Child Secure: A Wearable Safety Solution for Children Integrated with ESP32-CAM

S.Priyavathani[1], Mr.Naga Prasad Rao[2], Tata Sreenidhi[3], Roshini Havilah Manchala[4], Goli Venkata Kota Akhilesh[5]

[1,2,3,4,5] Department of Computer Science and Engineering (IoT & CS incl BCT), Potti Sriramulu Chalavadhi Mallikarjuna Rao College of Engineering & Technology, Vijayawada, A.P., India.

Abstract

Child safety is still a significant challenge in the face of growing threats from both human and animal sources. Solutions currently available to monitor a child's location and vital signs are based on manual input, where parents need to send exact commands to access information. The reliance on this can cause delays in responding to emergencies. To address these shortcomings, we propose ChildSecure, a smart wearable device for real-time child protection. The system continuously tracks external pressure on the child's body and senses abnormal heart rate variation. When both conditions show possible distress, the device automatically triggers its inbuilt camera, taking a picture and sending an immediate alert to parents through a Telegram bot. The automated process obviates manual intervention, ensuring prompt response. Parents can also request updates, eg., pictures or locations, via easy bot commands. To add another layer of safety, the device makes an ultrasonic noise when an alert is activated, thereby discouraging any potential threats. ChildSecure provides a complete and trustworthy solution for child safety in different settings by combining real-time monitoring, automatic emergency alerts, and active threat deterrence.

Keywords

Child safety, Wearable Devices, Parental Solution, Ultrasonic Animal Deterrent, Real-time alerts, Telegram Bot.

1. Introduction

The increasing cases of child abduction, abuse, and attacks by animals have made safety for children a growing concern[6]. According to reports, the incidence of child endangerment has been on the rise in the recent past, prompting the need to institute preventive measures of safety. Although there are currently child safety solutions that emphasize the tracking of a child's location and vital signs tend to rely on human intervention. Parents have to send specialized commands over mobile applications to receive real-time information, rendering such systems ineffective in panic situations. In addition, traditional safety features like GPS tracking and panic buttons are effective only when there is the promise of prompt external help

To overcome these limitations, we suggest Childsecure, an IoT-enabled wearable device for real-time child tracking and automatic emergency response. Differing from conventional safety devices, Childsecure automatically identifies distress by monitoring two major physiological parameters: anomalous heart rate(BPM) and pressure exerted on the child's body from outside[7]. When both conditions show a possible danger, the device will automatically trigger an in-built camera to take a photo and send an instant alert to the parents through a Telegram bot. The automated method eliminates the necessity for manual commands, allowing for instant response even if parents are not around to make requests[8].

Moreover, ChildSecure has a check-up function in manual mode. With this feature, parents can check the safety of their child at any moment by clicking on a message that is automatically sent by the bot. The immediate reaction, such as taking a picture and posting the child's whereabouts[9]. To offer more security and safety of a child, the gadget has an ultrasonic sound which transmits the sound which turns on the alert event and warding off potential animal threats. Through the combination of the automated monitoring, real-time notification, and proactive threat prevention, child secure offers an all-around and trustworthy child protection solution[10].This technology is fully filled with the gap between passive monitoring and active intervention, giving parents a sense of security while maintaining the child's safety in various environments.

2. Literature Survey

[1] Shubham Kumar – Child Safety Wearable Device Shubham Kumar's studies focuses on a wearable safety device which is designed and enables parents to track their child's whereabouts in real-time. The wearable device uses an SMS-based communication system allowing parents to request the parents text message requesting for instance a location update Unlike conventional systems that rely on internet connectivity, this wearable ensures reliable communication in areas with limited network access. Additionally, the device eliminates the need for high-end smartphones, making it accessible to a broader user base. However, one major drawback is the manual nature of the system. Parents must actively send requests to receive updates. This delay could be problematic in emergencies where immediate alerts are crucial. To address this, the study suggests incorporating automation features to enable real-time distress detection and alerts

