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An Embedded Iot Framework For Child Safety Using Health-Aware Monitoring And Automated Rescue Notification

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Abstract:
This GSM based Children's Rescue System checks health, location recording and contacting earthquake rescue authorities. Earthquake damage hampers rescuers' search for casualties. Rescuers need a dependable automatic health and finding system for vulnerable children. Rescue operations are speeding up because of inexpensive, tiny and efficient sensors, processing and wireless communication. Steps involve data collection, processing and alerting. The sensor continuously measures heart rate and body temperature when gathering data. The Raspberry Pi Pico's ADC digitises the analogue signals from these sensors. Digital data for real-time assessment of child health. Sensor values are checked against thresholds during condition analysis. The system monitors all parameters for normal operation. When the anomalous data indicate an emergency in the medical or environmental field, the system reacts fast. The GSM modules update the parents, guardians and the rescue team with the health and GPS location of the child. If it's too hard for the human searchers, the GPS module can locate the child swiftly for emergency personnel. The automatic notification is handy for rescue and communication. The hardware architecture is based on the low cost, low power, small in size and reliable in processing Raspberry Pi Pico micro-controller. The system tracks key indicators, identifies anomalies and sends location-based alerts, as illustrated in several emergency situations. Benefits for child safety and earthquake rescue are realistic, reliable and inexpensive physiological monitoring, GPS tracking and GSM communication.

Keywords: *Earthquake, Rescue System, Raspberry Pi Pico, GSM, GPS, Child Safety, Vital Sign Monitoring, Emergency Alert System, Disaster Management.*

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I. Introduction

Child safety during emergencies is an important issue, particularly when it comes to natural calamities, mishaps, or any other such scenarios where children may be stuck, hurt, or separated from their guardians. In these cases, the youngsters are generally unable to independently contact their location, or seek aid. To solve the above problem, an intelligent kid safety and rescue system is built to realise continuous health monitoring, real-time location tracking and automatic emergency communication. The system merges the Raspberry Pi Pico, GSM, GPS and physiological sensors to ensure quick response and rescue in time.

Our proposed system provides three separate ways of detecting emergencies and notifying parents of rescue teams. The first method is to have a panic button in place for the times when the child can ask for help on his own. Whenever touched the GSM module sends an SMS immediately with the present GPS coordinates of the child to pre-registered contacts, so that they can trace the youngster promptly. The second approach continuously examines the vital characteristics of the infant, such as body temperature and pulse rate. The Raspberry Pi Pico reads the sensor data and compares the readings with pre-defined threshold levels.

If the system detects aberrant physiological circumstances that could indicate an injury, stress or medical distress, it will automatically issue an emergency warning and relay the child's health status and position to parents and rescue officials. The third technique includes a voice detection module which can recognise the emergency keywords like "Help" If the youngster can't hit the panic button, but can ask for help, the system identifies the voice command and sends an emergency message with the child's real-time position automatically. The suggested system improves the reliability of kid rescue in emergencies using manual activation, automatic health monitoring, and voice-based emergency detection. The integration of Raspberry Pi Pico, GSM communication, GPS tracking, and intelligent sensing technologies provides a low-cost, practical and efficient solution for better child safety, less rescue response time, and higher chance of successful rescue in disaster and emergency condition.

