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Iot-Enabled Safety Device For Women And Children Using Raspberry Pi Pico And Esp 32-Cam Live Alerts

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ABSTRACT

In recent times, the security of women and children has gained importance among other societal concerns owing to rising crime rates and non-existence of instantaneous aid mechanisms. In this context, this paper proposes an IoT-based safety solution through integration of Raspberry Pi Pico along with ESP32-CAM, GPS, and GSM modules. The proposed IoT solution will be capable of locating the user, sending emergency message notifications and calls to specified contacts, and even capturing the live image of the concerned individual. The activation of the alarm will occur through pressing of a panic button and indication of system activity will take place with LEDs. Once activated, the system will send location information of the user through SMS and along with capturing of the live image using ESP32- CAM.

1. INTRODUCTION

Safety of women and children has become a global issue due to increased instances of harassment, kidnapping, and violence. Traditional safety methods like the availability of helpline numbers or mobile applications may not be effective since they take time to respond and depend on mobiles.

The emergence of IoT has made it possible to develop smart safety devices that give instant responses, alert services, and visual proof in case of emergencies. IoT-based technologies such as GPS and GSM help achieve this.

This study suggests a mini IoT-based safety device using Raspberry Pi Pico and ESP32-CAM. The suggested product can give instant alerts, location information, and visual proof during emergencies.

Individual security is one of the most pressing concerns globally today, especially concerning women and children who face cases of harassment, kidnapping, and emergency situations. Issues related to fast-paced city life, increased mobility, and travelling in isolation have made it more complex. Personal safety measures like telephonic services or mobile apps do not work efficiently during emergency circumstances. Thus, the need for an automated and robust safety mechanism based on technological advancements becomes evident.

The latest developments in the field of embedded systems and the Internet of Things (IoT) technologies have made it possible to create sophisticated wearable technologies that can collect, process, and send real-time information. The use of instant alerts, precise location, and video evidence can prove highly effective while

dealing with emergencies. The use of affordable components such as microcontrollers, GPS systems, GSM communication, and mini cameras allows implementing more efficient solutions. Moreover, the use of cloud services and mobile application enables a system to be more reliable because it will operate autonomously without much interference from the user.

1.1 NEED FOR IoT-BASED PERSONAL SAFETY SYSTEMS

The current safety application relies heavily on the use of a manual interface which might not be practical during emergencies when the victim may not be able to handle his/her mobile phone. This may happen because the person is panicked, physically restrained or even due to damages to the mobile phone. In order to make an emergency system more effective, there should be automatic triggering capability, constant monitoring and communication of location, as well as provision of visual evidence. All these facilities can be provided through IoT technology where sensors, microcontrollers and communication modules work together.

1.2 IMPORTANCE AND SOCIAL IMPACT

The proposed system provides great benefits from the point of view of personal safety. It enables fast reaction in emergency situation and helps to identify the position of the victim easily. Besides, it serves as an aid for the police as they can use the visual evidence obtained through the system. Another important function is that the proposed system can help parents track their children in crowds and protect them against any potential threat. Thus, the system helps to improve social well-being in terms of safety.

1.3 TECHNOLOGICAL RELAVENCE

This project aligns with current technological trends, where IoT-based solutions are widely used in security, healthcare, and smart living applications. IoT integration enables remote monitoring and efficient communication, while GSM and Wi-Fi technologies support long-distance data transmission.

The inclusion of real-time image capture enhances situational awareness, and cloud integration allows secure storage and easy access to critical data. Overall, the project demonstrates how modern technologies can be effectively combined to develop practical and scalable solutions for real-world safety challenges.

2. PROBLEM STATEMENT

The rising number of cases of harassment, abduction, and risky conditions for women and children clearly reflects the dire necessity for immediate solutions that offer reliable safety measures. Most of the existing systems rely on applications available on smartphones or helplines that require access to the Internet or some human interference. Furthermore, most of the solutions available fail in terms of location tracking efficiency and provision of any sort of visual evidence. The delay in responding to emergencies and the need for a comprehensive solution that does not rely on any additional resources make the situation even more alarming. This calls for the development of a small-sized, efficient, and affordable system.

