these innovations remain, such as in terms of functionality, design, and usability. For instance, Sultana et al. (2021) were able to design a safety device that is built to aid in safeguarding lives during potentially dangerous situations including sudden abduction, robbery, or sudden illness.

However, it faced the drawback of being too bulky and non-wearable, which limits its practicality and reliability for everyday use. On the other hand, another study attempted to develop a wearable safety system based on GPS and GSM to protect women from being harassed (Dave et al., 2020). Yet its effectiveness was hindered by its strong dependence on user activation, and it requires a manual pressing of a button, which may not always be possible in cases of sudden danger.

In recent years, technological advancements have catalyzed the development of real-time health monitoring solutions such as the IOT-based Patient Health and Fall Monitoring System (Arun et al., 2025). This system integrated an Arduino Uno Microcontroller with several biomedical sensors to ensure a scalable and cost effective design. However, limitations persisted due to some of its components such as the Global System for Mobile (GSM) module which limited the system's functionality due to its heavy reliance on cellular network coverage which may not perform as optimally in signal-poor environments.

Considering the stated gaps, this study aims to fill the gap by developing an Arduino-based emergency signaling system wristband specifically for elderly people and people with disabilities living alone. This device will be able to send alert messages through the e-mail account of the receiver.

In addition, various sensors of this device, such as the pulse sensor and accelerometer sensor, can detect sudden pulse change or sudden movements, which may be caused by risky situations, reducing the need for manual activation by its capability of automatically transmitting signals. Lastly, it is designed to provide user-friendly convenience through its compact and wearable design, allowing users to utilize it for everyday use. This approach ensures that the proposed system will provide a more accessible and practical solution to support timely emergency response for those at risk.

### Objectives of the Study

The main objective of this study is to develop an Arduino-based wristband signaling system that ensures reliable and efficient alert communication during emergency situations. Specifically, this study also aims to: (1) Develop an Arduino-based wristband emergency signalling system that has various sensors such as the pulse detection, fall detection, location tracking, and manual button; and, (2) Assess the functionality of the different sensors as well as the effectiveness of the device in sending emergency signals through observation and

testing under controlled conditions.

## Literature Review

### Technology Foundation: Microcontrollers and IoT in Safety Devices

In order to address the persistent concerns regarding the security of vulnerable people during emergencies, integrating technology in producing safety devices has become one of the significant technological advances. Central to this advancement is the use of different microcontroller chips designed for use in embedded systems and the Internet of Things (IoT).

In 2021, the study of Sultana et al. discusses the development of a safety device for emergencies, focusing on implementing Arduino and GSM Modules. Their model used the Arduino Uno microcontroller which allowed the integration of various sensors such as the pulse detection, GPS, GSM Module, press-push button, and voice command.

They were able to produce a safety device that sends an emergency signal when the recognized voice commands "danger" or "help", when the button is pushed, and when an abnormal heartbeat is detected. According to them, this type of safety device has the potential to provide safety and a supporting hand to vulnerable individuals such as the elderly, women and children amidst the increasing crime rates and health issues.

Aside from Arduino Uno, ESP microcontrollers have also been used to develop safety devices. In an existing study, Jayasudha and Balakrishnamoorthy (2024) were able to develop an emergency alert system using ESP32 microcontroller for patients which aimed to provide assistance for patients through monitoring their health status. The researchers used the ESP32 as the main component of their product innovation, which allowed them to control the components, encode the program as intended and test it. practical and accessible innovations such as this safety device can further help patients, reduce risks, and address critical medical concerns.

The microcontroller that the researchers used also enabled the device to be convenient, user-friendly and wearable for users. Moreover, the devices also proved to have a long-lasting battery life, accurate location tracking, and fast response time in sending alerts. This demonstrates that practical and accessible innovations such as this safety device can further help patients, reduce risks, and address critical medical concerns.