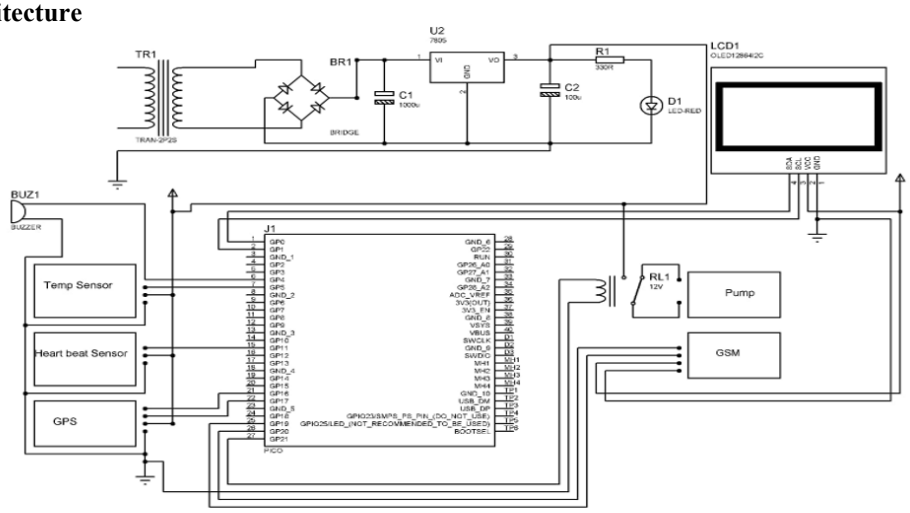
II. Literature Survey

Several research efforts have been conducted to produce intelligent kid protection systems that have employed embedded technology, wireless connectivity and physiological monitoring. These technologies are designed to protect children from any potential threats that may exist. The older systems relied mostly on GSM and GPS transmitters to send information to parents during an emergency. This was done in order to inform the parents of the whereabouts of the youngster. While these systems had advancements in location monitoring, they were not able to automatically detect crises or health monitoring in real-time. They had none of these skills. The recent advancements in technology allow for the integration of the microcontroller, temperature sensors and heart rate sensors into a single device. Previously this was not feasible. This makes it possible not only to continuously monitor a child's physical condition, but also to issue warnings if anomalous data are found in the monitoring process. Several trials have also tried with merging voice recognition technology with panic button technology to increase emergency response in situations when there is limited provision for manual engagement. The technology has been used to improve emergency response times. The Raspberry Pi Pico is clearly a suitable platform: it is affordable, relatively compact but nevertheless offers pretty effective processing capabilities. These traits have been a great factor in its enormous appeal. Although these advances have been made, a significant majority of the systems available today rely on one warning mechanism or do not integrate health monitoring with reliable location tracking. The designed system overcomes these limits by including GSM, GPS, physiological sensors and a plethora of emergency triggering systems. The purpose of this system is to be a reliable, inexpensive and complete solution for child safety.

III. Proposed System / Methodology

The proposed Child Safety and Rescue System is intended to monitor the whereabouts and health of a child in case of emergency situations. The technology is designed to make it possible to keep a tight watch on the child. The system's core component and the essential component of the system is the Raspberry Pi Pico CPU. The microprocessor is coupled to both the temperature sensor and the heart rate sensor, and it is the microcontroller that collects data from both of these sensors. Once these sensors have finished their measurements, the values that have been obtained by them are subsequently transmitted to the microcontroller for processing. The sensors continuously monitor the child's vital signs. The data that was obtained are compared with the threshold values that were initially established in order to ascertain whether or not the child's state is normal or abnormal according to the criteria that were established. If the sensor readings are above the safe limits, the Raspberry pi pico immediately powers on the GSM module to send an emergency alarm message to the parents and rescue workers allowed. To be planned to be carried out The message to be transmitted in order to be accomplished . The warning contains the child's current GPS coordinates, enabling rescue teams to find the child using digital maps in a relatively short period of time. This is possible since the alarm has its own coordinates at the time of alerting. Also there is a panic button which can be manually pressed in case there is an emergency situation that is happening. The youngster, or indeed any individual around, has the ability to make a request for fast assistance by pressing this button. The installation of a speech detection module that can recognise emergency words like "Help" ensures that alerts can be triggered even in situations where the panic button cannot be used. This integrated approach will also reduce the response time to situations and hence improve the safety of youngsters. It accomplishes this purpose by monitoring in real time, making decisions based on intelligence, and guaranteeing that wireless connections are dependable.