3. PROPOSED SYSTEM

The proposed system introduces a security gadget made from Raspberry Pi Pico and ESP32-CAM for prompt responses in case of emergencies. It involves the application of the panic button, which initiates several actions when pressed. It detects the exact location of the individual with the help of the GPS module and sends the details to selected contacts with the help of the GSM module. Also, the ESP32-CAM camera will capture images around the individual to provide some visual cues that can aid in identifying any danger to the individual. The operation of the system is indicated with LEDs.

4. SYSTEM ARCHITECTURE

1. **Input Layer (Panic Button):** The panic button is designed to be a digital input device interfacing with the GPIO pin of the Raspberry Pi Pico with an internal pull-up/pull-down resistor. The panic button will act as an interrupt-based triggering mechanism, allowing the system to activate instantly upon pressing the button.
2. **Processing Layer (Raspberry Pi Pico):** The Raspberry Pi Pico board is equipped with the RP2040 microcontroller and acts as the processing unit of the project. It is responsible for processing the input signals

and executing the embedded firmware of the project. Communication protocols are handled using UART.

3. **Tracking Layer (GPS Module):** The GPS module (for example, Neo-6M) works with satellites for determining location information such as real-time latitude and longitude coordinates. Communication with the microcontroller occurs through UART interfaces, while the output is in the form of NMEA sentences.
4. **Communication Layer (GSM Module):** The GSM module (for example, SIM800/900) works wirelessly by utilizing cellular network protocols. It is responsible for sending SMS messages by utilizing AT command protocols through UART interfaces. Location data can be sent to pre-defined mobile phones through SMSs without internet access.
5. **Monitoring Layer (ESP32-CAM):** The ESP32-CAM consists of a microcontroller combined with an inbuilt camera (OV2640 camera). It takes snapshots or video feeds when triggered and can either send it via Wi-Fi or save it on the device itself.
6. **Output Layer (SMS Alert and LED Indicators):**This layer comprises SMS alerts and LED indicators. The former is produced using the GSM module, whereas LEDs, which are red and green, are connected to GPIO pins for indicating various conditions such as normal operations, alert conditions, and faults.

