Empowering Woman's Safety through IoT

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***Abstract*— Women's safety has been identified as one of the hectic concerns of any of the society where most of the women are facing multiple issues. Internet of Things (IoT) is becoming a promising technology to support day-to-day concerns and provide support in handling various affairs.This study presents a systematic literature review of research studies exhibiting the IoT devices for women's safety. The advantageous features of these devices serve a good technology as well as the watches, sensor devices are used. The review is carried out by carefully examining and synthesizing the research articles published between 2016 to 2023 in well-reputed research venues.**

The findings indicate a prevalent trend in utilizing various sensor types to monitor the safety of women, with pulse-rate and pressure sensors emerging as the primary choices for such applications.

INDEX TERMS **Women's safety,women's safety using IoT Safety devices,human safety,IoT-based security devices.**

I.INTRODUCTION

Women's safety has been one of the critical issues where several women are globally facing different types of threats such as violence, molestation, and harassment. Many organizations reported the statistics about women's violence cases indicating the worldwide severity of the issue. The IoT-based devices for women's safety also use several sensors to sense the state and movement of women in order to detect any safety threats. Applying the machine learning algorithms on the input data captured through these sensors would result in making decisions reflecting whether the particular state of women could be considered as unsafe or not. Consequently, a diverse array of machine learning algorithms is implemented within IoT devices designed for enhancing women's safety, aiming to discern and respond to the condition or situation of the women. The central objective of this literature review is to delve into the utilization and effectiveness of these algorithms in advancing the field of women's safety through IoT technologies. highlight the flaws of apps and devices introduced to date. Many studies have been published in this field and gaining importance due to women's independence and courage to go out from home for work purposes.

Furthermore, this research introduces an architectural framework outlining essential components required for the construction of IoT devices aimed at enhancing women's safety. Finally, the study underscores the significance of employing diverse sensor combinations to obtain varied input data types, thereby enhancing the accuracy and precision in identifying potential threats.

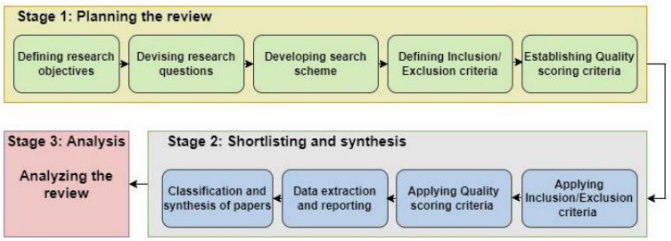
II.RELATED WORK

Few studies identified the IoT-based devices for women's safety, to the best of our knowledge. A research presented survey on women's safety using IoT . The scope of this survey was mainly focused on mechanisms used for detecting human body sensors as well as highlighted the limitations of previous studies. Another study presented a survey and comparison of existing works discussing the guardian device for the protection of women.The device is designed to work with the sensors and women in danger require to trigger the button for sending alert to guardian. Though the device depicts an effective solution for potential victims, yet a shortcoming is observed, as the victim has to operate the device for its activation where the people in danger are generally immobilized due to which some specific actions from them could not be taken. a literature review on recent and emerging technologies used for the safety and protection of the women. The researchers gathered and conducted online searches on women's safety devices showing new as well as emerging technologies. However, this study has utilized the IoT-based technologies efficiently by proposing an IoT based women's safety architectural model. The study is conducted a systematic literature review on evolution of women's safety devices using IoT by reviewing a few sensors and dominating features used in existing IoT-based women's safety devices. However, the taxonomy proposed in this review highlights a number sensors and dominating features of IoT-based women's safety devices. Whereas, the researchers presented a Woman Safety System (WSS) that is designed especially for the protection of women and send message for the situation of danger. The Women's Safety and Security (WSS) device is integrated into a smart jacket, which may not be suitable for universal wearability due to specific contexts or preferences. Nonetheless, the model proposed in this study offers

adaptability to a wide range of wearable devices, ensuring usability across diverse situations and environments.Page Style