Using the NodeMCU ESP8266, Alabbas (2022) was also able to design an elderly care room-based monitoring system that focused on heat, smoke, and fire detection. The NodeMCU ESP8266 is a low-cost, Arduino-compatible microcontroller with Wi-Fi capability, and hardware based on ESP-12 module. The system allows monitoring of a safe environment for the users by immediately triggering an alert once abnormal environmental conditions are detected. However, despite its effectiveness, the system mainly focused on monitoring environmental conditions. This creates an opportunity for further development of wearable devices that are more compact, user-centered, and focuses more on the personal conditions of its user.

While microcontrollers provide the hardware platform to successfully integrate various sensors and modules in safety devices, its functionality becomes even more effective when combined with Internet of Things (IoT). IoT offers real-time monitoring, automating security, and enhancing the efficiency of operations with the aid of connected devices and a network of sensors (Ghasemi & Babaie, 2024, as cited by Sun, 2025).

A study by Kamalov et al. (2023) emphasized that IoT is now intertwined with various aspects in modern society. Their study indicated how IoT developed its application in various fields, such as theft protection, through its ability to connect directly to the Internet or another component allowing communication between devices and systems.

This existing knowledge shows how microcontroller chips such as Arduino and ESP microcontrollers ensure the smooth integration of different modules and sensors into one single platform while remaining low-cost and effective, and how the Internet of Things provides real-time response, processing of data, and communication between devices, which can be used in various aspects of life, including health and safety.

The functionality and application of microcontroller chips and IoT in developing systems and devices highlights how combining the two could provide a strong foundation for developers and researchers to design innovative safety solutions that are low-cost and efficient in addressing emergencies in high-risk situations or environments.

#### **Wearable Technology: Wristbands and Smart Bracelets**

A wristband is commonly known as a fashion or jewellery item nowadays. But some people showed much interest and put much effort into making this happen. Smart wristbands often serve as a clock to check the real time, but these bands are different as these researchers innovate something helpful in tracking your health and keeping you safe.

In the study of Vo et al. (2024), Wearable Biosensors, which are integrated into clothes and accessories or even directly applied to the skin, provide continuous, real-time monitoring of physiological and biochemical parameters such as heart rate, glucose levels, and hydration status. Recent breakthroughs in downsizing, materials science, and wireless communication have greatly improved the functionality, comfort, and accessibility of wearable biosensors.

As stated in the study of Luo & Gao (2021), wearable biosensors are gaining tremendous interest in the clinical and biological medical fields for their potential in providing patients with real-time diagnostic tools, time-sensitive information, and non-invasive measurements of biochemical markers distributed in body fluids throughout the body. These sensors replace part of the equipment that can only be installed in hospitals and become a new choice for assessing human health. Herein, critical perspectives regarding wearable sensors in the future digital health monitoring industry are put forward.

Meanwhile in study of Kulkarni M., et al. (2024), these smart wearable sensors offer an innovative option for evaluating and continuously monitoring human health by incorporating recent advances in technology and engineering that can enhance real time accurate monitoring and point to point care capabilities.

Smart wearable sensors have emerged progressively with multiplexed biosensing, microfluidic sampling, and data acquisition systems incorporated with flexible substrates and bodily attachments for enhanced wearability, portability, and reliability. For comfortable use of the user. In a real-time application, many innovators utilize the number of sensors to put into the SOS Band.

According to the study of Idris S., et al. (2022), to keep up in modern society, 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.

Moreover, in a study of Karmakar A., et al. (2021), they developed a system involving an EMG sensor and pulse sensor named SafeBand. These bands can send SOS signals after decoding the movement of a muscle caused by hand gestures. SafeBand works on EMG muscle sensor, pulse sensor, Arduino Uno, and ESP8266 Wi-Fi module and is powered by a rechargeable battery.

The unit connects to the user's smartphone, which can send the user's GPS coordinates to the local authorities. The smartphone acts as a gateway to notify users' emergency contacts for help through text, voice, and messages on social media.