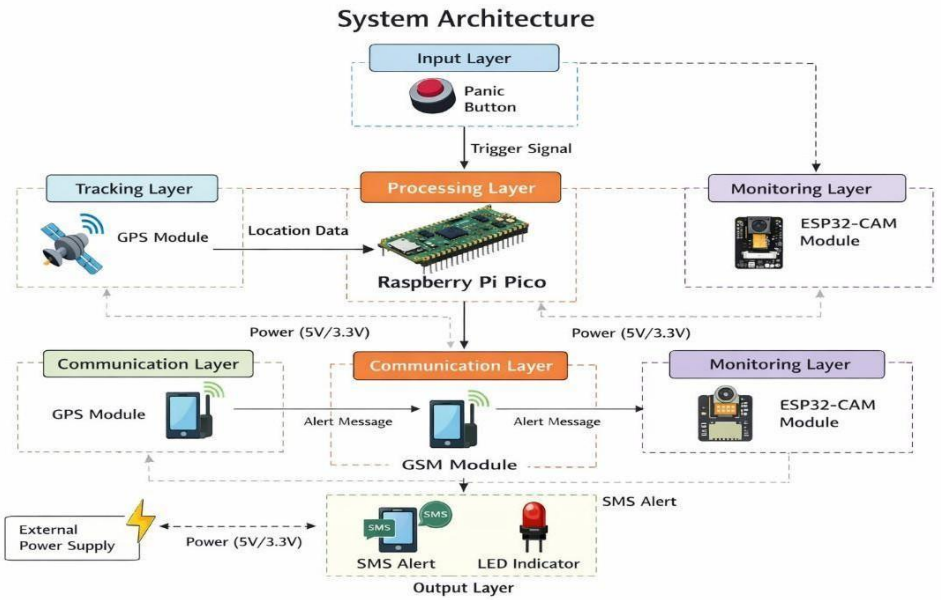

Fig 1: SYSTEM ARCHITECTURE

5. OBJECTIVE

The primary objective of this system is to enhance the safety of women and children by providing a reliable and immediate response mechanism during emergencies. The system aims to deliver accurate real-time location tracking and ensure instant communication with guardians or authorities. Another important objective is to incorporate image capturing capabilities to provide visual evidence during distress situations. Additionally, the system is designed to be portable, cost-effective, and easy to operate so that it can be widely adopted. Ensuring low power consumption and high reliability are also key objectives of the proposed solution.

6. METHODOLOGY

System development for the proposed design has been done through a systematic procedure that starts with hardware connection and software configuration. The hardware includes the Raspberry Pi Pico, the GPS module, the GSM module, the ESP32-CAM, the LEDs, and the panic button, which have been interfaced as appropriate. Embedded C or Micro Python has been used in programming to implement protocols like UART for inter-modular data transfer. The panic button has been configured to be able to trigger the interrupt routine. As soon as the system is triggered, it obtains the GPS coordinates, transmits SMS alerts using the GSM module while simultaneously triggering image capture through the ESP32-CAM.

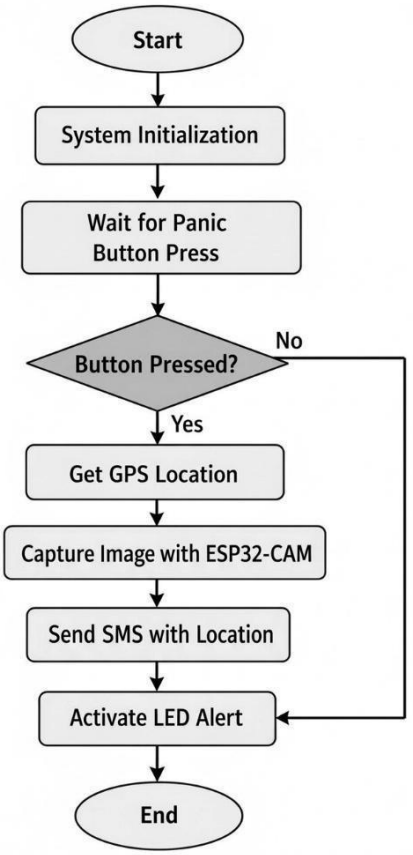

Fig 2: WORKFLOW OF THE SYSTEM

7. ALGORITHM

Step 1: Initialization of the system

The initialization of all connected devices including the GPS, GSM and ESP32-CAM modules occurs. UART interfaces between the microcontroller and connected devices are initialized along with GPIO pins which are enabled for input/ output functions and the system is put into idle mode.

Step 2: Input Monitoring

The microcontroller continually checks the state of the panic button through its GPIO port. This can be done either by interrupt based method or by polling to enable instant detection.

Step 3: Processing upon Activation of the panic button

In case the panic button is activated the microcontroller executes the following actions:

a. Acquistion of GPS data

The GPS module gathers real time data in NMEA format. The microcontroller then processes these sentences to retrieve GPS coordinates.

b. Image capture using ESP32-CAM

A signal is generated from the microcontroller that triggers the ESP32-CAM device to take an image of the surrounding area.

c. Sending SMS using GSM module

GSM module is controlled via UART interface to perform SMS operations using AT commands. The SMS contains the location data acquired in step (a) in a linkable format and sent to pre-determined contacts.

Step 4: Alert Static Notification

In case of an emergency situation, the program activates a red LED connected to a GPIO pin to notify the operator of the alert condition.

Step 5: Hold/Reset Condition

After activating the alert sequence, the system either holds on to the alert state or reverts back to standby condition according to the logic of the software.

8. EXPERIMENTAL SETUP

The experimental setup entails putting together the electronic hardware components and configuring the device properly. In this case, the Raspberry Pi Pico is interfaced to both GSM and GPS modules using UART interface communication.