III.RESEARCH METHODOLOGY

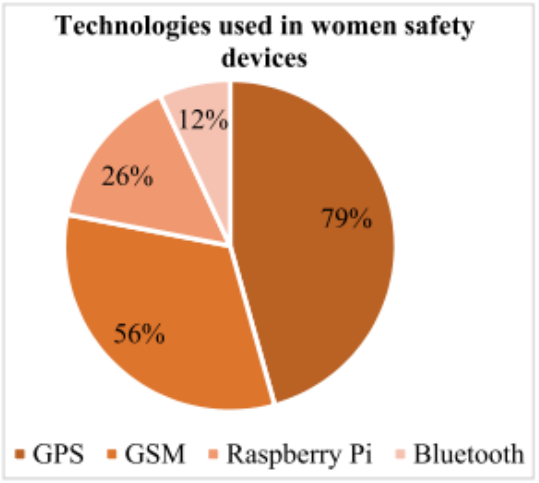
A Systematic Literature Review (SLR) was employed for this study due to its structured methodology, which facilitates systematic searching, classification, and synthesis of literature in alignment with predetermined objectives. This approach aids in identifying key areas within the specified domain that can inform future research directions. The research methodology is outlined in Figure 1,



illustrating the three stages involved in the review process. The review process commenced with defining clear research objectives, from which specific research questions were formulated. Subsequently, a comprehensive search strategy was devised to identify relevant literature. Following this, criteria for inclusion/exclusion and quality assessment were established. The studies were then screened based on these criteria, leading to the selection of a subset of relevant literature. Each selected study was evaluated based on predefined quality scoring criteria. The next step involved categorizing and synthesizing the chosen studies according to the key areas under investigation in this study. Finally, the findings were analyzed and discussed in detail to draw meaningful conclusions.

In Jesudossas' study, a device was proposed that combines GPS technology for real-time location tracking with Raspberry Pi, interfaced with Arduino. However, a limitation of this approach is its hardware-centric nature due to the reliance on Arduino, a microcontroller. This setup lacks an automatic emergency alert system crucial for women's safety. Arduino Uno, the current version, offers several connectivity options including USB interface, analog input pins, and digital ports, facilitating integration with external circuits. Among its features, 6 PWM output pins are available .

In another study , the author introduced a device utilizing IoT technologies like GPS and GSM modules for location tracking and messaging. However, its functionality relies on manual activation via a trigger button. Once activated, the device emits two successive buzzers with delays, requiring user interaction. This manual approach introduces delays and leaves the device inactive during an attack. Additionally, relocating necessitates reactivation through the same manual process. An automatic activation mechanism is imperative for seamless operation and enhanced safety.



Sensors	Operations
Acceleration sensor	For women safety it additionally detects the presence or lack of motion and if the acceleration on any axis exceeds a user-set level, then the system is activated [14].
Temperature sensor	it is important to monitor the human body temperature constantly. For women safety purpose temperature sensors like LM35 series are used [32].
Pulse-rate sensor	it is a small chip that monitors pulse-rate. Normal pulse-rate is 80 to 90, in case of increase in this value then it activates the system [15].
Heartbeat sensor	To monitor the safety of women heartbeat is taken for every 20 milliseconds. [18]
Flex sensor	Flex sensor is a compact device that is used as a sticker with the cloths. It calculates the pressurized movement of women hand [19]
Tilt sensor	Tilt sensors are used to find orientation of body. For women safety the orientation of body is calculated every 20 milliseconds [18]
Vibration sensor	It measures the frequency of the wearable device.

The key features of women's safety devices. In a model developed a jacket equipped with GPS periodically tracks the wearer's location. Additionally, it incorporates a temperature sensor, a buzzer, and an electric shock generator for self-defense purposes. However, a drawback of this design is the audible activation of the buzzer, which could inadvertently alert the attacker. Similarly, devised a device comprising a panic button, GPS tracker, and GSM module. This system utilizes IoT technology to track the wearer's location regularly. Moreover, an accelerometer triggers the buzzer as an alarm if the wearer falls. While this jacket-based device offers portability, it may not be suitable for constant wear.