[2] M. Benisha – Design of Wearable Device for Child Safety M. Benisha and her research team worked on an IoT-integrated wearable for child safety by means of real-time monitoring of health and location. The system is able to monitor heart rate and movement patterns continuously and sends alerts automatically based on activity abnormally. The controller is Arduino based and communicates through a GSM module. Among the salient features of the system proposed here is geofencing, whereby a parent can define a safe zone. once the child steps out of this boundary, an alert goes off. The proposed system automates emergency notifications, thus requiring less parental intervention than tracking systems on the market with higher manual intervention. But since it works with GSM networks, alerts may not reach in time in remote areas where network connection may not be good. it is recommended to develop an artificial intelligence system to predict potential threats with the early detection risk for the device.

[3] Bannuru Ranjeeth – Smart Child Safety Wearable Device The child safety device, introduced by Bannuru Ranjeeth and his team, is entitled IoT based Child Tracking and Monitoring Device. This device can track and monitor a child's movements continuously. One important feature of this device is that it stores the movement logs in a cloud platform where parents can view previous activities for behavior analysis. Unlike traditional safety devices, this model uses Wi-Fi connections, thus making all the data transfer from the child's safe device SMS-free. It's also equipped with machine learning algorithms for the analysis of movement and physiological signals, and for detecting any changes in normal patterns. When there is a sudden movement change or increase in heart rate, this system tends to automatically trigger an alert. It also has signal wearability with which the child can send an alert by clicking a button. Dependency on internet access might affect the efficacy of the device, especially in areas with high network coverage limitations. The study advises much better analysis such as a communication ability so that the alerts may not stop.

[4] Akash Moodbidri – Child Safety Wearable Device The research presented by Akash Moodbidri unfolds a different kind of child safety support system that is dependent on GSM and GPS technologies for real-time tracking and emergency response. it is not like earlier devices, which relied on Bluetooth or Wi-Fi for their operational stability, this device runs on an SMS-based platform. Parents can ask the device through messages for location tracking and status updates on the child's safety. A significant characteristic of this system includes the SOS alarm, which releases loud sound and activates emergency lights when switched on. Thus, the parents will not actually be needed to rush there as bystanders will help the child in distress. The system offers enormous communication reliability but is not automated. it requires manual inputs from the parents. The study recommends that automatic detection of distress through AI-enabled features hence the proactive alert given.

[5] SeungHee Lee – Development of Wearable Device by Kid's Friendly Design for Kid's Safety SeungHee Lee and his team have designed a wearable safety solution that is tailored specifically towards young children. Their study demonstrates that most of the existing child safety solutions are uncomfortable for children and hence are avoided. Therefore, a lightweight and ergonomically designed wearable safety device has been proposed to ensure easy acceptance by the child. It incorporates a heart rate sensor, an accelerometer, GPS tracking, and a built-in camera. A unique feature of the system is that it detects acute physiological changes such as increased heart rate or sudden movement, thereby activating an image capture on the camera for review by the parents. Unlike previous systems that depended solely on parental input, this safety net so that teachers and emergency responders can receive alerts within the safety window. Therefore, although it offers fairly comprehensive safety for the child, battery life and data security need some fine-tuning. Suggestion for enhancement and reliable functioning includes refinement of power management strategies and strengthening of encryption protocols.

Table 1: Comparison Table

Author Name	Components	Merits	Limitations
Shubham Kumar	GPS, GSM module, SMS-based tracking	- Works without internet connectivity - Compatible with basic mobile phones - Provides real-time location updates via SMS	- Requires manual input from parents - No automated distress detection - Lacks additional safety features like sensors or alarms
M. Benisha	Arduino UNO, Heartbeat sensor, MEMS accelerometer, GSM module, Geofencing	- Automates emergency alerts - Sends notifications when the child leaves a predefined area - Monitors health parameters in real-time	- Relies on GSM networks, which may fail in low-connectivity areas - No camera integration for visual monitoring
Bannuru Ranjeeth	Wi-Fi module, Cloud storage, GPS, Machine Learning algorithms, SOS button	- Stores historical data for behavioral analysis - Uses AI to detect unusual movement patterns - Provides real-time alerts	- Dependent on stable internet connectivity - Limited functionality in offline scenarios - High power consumption due to continuous monitoring