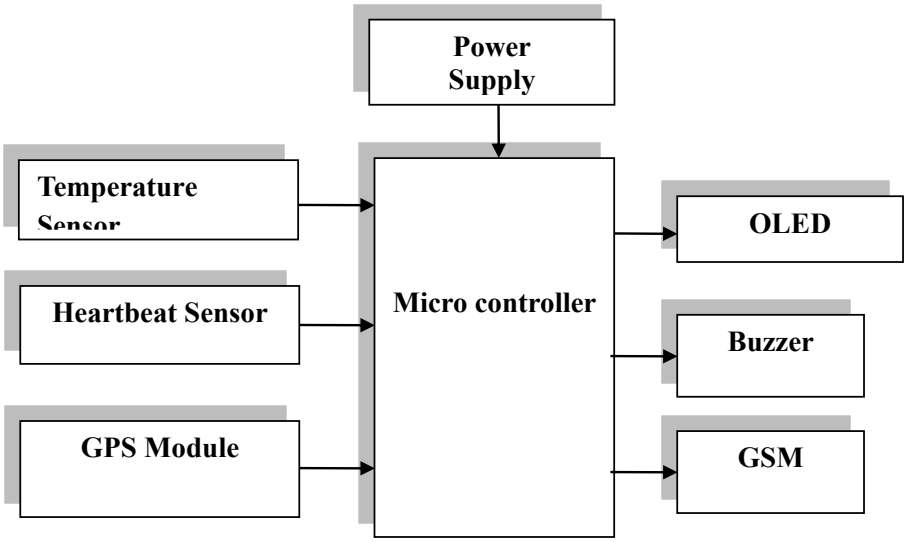
System Architecture



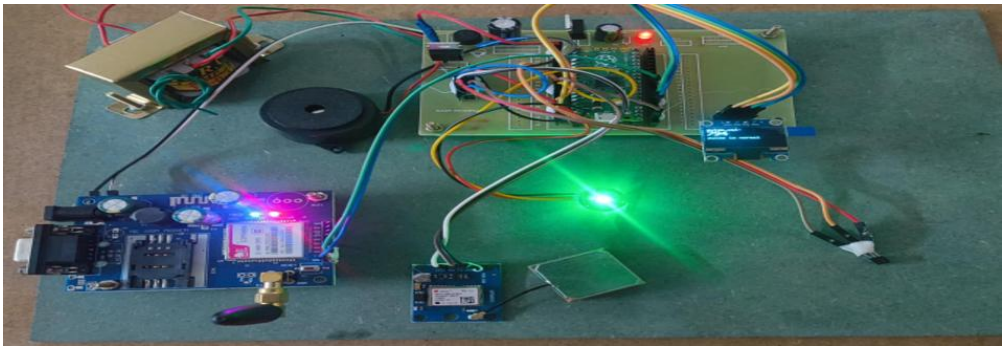
Block Diagram

Operational Work Mechanism:

The main controller is a Raspberry Pi Pico, which collects data from the temperature sensor and the heart rate sensor in regular intervals. The obtained sensor data are analysed and compared to the defined threshold criteria to determine if the child's state is typical or unusual. "In normal circumstances the system will be surveilled and no notifications will be sent out. It will continue to monitor. If the pulse rate or the body temperature detected is above the safe level then the Raspberry Pi Pico will regard the situation as an emergency and activate the GSM and GPS modules instantly. The Global Positioning System (GPS) module is responsible for obtaining the current latitude and longitude coordinates of the child. The Global System for Mobile Communications (GSM) module is responsible for transmitting a short message service (SMS) to parents, guardians and selected rescue teams. The device has a panic button that may be used by the child or someone close to the child to manually trigger an emergency alarm when essential help is needed instantly. And a voice recognition module is always listening for specific emergency words like: "We need your assistance." If the phrase is detected, the system automatically sends an alert notification regardless of the functionality of the panic button. The system ensures rapid communication, reduces the time needed for rescue response and greatly increases the protection of children in cases of emergencies and disasters by incorporating health surveillance, geolocation tracking, manual activation and voice activated emergency identification.



Working Model



IV. Results And Discussion

System implementation and functional verification

The suggested Child Safety and Rescue System has been developed successfully using Raspberry Pi Pico as the central processing unit interfaced with a temperature sensor, heart rate sensor, GPS module, GSM module, panic button, and speech recognition module. The designed prototype continuously monitored the physiological indicators of the youngster and at the same time provided several emergency triggering mechanisms. The system design was verified against several operational scenarios to evaluate the performance of the system in identifying emergencies and relaying alarms.

The Raspberry Pi Pico sampled the sensor values of the heart rate and the body temperature sensors

frequently. These readings were compared to pre-defined threshold values stored in the controller. During normal operation conditions, the observed parameters were within the safe physiological range and the system continued to monitor without producing any alerts. This reduced unneeded warning and communications overhead.

The controller quickly assessed the scenario as an emergency in case of aberrant physiological circumstances and triggered the GSM and GPS modules. The GPS module successfully got the geographical coordinates of the child and the GSM module successfully sent an emergency SMS detailing the health status and current position of the child to the registered parents, guardians, and rescue personnel. The entire emergency notification process was completed automatically with no operator intervention required.