PERCENTAGES OF WEARABLES

IoT-based wearable devices incorporate embedded sensors that continuously gather data from their surroundings. These sensors monitor various parameters, and if specific threshold values are exceeded, they trigger corresponding modules via an internet connection. In the realm of women's safety devices, IoT-based wearables manifest in the form of smart clothing, wristbands, and accessories. However, a review of existing literature reveals a relatively limited diversity in technology adoption within this domain. Researchers predominantly focus on developing devices resembling smart wristbands, accounting for 35% of the implementations. Meanwhile, smart jackets and other clothing-based devices represent approximately 6% of the literature, with smart rings and shoes making up around 3%, as illustrated in Figure 8. Detailed information on the sensors utilized in different wearable configurations is provided in Table

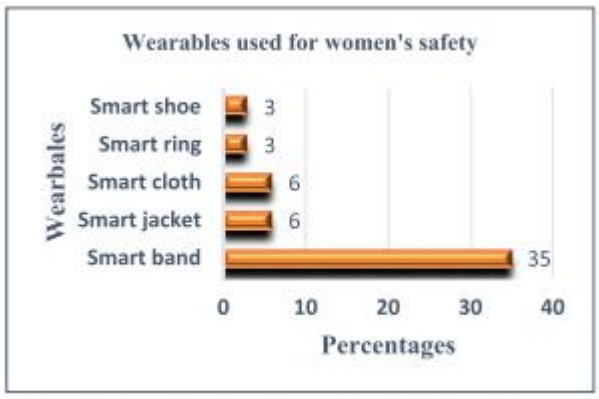


FIGURE 8. Percentages of wearables used in women's safety devices.

PERCENTAGES OF MACHINE LEARNING ALGORITHMS USED IN LITERATURE

a: LOGISTIC REGRESSION

Logistic regression, a method primarily used for binary classification, is employed in women's safety devices to anticipate potential danger. This approach utilizes pulse-rate and body temperature as independent variables to predict whether a woman is in a dangerous situation (yes) or not (no). Predictions are expressed as probabilities ranging from 0 to 1, with the application of a logarithmic function to ensure the output falls within this range. In a specific instance described, a smart wristband utilizes this logistic regression model to analyze sensor data and make real-time predictions about a woman's safety status. However, it's essential to note that the accuracy of predictions relies heavily on the availability of real-time data, as delays in data acquisition may compromise the reliability of the predictions.

b: HIDDEN MARKOV MODEL

The Hidden Markov Model (HMM) offers advanced predictive capabilities and robust detection of suspicious activities. In the context of women's safety, it enables analysis of facial recognition and interpretation of verbal conversations. Reported to achieve an impressive accuracy rate of 94.7%, as demonstrated,the HMM-equipped device activates in response to post-event shocks, while otherwise providing preemptive warnings. Additionally, another HMM-based device detailed employs IoT technology to gather data, utilizing voice recognition from the victim. Speech recognition proves effective in conjunction with HMM. However, it's crucial to note that the device may prove ineffective in extreme situations if the attacker identifies and obstructs the victim's communication, especially considering the absence of attached sensors.

c: DECISION TREE CLASSIFIER

A decision tree algorithm utilizes a dataset to iteratively split it into branches based on various attributes, enabling it to make binary predictions (yes or no). In the context of women's safety, this methodology is employed to determine whether a woman is in a potentially dangerous situation.

In a detailed study, a device named MoveFree utilizes a decision tree classifier to predict a woman's safety status. It collects data on parameters such as breathing, heartbeat, blood flow rate, and glucose levels, categorizing them as normal or abnormal. MoveFree identifies readings exceeding predetermined threshold values, determined in consultation with healthcare experts, as abnormal. The algorithm identifies sweating as a crucial indicator of danger; if detected, the device alerts the guardian. However, a notable limitation is the potential for false positives, as sweating can occur due to various factors, including weather conditions, leading to inaccurate predictions.

d: OUTLIER DETECTION

Pressure sensors and temperature sensors play a crucial role in women's safety systems by facilitating outlier detection. When any of these sensors detect anomalies, potential danger is identified. For instance, the temperature sensor triggers an alert if there's a sudden rise in temperature around the woman, indicating potential danger. However, a limitation of this outlier detection method is that temperature fluctuations can occur due to various factors, including health-related issues, potentially leading to false alarms.