Expanding on these safety-oriented applications, Chandak, Chaturvedi, and Dhiraj (2022), citing the work of Khojasteh et al. (2018), underscored the importance of on-wrist fall detection. It demonstrated that rule-based fall detection using wrist-worn accelerometers offers high specificity with low computational cost, making it suitable for embedding in smartphones or wearable devices.

They combined optimised thresholding techniques with machine learning models, such as support vector machines, to further improve performance, enabling accurate fall detection. This demonstrated the feasibility of embedding fall detection features into wearable wristbands and smartphones, reinforcing their role as practical safety devices in emergencies.

Lastly, apart from using wristband devices as a trusted tool for physical health monitoring, a study by Mitro et al. (2023) also showed that these technologies have also significantly contributed to stress detection. The researchers presented an AI-enabled smart wristband capable of real-time monitoring of vital signs and stress detection. Utilizing biosensors such as Photoplethysmography (PPG), oxygen saturation (SpO<sub>2</sub>), and pulse rate variability (PRV), their device successfully functioned providing essential biometric data and real-time stress detection with an accuracy score of 91%.

Overall, the studies cited demonstrate the development of a wristband going from basic timepieces or fashion accessories into advanced health-monitoring and safety-enhancing devices. Wearable biosensor technology has developed wristbands into powerful tools that can keep track of important physiological and biochemical parameters in real-time, such as heart rate and blood sugar.

Modern devices are now more portable and reliable because they use modern materials, smaller components and wireless communication technologies which makes them usable outside of a hospital or clinical setting. Smart wristbands now have important safety features, such as fall detection and SOS alert systems, that use biosensors, muscle sensors, pulse sensors, and GPS information to obtain help quickly in an emergency. Throughout history these changes have now established smart wristbands as an essential component of an individual's health monitoring, enhancing emergency response and one's well-being.

## Development and Usability Testing of an Emergency Alert Device for Elderly People and People with Disabilities

According to the United Nations' Convention on the Rights of Persons with Disabilities (CRPD, 2006), an individual is regarded as disabled when they have mental or long-term physical impairments that significantly limit their ability to participate fully and effectively in society. Similarly, older adults, who often experience age-related declines in mobility and overall health, are particularly vulnerable to falls, accidents, and medical emergencies, especially when living independently.

Globally, approximately 1.3 billion people live with significant disabilities (World Health Organization, 2023). In the context of an aging population and the persistent challenges faced by persons with disabilities (PWDs), the need for innovative technologies that enhance safety, health, and overall quality of life has become increasingly urgent.

One promising solution lies in integrating Internet of Things (IoT)-based technologies into everyday living environments. These systems can provide real-time monitoring of vital health indicators, support medication adherence, and improve environmental safety within the home.

Equipped with smart sensors, IoT-enabled devices can detect falls and transmit emergency alerts to caregivers or healthcare providers, ensuring rapid response in critical situations (Tariq et al., 2024). Such advancements highlight the potential of wearable and home-based assistive technologies to reduce risks and promote greater independence among elderly individuals and PWDs.

Wearable devices such as wristbands offer greater portability and user comfort than home-based IoT systems. Lersilp et al. (2020) developed and evaluated an emergency alert wristband for elderly individuals and persons with disabilities. The device incorporated two alert mechanisms: a conscious alert, activated when users pressed an SOS button designed with a recessed surface and a two-second delay to avoid accidental triggers, and an unconscious alert, which was automatically activated through continuous monitoring of heart rate (HR) and oxygen saturation (SpO<sub>2</sub>).

In both cases, the system transmitted signals to a receiver and relayed them through the Clever Dog application to caregivers' mobile phones. Usability testing demonstrated that the prototype was functional and beneficial, although users recommended refinements regarding display clarity, device size, and comfort to improve.