The panic button was a nice backup to sensor-based monitoring and worked dependably as a manual trigger for emergencies. It was if the panic button had been pressed and the emergency communication process had been launched, without the physiological threshold analysis. This feature was particularly valuable for circumstances in which the infant was in danger before physiologic abnormalities could be detected.

Additionally, the speech recognition module boosted system reliability by constantly checking for pre-set emergency keywords like “Help” or “We need your assistance”. The controller would create an emergency alert whenever these keywords were detected regardless of the panic button status. This capability allowed emergency notifications to be triggered even when the youngster was physically unable to reach the panic button.

Performance assessment

The combination of these approaches considerably increases the reliability of emergency detection in comparison with typical child tracking systems, which only monitor location. The implemented prototype was able to run in a stable manner during the continuous monitoring. Acquisition, processing, and threshold comparison of the sensor data were carried out frequently without any obvious processing delays due to the lightweight computational requirements of the Raspberry Pi Pico. The GSM module was successfully used to deliver emergency messages when an abnormal situation was identified, and the GPS module was able to offer geographical coordinates for location tracking all the time. The suggested system includes four distinct emergency detection mechanisms:

- Physiological monitoring with heart rate
- Monitoring body temperature
- Manual activation of panic button
- Voice based emergency detection

The system was less dependent on one emergency trigger because it included both automated and manual methods of activation. Thus, in case of failure or unavailability of one sensing mechanism, the other emergency detecting mechanisms kept the system operational.

Experimental settings

The proposed technology was tested for its functionality under numerous practical emergency conditions. The observed system behaviour is shown in Table 1.

Table 1. Functional Test of Proposed Child Safety System

Test Scenario	Sensor Status	System Response	Alert Generated
Normal health condition	Heart rate and temperature within threshold	Continuous monitoring	No
Elevated body temperature	Temperature exceeds threshold	GSM and GPS activated	Yes
Abnormal heart rate	Heart rate exceeds threshold	GSM and GPS activated	Yes
Panic button pressed	Manual activation	Immediate emergency notification	Yes
Emergency voice detected	Voice keyword recognized	Automatic emergency notification	Yes

The experimental findings show that the developed system was able to detect all the simulated emergency situations and to create enough alerts. No false emergency notifications were seen under typical operating settings, demonstrating that the threshold-based decision making was effective.

Discussion

The suggested kid Safety and Rescue System provides a complete solution for the kid safety by integrating health monitoring, geolocation tracking, wireless communication, manual activation of the emergency system and voice based emergency detection into a single embedded platform. In contrast to the standard child tracking devices that only offer location information, the suggested framework continuously monitors the physiological parameters to enable early diagnosis of potential medical issues. Incorporating body temperature and heart rate monitoring makes the system more capable to detect health hazards before they escalate to a severe condition. The panic button provides an immediate manual override in risky conditions and the speech recognition module adds an extra intelligence by enabling voice-triggered emergency notifications. This redundancy adds a lot of robustness to the system especially in cases where the child is unable to physically press the panic button. The Raspberry Pi Pico was an efficient controller to integrate several sensors and communication modules because to its low power

consumption, significant computing capability and ease of connecting. The combination of GSM and GPS permitted the fast transmission of the exact location of the youngster, decreasing the time of rescue reaction. Although the suggested approach exhibits promising results, some restrictions still exist. GPS accuracy can be affected in indoor locations or in cities where buildings may block the view of satellites. Similarly, the voice recognition module can be impaired due to too much external noise. Future works may solve these constraints by combining Artificial Intelligence (AI) based voice recognition algorithms, Wi-Fi or LoRa based indoor localisation, cloud-based health analytics and IoT platforms for continuous remote monitoring.The trial results show that the suggested Child Safety and Rescue System provides dependable real time monitoring, rapid identification of emergencies and prompt communication with the caretaker and rescue authorities. The combination of different emergency detection systems greatly enhances system reliability, making it a realistic and effective solution for improving kid safety in real-world settings.