1V .DISCUSSIONS AND ANALYSIS

In this section, we delve into a comprehensive discussion and analysis of the outcomes derived from the review. Through meticulous examination of the findings, we formulate a taxonomy categorizing IoT-based women's safety devices. We illuminate the existing gaps and challenges prevalent in current device implementations. Additionally, we put forward a model tailored for practitioners and researchers, serving as a blueprint for the development of future IoT-based women's safety devices. Furthermore, we explore the implications of these findings, offering insights into potential future directions within this domain.

A. PROPOSED TAXONOMY

The research findings are synthesized into an IoT-based taxonomy for women's safety, as depicted in Figure 9. This taxonomy comprises four primary attributes: IoT-based safety sensors, predominant features, machine learning algorithms, and IoT-based wearables embedding sensors. It encompasses various IoT technologies that monitor, regulate, and track precision attacks and victim locations. The paper illustrates the utilization of IoT-based technologies in women's safety devices along with their respective sub-domains. Sensors play a crucial role in collecting and monitoring diverse variables, and the data they generate are transmitted via communication protocols such as the Internet, ZigBee, Bluetooth, and WIFI, enabling users or guardians to access pertinent information.

The taxonomy design comprises four main elements: IoT-based safety sensors, predominant features, machine learning algorithms, and IoT-based wearables embedding sensors. These elements encapsulate the majority of findings explored in this study. IoT technologies play a pivotal role in monitoring, regulating, and tracking precision attacks and victim locations. This study illustrates the utilization of IoT technologies in women's safety devices, along with their sub-domains. Sensors play a critical role in collecting and monitoring various variables, as extensively discussed. Additionally, the key features dominating IoT-based women's safety devices, enhancing their efficiency in diverse scenarios, are highlighted. Furthermore, the focus is on enabling automatic alert generation through sensor data collection. When sensor readings indicate potential threats to women's safety, machine learning modules are activated to generate and transmit alerts accordingly.

The wearables housing IoT devices for women's safety rely on sensors to collect user data, enabling device automation. To ensure discretion, these input sensors are often concealed within the wearables.Sogi introduced a smart ring-based device, combining Raspberry Pi with a server, albeit without utilizing any sensors. However, Sogi suggested enhancing compatibility by integrating sensors into the device. Conversely, another device outlined incorporates multiple sensors, proving its efficiency. Indeed, smart IoT-based wearables benefit significantly from sensor integration, enhancing both efficiency and portability. It's evident that IoT-based women's safety devices equipped with sensors offer portability and ease of use, minimizing human intervention. Yet, to enhance compatibility, it's suggested to integrate multiple sensors into a single device. Therefore, the proposed architecture in this literature review advocates for the inclusion of multiple sensors with varied functionalities within a single wearable device, ensuring women's protection in diverse scenarios.

B. GAPS AND CHALLENGES

In the 21st century, the focus on women's empowerment emphasizes not just financial security but also social security. Despite the widespread deployment of technologies like CCTV cameras, women still require protection, especially when their guardians cannot accompany them at all times due to modern lifestyles. Table 10 highlights potential flaws in IoT-based women's safety devices identified through research.

A notable gap in these devices is the reliance on only one or two sensors, whereas those with multiple sensors demonstrate better accuracy and performance. Devices equipped with various sensors can compensate for failures in individual sensors by detecting and utilizing alternative sensors during emergencies.

Given that women span different age groups with varying physiological norms, the activation of IoT-based wearables upon threat detection depends on sensor readings compared to age-specific normal ranges. Relying on a single sensor may not yield accurate threat assessments due to readings deviating from normal ranges for reasons unrelated to threats. Thus, leveraging multiple sensors and their combined input values can enhance threat determination accuracy.

Adjusting devices based on the user's age is seldom addressed in research, posing a challenge in device customization. Additionally, issues such as waterproofing and battery life affect the reliability of wearable devices, especially in adverse conditions like exposure to water and sweat.

A significant challenge highlighted in most studies is the reliance on human interaction with devices. To address this, there is a growing need for automatic, intervention-free systems, considering victims' compromised state during attacks. While some researchers propose human interaction-free systems, achieving full automation remains a priority.