In a related study, Sultana et al. (2021) proposed a more advanced safety device for old people and persons with disabilities (PWD) that integrated a pulse sensor with a Global Positioning System (GPS) module to monitor users' heart rate and location in real time. Their system supported multiple input methods, including voice commands ("Help" or "Danger"), a push-button for silent alerts, and automatic triggers based on heart rate abnormalities.

Once activated, the device transmitted Short Message Service (SMS) notifications with GPS coordinates to family members, police, or healthcare providers. While including heart rate monitoring and location tracking enhanced emergency response, the system did not incorporate fall detection—a critical feature given the high risk of falls among elderly individuals and persons with disabilities.

Although various emergency alert devices have been developed, many still face usability, design, and functionality limitations. Common issues include poor display readability, bulky form factors,

and limited comfort, which reduce user acceptance. Other systems integrate features such as heart rate monitoring and GPS, but often lack fall detection, depend on input methods like voice commands that may not always be reliable in emergencies, or are not designed in a wearable form.

These shortcomings underscore the need for a more comprehensive and user-centred solution combining fall detection, vital sign monitoring, and location tracking into a wearable device explicitly tailored for older adults and persons with disabilities.

## Research Framework

### Theoretical framework

According to the Shannon-Weaver Model, communication begins with the sender or information source, who formulates the message. The transmitter or encoder converts this message into signals, which may encounter interference during transmission. The receiver then decodes the signals back into a form understandable to the intended audience.

In the context of the SOS Band, the ESP-32 mini functions as the core platform that integrates sensors and modules to process and transmit signals. Through this system, real-time monitoring and emergency alerts are communicated effectively. When combined with IoT, the device enhances safety by enabling automated security, real-time data sharing, and operational efficiency.

### Conceptual framework

The conceptual framework of this study explains the systematic process of the emergency signaling device. Starting with its sensors that is responsible for receiving the signals from the user which are composed of the following: (1) A pulse sensor to measure heart rate, (2) An accelerometer to detect fall, (3) A NEO-6M GPS Module to capture location, (4) A sim card and GSM Module to send the signals, (5) A push button for manual activation, and (6) a CR2032 Battery to serve as power supply. The Arduino pro mini will then act as the processor to detect the location's coordinates, and to command the GSM module to send the SMS/ Call with indicated location if the following conditions are met : (1) abnormality in pulse rate is detected, (2) fall is detected, or (3) manual button is pressed.

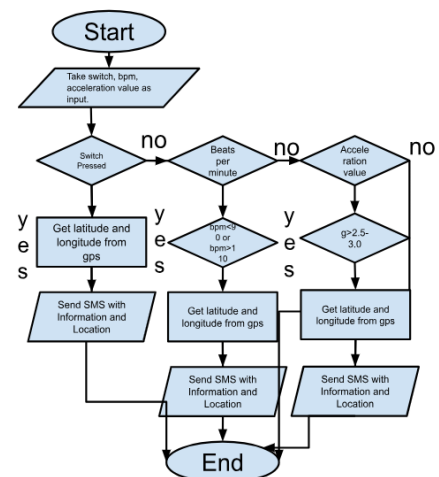


Figure 1. Conceptual framework of the study

### Scope and Limitations

This study aims to design and develop an Arduino-based wristband prototype with integrated safety features. The device includes a manual switch button for conscious activation, an automatic trigger for emergencies, a pulse sensor for heart rate monitoring, fall and

motion detection, a GPS module for location tracking. These components enable the system to send emergency notifications and coordinates to designated contacts.

The scope is limited to demonstrating core functions—manual button activation, pulse detection, and fall detection. It will not cover commercialization, advanced health metrics such as blood pressure, unconsciousness without any abnormal pulse or fall event, and blood sugar tracking, or additional features like two-way communication. Long-term durability testing and comparisons with existing devices are also excluded, focusing only on verifying if the prototype works as intended. Lastly, due to the time constraints, the researchers were unable to include offline features to the device.