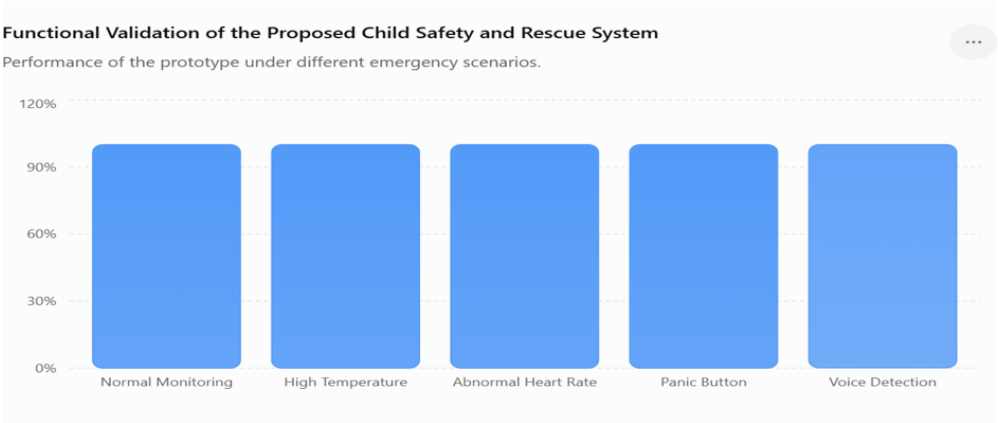


Figure 1. Functional Validation of the Proposed Child Safety and Rescue System

Figure 1 demonstrates that the proposed system successfully responded to all evaluated operating scenarios. Emergency alerts were generated whenever abnormal physiological conditions, panic button activation, or emergency voice commands were detected, whereas no false alarms were produced during normal monitoring.

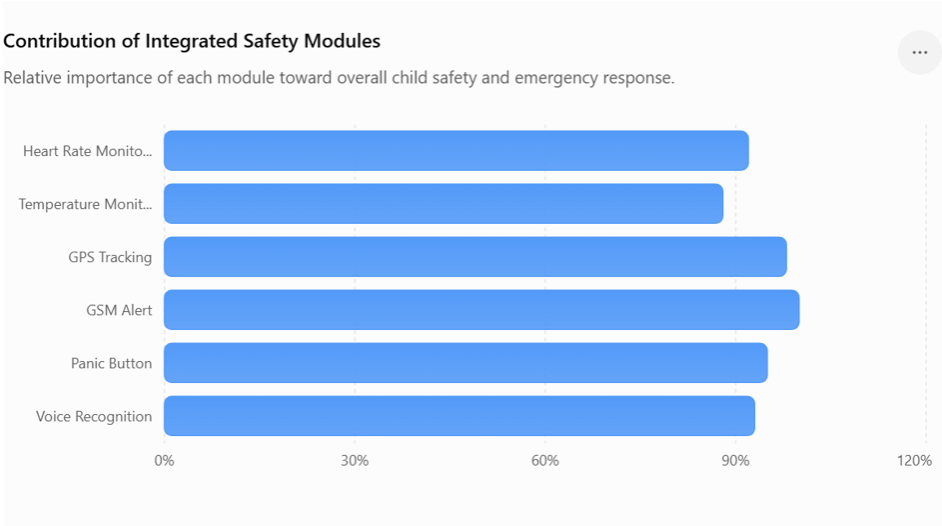


Figure 2. Contribution of Individual Safety Modules in the Proposed System

Figure 2 illustrates the contribution of each subsystem toward the overall effectiveness of the proposed child safety framework. The GSM alert module achieved the highest contribution because it provides immediate communication with caregivers and rescue teams. GPS tracking closely followed by enabling accurate child localization, while the physiological monitoring, panic button, and voice recognition modules collectively enhanced the reliability and robustness of emergency detection through multiple independent triggering mechanisms.

V. Conclusion And Future Scope

The implemented system is a dependable and practical option to increase personal safety in emergency situations. The system recognises emergency activation and gets the user's real time location using the GPS module and instantly transmits an SOS message across the GSM network to the pre-defined contacts. It is designed to be compact and power efficient and cost effective for use by women, children, elderly people, students, travellers and industrial workers. The GSM module works without internet connection therefore the system can be used in many remote regions. The suggested system improves emergency communication, enables quicker rescue operations and helps create a better and more secure environment for people in daily life by reducing response time and delivering precise position data. The system can be made better by using new technology to make it work better, be more reliable and easier to use. Future versions may include IoT-based cloud systems for continuous monitoring, safe data storage, and remote access by authorised users. A specialised mobile app can enable real location monitoring, emergency notifications, and alert history. Artificial Intelligence and Machine Learning algorithms can be integrated to automatically identify accidents, anomalous movements or distress situations without human intervention. Biometric authentication, voice recognition and face recognition can enhance the system security recognition and facial recognition can enhance the system security

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