Furthermore, the accuracy of devices, even when leveraging machine learning algorithms, has room for improvement. While these algorithms yield better results, enhancing prediction accuracy requires refining the datasets used.

Despite the development of numerous devices, each exhibits flaws, with the foremost challenge being human interaction dependency. Victims often lack the presence of mind to operate devices during attacks, emphasizing the need for devices capable of automatic rescue interventions.

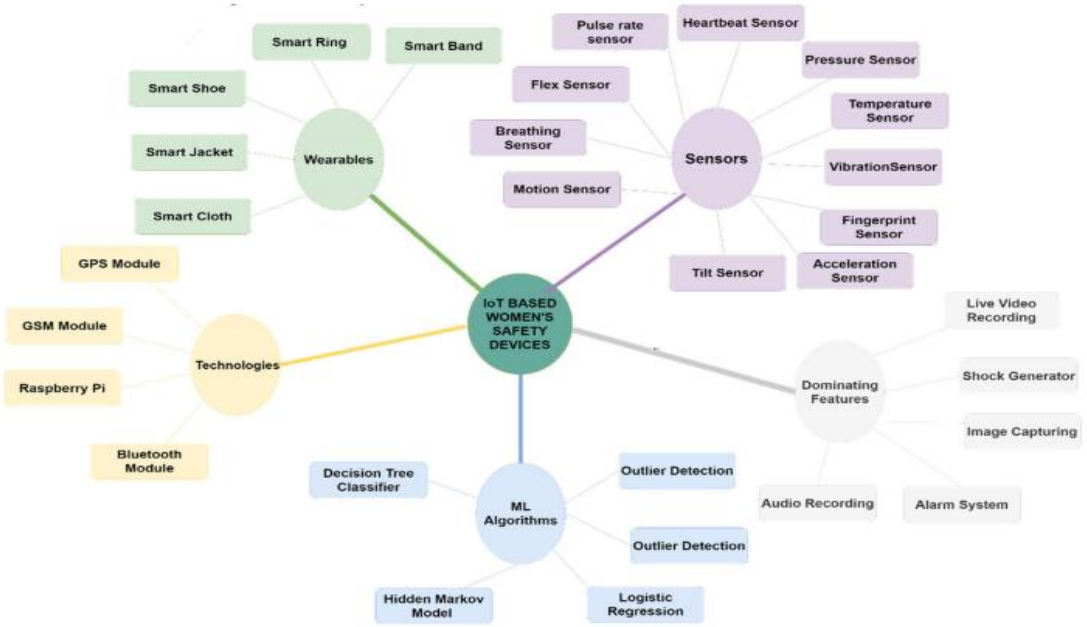


FIGURE 9. Taxonomy of IoT-based women's safety devices.

The devices previously proposed have not proven entirely effective in providing comprehensive protection to women in our society. Despite the integration of machine learning algorithms, researchers encountered limitations in achieving high accuracies and precise results. This challenge stems from fluctuations in body temperature and heart rate, which can occur due to various factors including health issues or changes in physical activity levels such as running or brisk walking. Consequently, all of these devices exhibit some inherent flaws.