Akash Moodbidri	GSM module, GPS, SOS alarm, LED light for distress signals	- Uses SMS-based alerts, ensuring reliable communication - Incorporates a distress alarm for immediate attention - No smartphone dependency	- Lacks automation, requiring manual input - No health monitoring features - Cannot provide predictive safety measures
SeungHee Lee	Heart rate sensor, Accelerometer, GPS, Built-in camera, Local safety network integration	- Designed with ergonomic features for young children - Captures and sends images when distress is detected - Share data with parents, teachers, and emergency responders	- High battery consumption due to multiple sensors - Data privacy concerns in network-based sharing - Requires optimization for power efficiency

3. Proposed Methodology

3.1. Arduino Nano with Sensor Shield: The **Arduino Nano** is a compact microcontroller board based on the ATmega328P, commonly used for embedded systems and IoT applications. It manages sensor data collection and communication with other modules. The **sensor shield** simplifies connections by providing multiple ports for sensors, actuators, and communication modules. This project acts as the primary controller, processing inputs from the heartbeat and pressure sensors, triggering alerts, and coordinating actions such as activating the camera.

Figure 1: Arduino Nano

3.2. ESP32-CAM: The **ESP32-CAM** is a small camera module with built-in Wi-Fi and Bluetooth capabilities.it is in charge of taking pictures whenever an alert is set off. Data from the pressure and heartbeat sensors is processed by

the microcontroller, if an irregularity is found, the ESP32-CAM captures a picture and sends it to the parent through the Telegram bot. This module is necessary to ensure prompt emergency response and to proof in real time.

Figure 2: ESP32-CAM

3.3. Heartbeat Sensor: The **Heartbeat sensor** uses photoplethysmography(PPG) technology to measure the Heartbeat sensor. An LED and a photodetector that measures the blood flow make up the heart rate sensor. The pulse rate is a sign that the youngster may be experiencing stress or fear if it has a threshold value that the user has set. The system will be able to find and identify early indicators of a possible threat or distress threat

Figure 3: Heartbeat Sensor

3.4. PressureSensor: The **pressure sensor** detects any external force applied to the child's body, such as excessive gripping or impact. If abnormal pressure is exerted, it acts as a trigger for the ESP32-CAM to capture an image and alert the parents. It plays a crucial role in identifying physical threats, such as forceful grabbing or restraint.

Figure 4: Pressure Sensor

3.5. GPS Module: The **GPS module** continuously tracks the child's location and sends real-time updates. When an alert is triggered, it provides the parent with the exact coordinates, allowing for immediate intervention. The GPS data is integrated with the Telegram bot, ensuring that location updates are accessible instantly.

Figure 5: GPS Module

3.6. Buzzer with Ultrasonic Sound Output: The **buzzer** serves as an alarm to alert nearby individuals when an emergency is detected. Additionally, the **ultrasonic sound output** is designed to deter animals, making the device effective against both human and animal threats. The high-frequency ultrasonic waves cause discomfort to animals, preventing potential attacks.

Figure 6: Buzzer

The child safety device continuously monitors vital signs and surroundings, ensuring real-time alerts in case of emergencies. It is equipped with an **Arduino Nano** to process sensor data and an **ESP32-CAM** to capture images and communicate with parents via a Telegram bot. The system initializes by connecting to WiFi and setting up the required components, including the **heartbeat sensor, pressure sensor, GPS module, and buzzer**. Once operational, it remains in a constant monitoring state. When the **heartbeat sensor** detects an abnormal heart rate (above a defined threshold, e.g., 100 BPM), the system assumes a state of distress and triggers the ESP32-CAM to capture an image. This image is immediately sent to the parents via the Telegram bot. Similarly, if the **pressure sensor** records an unusual force applied to the device, it signals a possible struggle or threat. This also prompts the camera to take a picture and send an alert. Additionally, in emergencies, the **buzzer emits ultrasonic sounds** to deter potential threats, such as animal attacks.