## METHODOLOGY

### Research Design

This study will utilize a developmental research design, which involves the process of designing and developing a product, and analyzing its effectiveness in terms of usability (Richey & Klein, 2005, as cited by Yu et al., 2025). The design is non-iterative, meaning it will follow a linear process rather than a continuous cycle of refinement and improvement.

This design will allow the research to undergo the three stages. First, analysis and formulation, where the researchers will review similar existing solutions, and identify the core objectives, target users, and intended functions of the SOS Band. Next, it will undergo the Design and development stage where necessary hardware components and programming will be integrated to construct a single prototype.

Lastly, this research will undergo evaluation, which involves a comprehensive assessment of the pulse detection, fall detection, location detection, and the accuracy of the message transmission to the designated receiver, ensuring that the product performs according to its intended purpose. This aims to demonstrate a linear process of systematically developing the SOS Band, and present its feasibility and performance based on the functionality of its features.

### Research Procedure

The study was conducted through a systematic process involving material gathering, system development, fabrication, and testing. The device was developed using an ESP-32 Mini as the central processing unit, integrated with various sensors and modules. These included a pulse sensor for heart rate monitoring, an MPU6050 accelerometer and gyroscope for fall detection, and a NEO-6M GPS module for real-time location tracking. A manual activation switch was also incorporated, while a lithium battery served as the power source. Communication of alerts was facilitated through an email account.

In the system development phase, all necessary components were prepared and assembled. The sensors, GPS module, and switch button were connected to the ESP-32 Mini microcontroller through soldered tin-plated wires. The lithium battery was likewise connected to provide power to the device. The programmed code, developed using the Arduino IDE platform, was uploaded to the microcontroller via a CH340 UART serial converter cable. Once the system integration was complete, all components were enclosed in an acrylic hard-shell casing for durability and protection. The casing was then fitted into a pre-made silicone strap to ensure wearability and user comfort.

For the fabrication of the silicone casing, a mold box was first designed and produced using a 3D printer with PLA filament. The

printed mold was then sanded and finished, followed by the application of a mold release agent to prevent adhesion. Silicone was mixed, poured into the mold, and allowed to cure for 12 to 24 hours before being carefully removed.

Testing and evaluation were conducted through observation-based methods to assess the system's functionality, accuracy, and responsiveness. Pulse detection accuracy was evaluated by comparing readings from the device with those from a reference pulse oximeter. Fall detection performance was tested using controlled and simulated scenarios, with outcomes categorized into true positives, true negatives, false positives, and false negatives to determine sensitivity and false alarm rates. GPS accuracy was assessed by comparing recorded coordinates from known reference locations in both indoor and outdoor environments. Lastly, system responsiveness was measured by conducting multiple trials and calculating the average response time based on recorded timestamps.

### Research Instrument

The study utilized a researcher-made data collection instrument designed to evaluate the performance of the SOS Wristband: Arduino Based Emergency Signaling System. The instrument consists of structured tables that measure the device's four primary functions: pulse detection, fall detection, GPS location accuracy, and system responsiveness. These instruments were developed by the researchers to ensure accurate, systematic and consistent recording of experimental data.

### Statistical Treatment

The researchers utilized Descriptive Statistics to analyze the recorded data gathered in the testing. Descriptive Statistics synthesizes a data set, providing an organized summarization of data which allows easier comparison for analysis and drawing conclusions (Dong, 2025).

The measure of central tendency: Mean, gives an interpretation of the data by providing and representing the center of the data. It was used in this study for percent errors, accuracy percentage, and response time measurement. The computation follows the formula, where  $\sum x$  = sum of the values of the data points and  $n$  = total number of data points

$$Mean(x) = \frac{\sum x}{n}$$

### Ethical Consideration

Review of Risks and Measures to Mitigate. There were no risks involved in this study because no human participants were included at any stage of the experiment. All procedures were conducted using non-human materials and devices for testing, ensuring that no individuals were exposed to physical, psychological, or environmental harm. As a result, the study fully complies with ethical guidelines regarding the protection of human respondents.