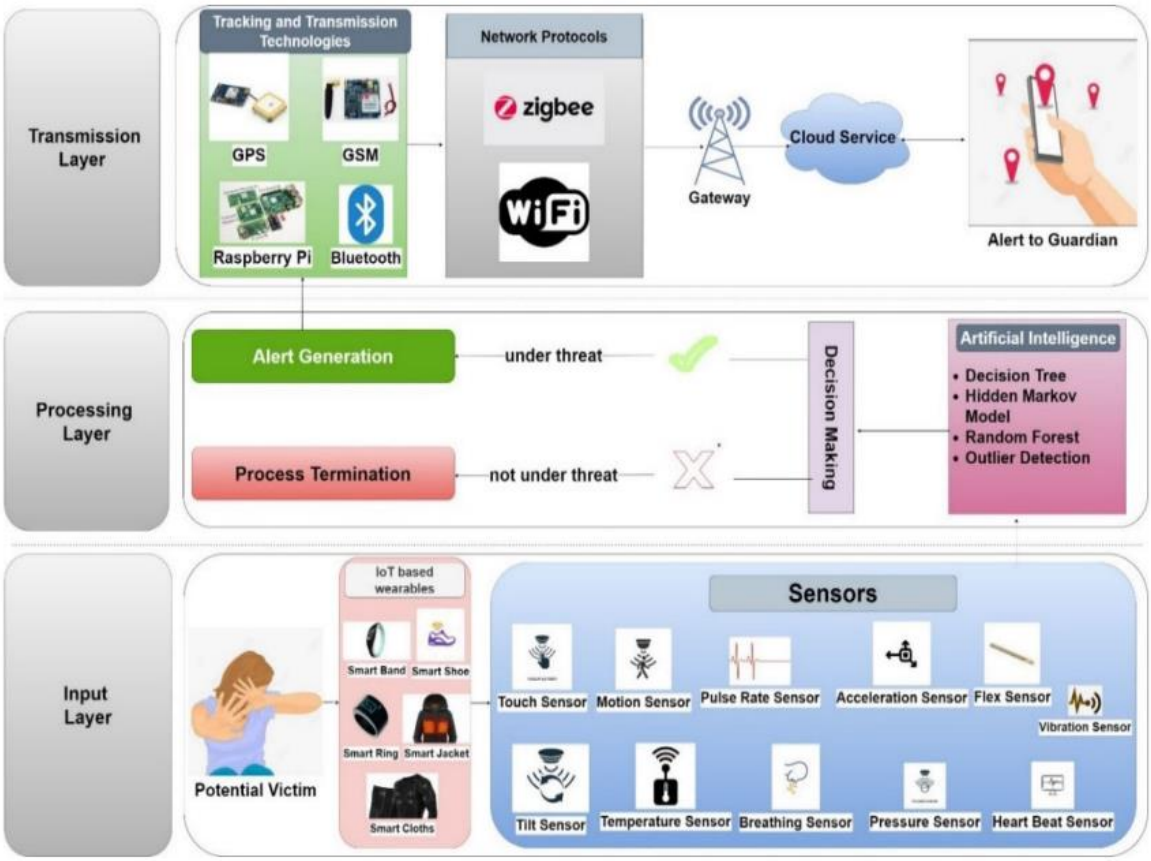
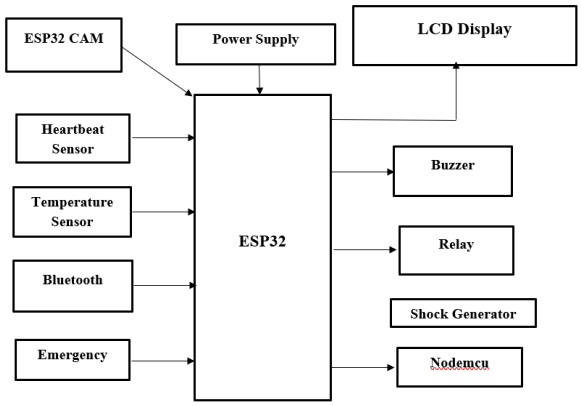


FIGURE 10. An architectural model for IoT-based women's safety devices.

IoT-enabled women's safety devices currently lack robust security measures, making it challenging to anticipate and address all potential threats in this domain. However, as researchers explore various security solutions to address known issues, they must also develop systems capable of protecting women from unforeseen and unpredictable attacks. Achieving such a security solution requires the design and implementation of a robust security system with stringent properties. For instance, envision a security system equipped with various sensors and detection schemes to identify attacks against women. Now, imagine expanding this women's protection system to encompass a wider range of security measures.

C.PROPOSED ARCHITECTURAL MODEL



The proposed architecture addresses the shortcomings and challenges observed in existing devices. Previous devices often required physical interaction from humans and exhibited room for improvement in the accuracy of machine learning algorithms. In contrast, our architectural model eliminates the need for human intervention and leverages lightweight and efficient machine learning algorithms to enhance decision-making.