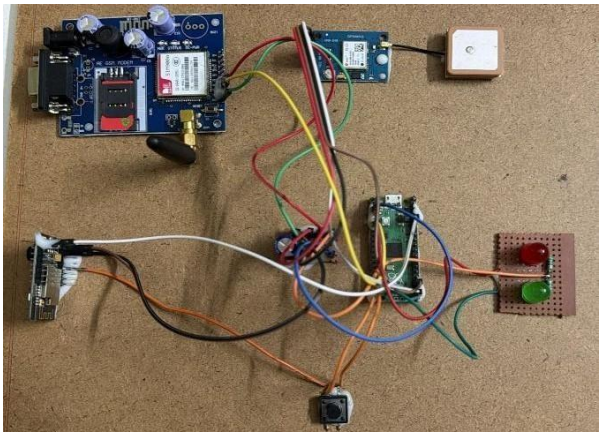

Fig 3: SAFETY MODEL SYSTEM

On the other hand, ESP32-CAM camera is configured separately from the primary controller and only serves as the component capturing image data. Sim card is installed into the GSM module to facilitate the sending SMS feature. Also, the circuit is supplied with steady power from the power supply to guarantee successful functioning of the system. Performance testing is done indoors and outdoors.

9. RESULT AND ANALYSIS

The Experimental outcomes show that the system operates effectively under different test scenarios. The efficiency is reflected in high reliability of the system during several tests. The combination of different modules increases the functionality and makes the system more efficient than existing safety systems.

9.1 GSM Module Performance

To test whether the GSM module was capable of sending SMS and initiating calls, two parameters were considered. First, it was tested whether the SMS alert can be sent through the GSM module. The experimental results show that the average time taken by the module to deliver alerts via SMS is between 5 and 10 seconds. In addition to sending SMS alerts, the system can make automatic calls to preset contacts within 3 to 6 seconds. During testing, the success rates of sending SMS messages and establishing voice connections are found to be 95–98% and 92–96%, respectively. The module operates based on the AT command protocol using the Universal Asynchronous Receiver/Transmitter (UART). The GSM module does not depend on the internet connection since it uses cellular network technologies.