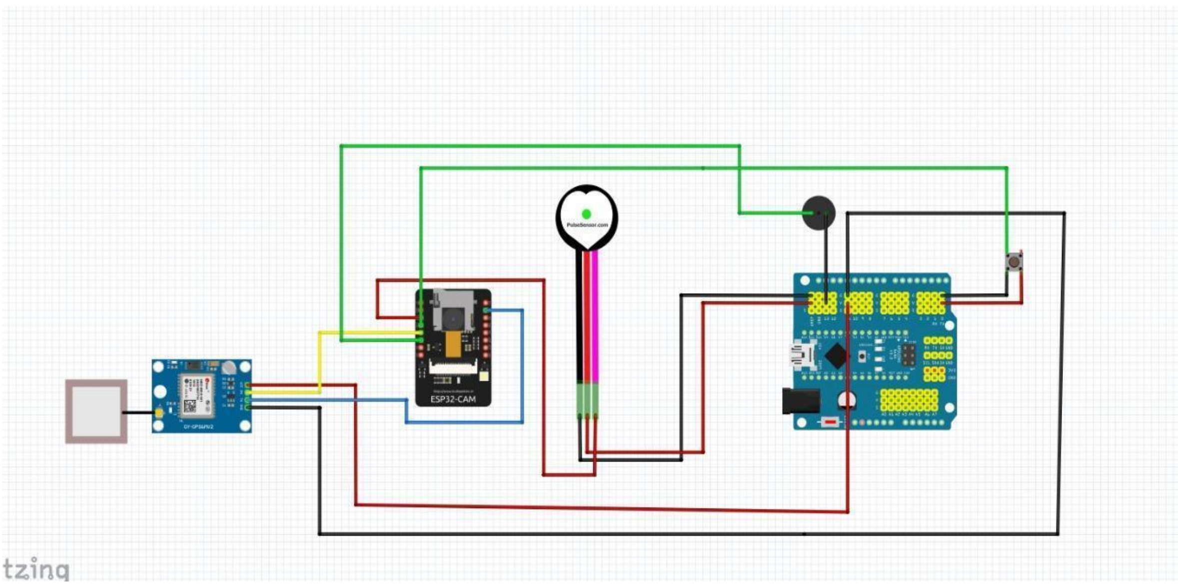

Figure 7: Circuit Diagram

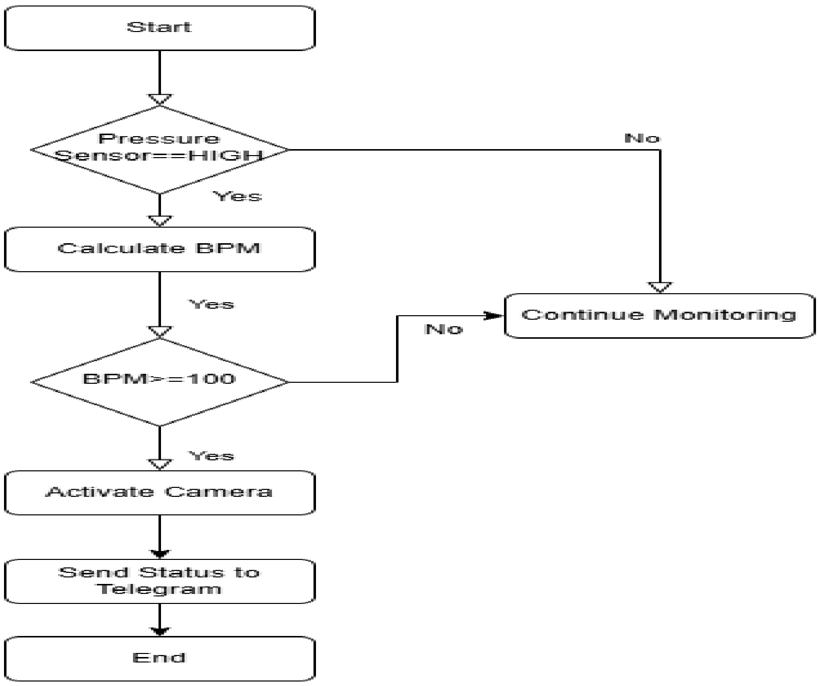

Figure 8: Working flow

Apart from automated alerts, parents can manually check their child's status through the **Telegram bot** by sending specific commands. A request for /photo causes the ESP32-CAM to snap a live image, and /location provides the child's current GPS coordinates. The /status command provides an image that displays the current bpm and location, and /flash toggles the flash on the ESP32–CAM for visibility in lower-light situations. This real-time system improves the safety of children quickly via alerts, real-time monitoring, and a child's current location. It uses biometric monitoring, an image of the child, and automated alerts to keep parents in the loop and allow for a fast response if necessary.

4. Result and Discussion

The proposed child safety system has been successfully developed and tested to demonstrate its capability of providing real-time monitoring for child safety. The prototype comprises an ESP32-CAM module, a heartbeat sensor, a pressure sensor, and power supply devices, along with an Arduino board utilized to upload code and supply power. The ESP32-CAM is inactive by default and only operates