Our system functions as an automatic danger detection tool driven by artificial intelligence, operating seamlessly without human intervention even in areas with no internet connectivity. While a similar device has been proposed, which requires manual activation through button pressing, our architecture autonomously collects data via sensors and alerts the guardian of a woman in danger. The sensors utilized in our model are sophisticated enough to detect complex signals akin to those of the human brain. These sensors enable the development of intelligent wearable devices capable of protecting women in peril, potentially providing immediate self-defense mechanisms.

To address internet connectivity issues, we utilize ZigBee Mesh Network, a cost-effective and low-data-consumption alternative. This network extends the range of data transmission through multiple hops, ultimately reaching the gateway connected to the internet. This approach, as demonstrated by Muskan, enhances system efficiency by ensuring continuous operation in areas lacking internet connectivity.

At the transmission layer, a gateway links to cloud services, facilitating the transmission of live location updates and attack alerts to the victim's guardian. The integration of machine learning algorithms empowers devices to autonomously learn and adapt, complementing the intelligence of IoT-based sensors. Through this integration, our system demonstrates efficacy in safeguarding women from potential dangers.

D. METHODOLOGY

The IoT-based system is primarily composed of an Arduino board, which receives signals from a GPS system containing location data. The Arduino Uno controller then facilitates the transmission of alert messages, along with the woman's location, to preconfigured contact numbers.

In instances of potential danger, the system leverages a pulse rate sensor to monitor heart rate fluctuations, sending out alerts along with location details via message.

Moreover, activation of an auto defender system is initiated upon pressing a designated button. This system incorporates a buzzer, emitting audible alerts to attract attention from nearby individuals, empowering the woman to potentially defend herself.

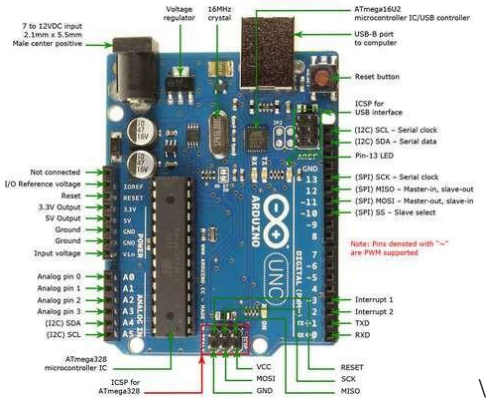
E. WORKING

The proposed system incorporates electronic sensors to measure women's health parameters, transmitting the data remotely to healthcare professionals. Unlike traditional analog systems, which display data on screens like a CRO or computer, our system integrates converters like ADC and DAC within the ESP32, facilitating seamless analog-to-digital conversion.

This system serves individuals requiring continuous healthcare, particularly those unable to access hospital facilities. Additionally, it contributes to women's security by incorporating a GPS system to track and alert predefined contacts about the user's location in case of emergency. Upon pressing a button, the auto defender system activates, emitting a buzzer sound to attract nearby assistance.

Upon activation, the system utilizes a Nodemcu module and Wi-Fi to track and transmit the user's location information via SMS and social media applications. Simultaneously, emergency signals are sent to selected contacts identified by the mobile user.

F.SNAPSHOTS OF THE DEVICES



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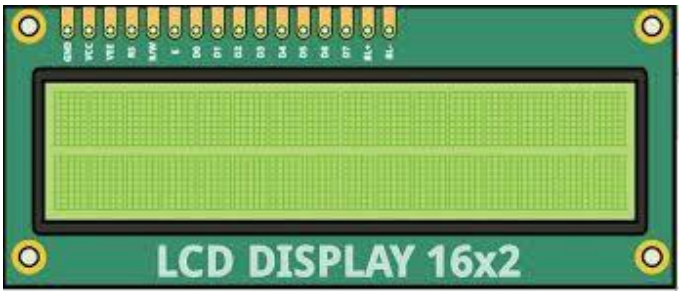
LCD Display:



Relay:

The LCD display provides real-time visual feedback, presenting data such as temperature readings and heart rate information for user monitoring. The relay serves as a switch, enabling control over external devices based on predefined conditions, enhancing system functionality. The temperature sensor measures ambient temperature, providing crucial environmental data for monitoring and safety applications. The buzzer emits audible alerts, signaling potential dangers or system status changes to the user or surrounding individuals. The heart rate sensor detects and monitors the user's heartbeat, offering vital health-related information for tracking and analysis. Collectively, these components contribute to an integrated system, facilitating comprehensive monitoring and response capabilities for enhanced safety and user awareness.