Data Privacy and Protection. Although no personal data from human participants were collected, the researchers ensured that all system-generated data (e.g., sensor readings, GPS coordinates, and test results) were handled securely. Any data transmitted by the device, such as location information sent through email alerts, was limited to designated recipients only. The system was designed to prevent unauthorized access and ensure that sensitive information remains confidential and protected.

Minimization of False Alerts. To address the possible false alarm, this study implemented careful testing and calibration of the sensors

under controlled conditions. Different scenarios were performed to determine actual emergency events from regular activities. Proper threshold values were set for the pulse sensor and accelerometer to ensure that only certain significant changes would trigger an alert. This helps reduce unnecessary notifications and ensures that alerts are only sent during real emergency situations.

Honesty and Integrity. The data gathered from the testing of the device underwent an honest processing and calculations. The researchers made sure to maintain transparency and integrity while conducting the study, with no manipulations on any outcome and/or test conditions.

## RESULTS AND DISCUSSION

This chapter presents the findings of the study evaluating the functionality of the device’s sensors and its effectiveness in transmitting emergency signals. The results were obtained through systematic observation and controlled testing. The data gathered from the series of tests are examined in terms of system responsiveness, pulse detection accuracy, fall detection accuracy for both Non-Fall and Fall events, and GPS location tracking accuracy. Collectively, these findings offer insights into the device’s overall performance, reliability, and operational viability.

**Table 1. Pulse Detection**

Condition	Total % Error	No. of Trials
Normal BPM	16.38%	5
High BPM	24.72%	5
Low BPM	29.76%	5
<b>Mean/Average Percent Error</b>	<b>4.72%</b>	

The performance of the pulse detection component was assessed across three heart rate conditions: normal, high, and low BPM. As shown in Table 1, the system recorded an overall mean percentage error of 4.72% across fifteen trials. A mean percentage error of 5% is typically acceptable for clinical use of heart rate sensors, with some contexts allowing up to 10%. Filguieras et.al. (2025). This indicates that the pulse detection module in the SOS band maintains an acceptable level of accuracy.

A mean percentage error of 3.276%, 4.944%, and 5.952% was recorded for normal, high, and low bpm respectively which shows that the system higher accuracy in normal bpm levels but remains within an acceptable range in high and low bpm levels allowing rapid detection in irregularities despite minor fluctuations.

Similar to what was demonstrated in the study of Karmakar A., et al. (2021) where a pulse sensor was integrated in their emergency signalling system. The outcome of 4.72% mean percentage error for pulse detection further validates its suitability for emergency-response functions.

**Table 2. Fall Detection : Fall Event**

	Detected		Outcome	
	Yes	No	TP	TN
Frequency	9	1	9	1
Percentage	90%	10%	90%	10%

The fall detection tests for actual fall events yielded a high detection rate, with the device correctly identifying 9 out of 10 induced falls. Only one trial resulted in a non-detection, indicating a potential false negative. These results suggest that while the fall detection system is generally reliable, it may still fail to register certain fall conditions, highlighting the need for further refinement and calibration.

**Table 3. Fall Detection : Non-Fall Event**

	Detected		Outcome	
	Yes	No	TP	TN
Frequency	0	8	0	8
Percentage	0	100%	0	100%

The accuracy test for non-fall events demonstrated exceptionally strong system performance, indicating that the device is highly capable of differentiating normal daily activities from actual fall incidents. Across all eight trials, which involved sitting, standing, waving, walking, lying down, jumping, dancing, and general movement, the device consistently recorded a “No” detection response. This indicates that the fall detection module did not misinterpret regular body motions as fall events. All outcomes were therefore classified as true negatives, resulting in a 100% accuracy rate for non-fall conditions.