when an alert condition happens or the authorized user commands it to do so. The heartbeat sensor continuously monitors the Child's pulse, and the pressure sensor senses abnormal external force. In the event of irregular readings and detected, the system captures an image of the activity and sends it to the parent and sends it to the parent via a Telegram bot.

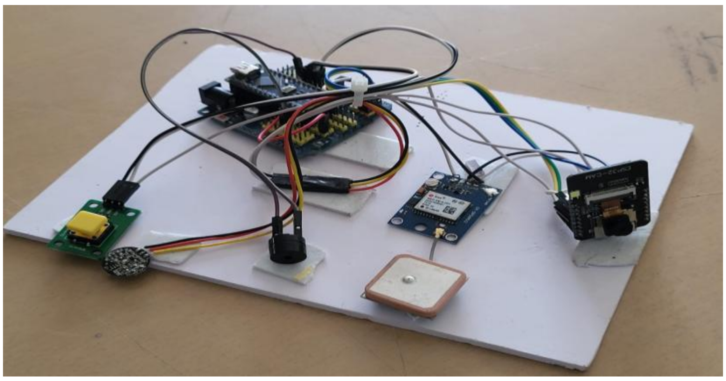

Figure 9: System Prototype with Connections

To improve portability, everything was arranged tightly inside a small bag that was designed to be comfortable for children to wear. The camera is located at the front to allow for clear image capture when turned on. This configuration allows the system to remain mysterious, While still monitoring the child's surroundings at all times.

Figure 10: Wearable Bag with Integrated Components

To ensure secure and restricted access, the Telegram bot ID was developed to communicate with the registered user IDs, thus preventing unauthorized access. The command signaled via /start initiates the bot and provides predefined options to make interaction easier for parents, without the need to individually type commands. The user selects /photo to have the ESP32-CAM capture and send an image immediately.