The system utilizes a microcontroller such as Arduino to interface with various components. The temperature sensor continuously monitors ambient temperature, relaying data to the microcontroller. Upon surpassing predefined thresholds, the microcontroller activates the relay, triggering external actions like cooling or heating systems. Simultaneously, the heart rate sensor measures the user's heartbeat, while the data is processed and displayed in real-time on the LCD screen, offering instant feedback. In critical situations, if danger is detected or user input is received, the buzzer emits audible alerts, alerting both the user and nearby individuals. This integrated setup provides comprehensive monitoring and response capabilities, enhancing safety and user awareness.

Pulse Rate Sensor

Temperature Sensor:

Buzzer:

operates by converting electrical energy into mechanical vibrations, generated by the flow of current through its coil, which creates a magnetic field to attract its armature, causing it to move and break contact, interrupting the current flow and collapsing the magnetic field, allowing the armature to return, re-establishing contact and completing the circuit, resulting in rapid cycles that produce audible sound waves as the armature

EXPERIMENTAL ANALYSIS

CATEGORY	AGE RANGE
CHILDREN/ YOUTH	12-18
ADULTS	18-50
OLDER ADULTS	50-75

CATEGORY	ELECTRIC POWER VOLTAGE
CHILDREN/ YOUTH	10-20V
ADULTS	20-30V
OLDER ADULTS	25-30V

Effects of Voltage Fluctuations on Human Physiology

- **Tingling or numbness in the area where the shock occurred.**
- **Muscle twitching or spasms.**
- **Pain or burning sensation at the site of contact.**
- **Momentary disorientation or confusion.**
- **In some cases, loss of consciousness (for more severe shocks).**

CONCLUSIONS

This study reports a systematic literature review of IoT-based devices designed for women's safety to protect them from threats like molestation, harassment, rape, and abuse. It was conducted by reviewing 34 research articles gathered through eminent publication sources.,sensors and machine learning algorithms. Various categories of these aspects are classified to present a taxon omy of IoT-based women's safety devices..This work will be helpful for the researchers to gain the state-of-the-art insight into the IoT-based women's safety devices as well as the practitioners to build useful and more effective IoT-based women safety devices.

To mitigate potential risks, the research employed a systematic approach in keyword selection, categorizing them into primary, secondary, and tertiary groups, and applying Boolean operators to construct search strings. Additionally, study classification was conducted by authors and reviewed by two independent reviewers. Any discrepancies were resolved through thorough discussions until a consensus was reached, resulting in a high interrater reliability of 0.92.

Following a detailed analysis of shortlisted studies, it was observed that IoT-based women's safety devices utilize various technologies, features, sensors, and machine learning algorithms. These aspects were categorized to develop a taxonomy of IoT-based women's safety devices, highlighting the diversity of functionalities offered by each system. Despite the unique features of these devices, they still exhibit shortcomings that hinder their effectiveness in addressing safety threats for women.

Furthermore, the study identified gaps and challenges associated with previous devices, which hindered their efficacy in serving their intended purpose. As a future recommendation, the review proposed an architectural model

for IoT-based women's safety devices. This model aims to provide researchers with insights into the state-of-the-art developments in IoT-based women's safety devices and assist practitioners in designing more effective solutions.

ACKNOWLEDGEMENT

We express our gratitude to the women who inspired us to develop this project, recognizing their courage and resilience in demanding safer environments. Our appreciation extends to the tireless efforts of our team members who dedicated themselves to leveraging IoT technology for women's safety. We acknowledge the invaluable support of our mentors and advisors who provided guidance and expertise throughout the project journey. Special thanks to the community members who actively contributed ideas and feedback, shaping the project into a robust solution. We recognize the significance of collaboration and collective action in addressing the pressing issue of women's safety. Lastly, we extend our appreciation to all stakeholders and partners who have joined hands with us in fostering a safer world for women through innovative initiatives like this..

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