The high level of accuracy in the findings for fall detection in both fall and non-fall events align with the study of Chandak, Chaturvedi, and Dhiraj (2022), citing Khojasteh et al. (2018) expanding on safety-oriented applications that wrist worn accelerometers offers high precision making it suitable for smartwatches and emergency signalling bands like the SOS band.

**Table 4. GPS Location Accuracy**

	Yes	No
Frequency	10	0
Percentage	100%	0

Table 4 shows that all ten trials, conducted in both outdoor and indoor settings, showed complete correspondence between the actual geographic coordinates and those recorded by the device. Each recorded location matched the reference coordinates exactly, resulting in a 100% accuracy rate with no observed discrepancies.

Similar to the study of Sultana et al. (2021) and Dave et al. (2020) which developed an emergency system integrated with GPS modules, the results of the GPS location accuracy test demonstrate that the device is highly precise in identifying and reporting geographical coordinates across varying environmental conditions.

This signifies that emergency systems with integrated GPS module is reliable and suitable for real-world incidents where precise and accurate location-tracking are critical for proper emergency response in aiding to the user’s safety.

**Table 4. GPS Location Accuracy**

	Total Response Time	No. of Trials
Fall Event	240.15 sec	5
Manual Press	254.17 sec	5
<b>Mean/Average Response Time</b>	<b>49.432 sec</b>	

Table 5 shows the results the researchers were able to gather to assess the responsiveness of the system. A total of ten (10) trials were conducted for this category — the researchers subjected the device to five (5) simulated fall events and five (5) manual activation of an emergency alert with the use of the switch. The researchers then recorded how long, in seconds, the device was able to respond and send alerts after a person experiences such incidents.

Data shows that on average, the emergency wristband is able to send emergency alerts 49.432 seconds after a risky situation happens to its user.

The researchers used email as a means of communication between the device and the receiver, and it is one of the core components of the broader IoT ecosystem. Therefore, the findings align with emergency the statement of Tariq et al.

(2024) which states that the use of IoT in emergency devices ensures rapid response when transmitting emergency signals.

## CONCLUSION

The objective of this study was to develop an Arduino-based wristband emergency signaling system equipped with pulse detection, fall detection, GPS location tracking, and manual activation features, and to assess the functionality and effectiveness of its components under controlled testing conditions. Based on the development process, the researchers successfully designed and assembled a functional wristband prototype that integrates pulse monitoring, fall detection, location tracking, and manual alert activation. This demonstrates that the device was able to fulfill its intended core system features, particularly for elderly individuals and persons with disabilities living independently.

The results of the testing phase showed that the integrated sensors performed accurately under controlled trials. The pulse sensor exhibited an acceptable level of accuracy, while the fall detection system demonstrated high reliability in identifying both fall and non-fall events. Additionally, the GPS module consistently identified and transmitted accurate location data across all testing conditions, confirming the effectiveness of the tracking component.

Furthermore, the evaluation of the alert transmission system revealed that the wristband was capable of sending emergency alerts with an average response time of approximately 49 seconds. This indicates that the device can provide timely emergency signaling and facilitate prompt assistance during critical situations, supporting its potential application as a reliable safety tool.

## Recommendations

Considering the findings and the limitations encountered in the study, several recommendations have been identified. These suggestions can help guide future research toward the intended direction of the project. The following outlines the proposed recommendations:

It is recommended to improve the accuracy of the pulse sensor by implementing advanced calibration techniques, applying signal filtering methods, or exploring the use of higher-precision sensors. Enhancing accuracy will reduce measurement errors, particularly for elderly individuals and persons with disabilities, ensuring that the device provides reliable physiological monitoring.

It is recommended to optimize the alert transmission system to reduce response time. This could involve improving the communication algorithm, using faster network connections, or minimizing data packet size, thereby ensuring that emergency signals reach caregivers or authorities as quickly as possible to provide timely assistance.

It is recommended to integrate an application that functions offline to further enhance the reliability and effectiveness of the device.

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