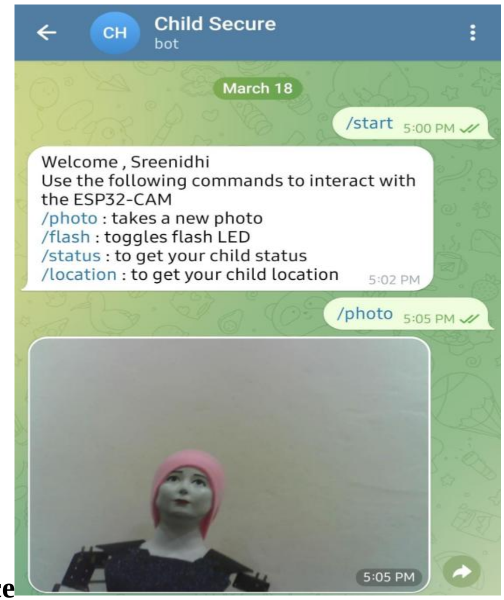

Figure 11: Secure Telegram Bot Interface

The system provides up-to-the-minute status updates. When the option /status is selected, the bot provides the child's heart rate readout, the coordinates of the child's current location, and the most recent picture of the child. When selecting /location shoes share the precise live GPS location of the child. These states of affairs allow parents to track their children in real-time. All of these options ensure that tracking takes place in real-time, and alerts can be sent out. If an abnormality occurs, and response action can done in real-time if needed. The results show the system does a good job of detecting any abnormalities, displaying the current image of the child in real time, and allowing a secure way for parents to monitor their child remotely using a telegram bot. The design is wearable and practical, while the limited access to the bot adds some security. The security of the design is validated with the successful integration of customizing sensors, controlling microcontrollers, and communication modes. The data makes it clear the solution works and can provide a partially secure method for monitoring children in situations where the children may be left alone.

Figure 12: Real-time Monitoring via Telegram Bot

5. Conclusion

ChildSecure wearable device is an effective and autonomous answer to child safety with real-time monitoring and instant alert. With the implementation of heart beat and pressure sensors, the system is able to detect distress conditions and respond instantly. The ESP32-CAM captures images in detecting an abnormal condition, while the GPS module ensures that parents receive the accurate location of the child and updates via telegram bot. The ultrasonic buzzer is also a precaution which protects against possible animal attack. The device fills the gap between automatic intervention and manual observation to keep parents updated without continuous input. Both manual checks and automate notifications which are enabled through the Telegram- based control system, making it a versatile and trustworthy safety device. With Iot and smart automation assistance, this deliverables helps to come up with safer and wiser solutions for safeguarding children.

References

[1] Mekala, M. S., Viswanathan, P., Kumar, M. V., & Basha, J. (2020). IoT-based Assistive Device for Deaf, Dumb, and Blind People. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(5), 234-239.

[2] Bannuru, R., Srinivasa Reddy, B., Manoj Kumar Reddy, Y., Suchitra, S., & Pavithra, B. (2020). Smart Child Safety Wearable Device. *Proceedings of the International Conference on Electronics and Sustainable Communication Systems (ICESC 2020)*, IEEE Xplore.

[3] Moodbidri, A., & Shahnasser, H. (2017). Child Safety Wearable Device. *Proceedings of the IEEE Conference on Wearable Technology*, San Francisco State University.

[4] Lee, S., Sohn, J., Usami, A., & Hamanaka, M. (2010). Development of Wearable Device by Kid's Friendly Design for Kid's Safety. *IFIP International Federation for Information Processing*, HCIS 2010, 80–85.

[5] Kumar, S., & Gupta, C. (2020). Child Safety Wearable Device. *International Journal of Scientific Research in Engineering and Technology (IJSRET)*, 9(3), 1731-1735.

[6] Benisha, M., Prabu, T. R., Gowri, M., Vishali, K., Priyadharshini, D. R., & Chezhiyan, P. (2021). Design of Wearable Device for Child Safety. *Proceedings of the Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV 2021)*, IEEE Xplore.

[7] Choi, Y., Jeon, Y.-M., Wang, L., & Kim, K. (2017). A Biological Signal-Based Stress Monitoring Framework for Children Using Wearable Devices. *Sensors*, 17(9), 1936.

[8] Sharmila, B., Keerthana, T., & Arun Prakash, P. (2017). Safety Wearable Device to Monitor Kids. *International Journal of Trendy Research in Engineering and Technology (IJTRET)*, 1(3), 8-9.

[9] Mahdi Atheeb, M., Mahdi Ethaeb, A., & Dawood Salman, M. (2021). Repellent of the Stray Animals Using Ultrasonic Technology. *IOP Conference Series: Earth and Environmental Science*, 735(1), 012084.

[10] İnkaya, M. F., & Gürkan, H. (2021). A YOLOv3-Based Smart City Application for Children's Playgrounds. *Journal of Innovative Science and Engineering (JISE)*, 5(1), 25-40.