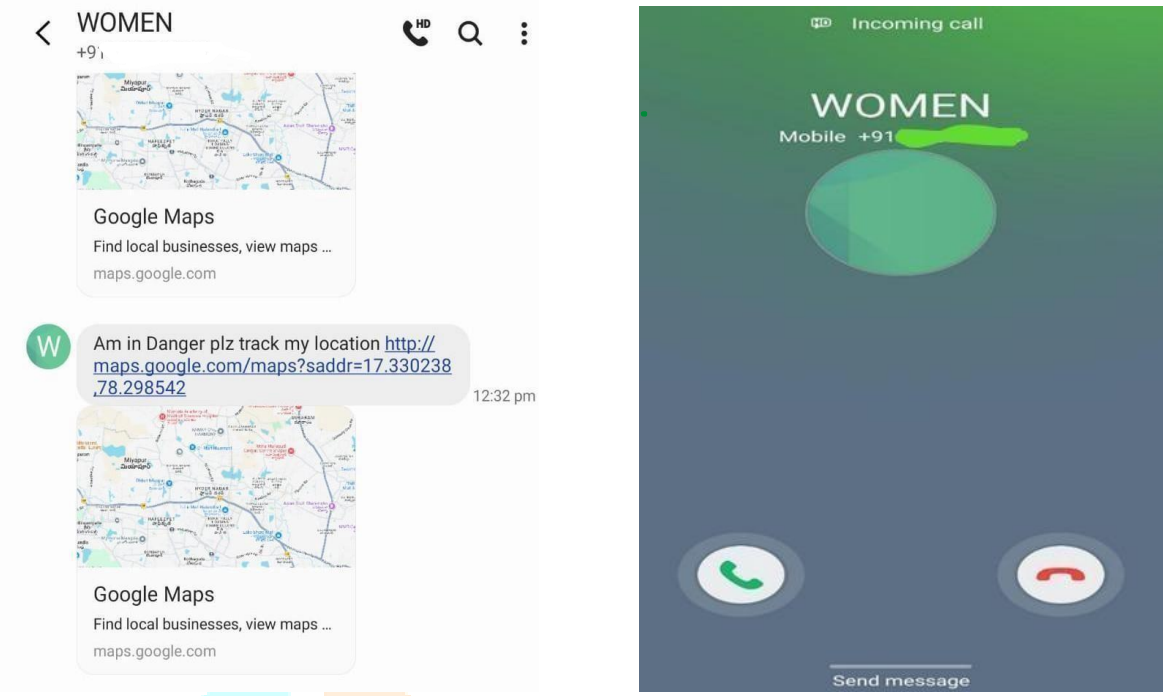

Fig 4: MESSAGE AND CALL SENT BY GSM MODULE

9.2 GPS Module Performance

The GPS module has been tested in terms of positioning accuracy and time for satellite lock. It provides locations with coordinates with accuracy up to ±5-10 meters in the open air. Satellite lock time for the GPS module is around 30-60 seconds (cold start). However, in warm start case, the time needed to read GPS coordinates is 1-5 seconds. Due to obstruction or indoors positioning accuracy gets slightly down due to signal attenuations; yet, it gives reasonable results in both cases.

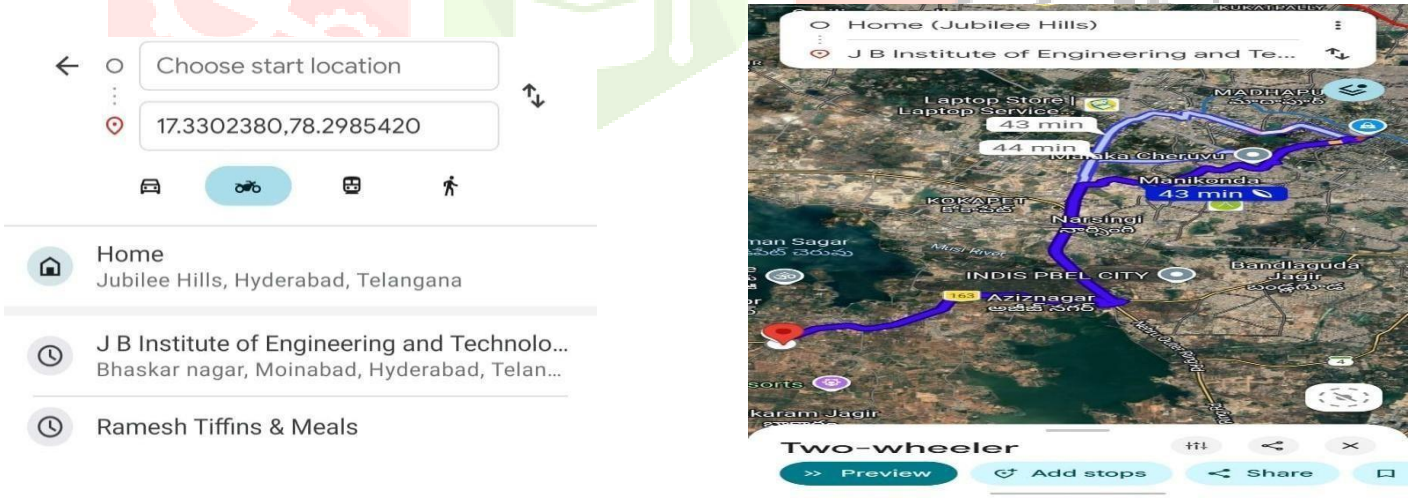

Fig 5: LOCATION OF THE VICTIM

9.3 ESP32-CAM Module Performance

Performance test for the ESP32-CAM module is done in terms of the time taken for image capturing and image processing delay. The module takes the signal from the control unit and starts capturing pictures of 2 Megapixels (1600 x 1200) resolution and then saves/transmits the pictures in JPEG format. The average time for picture capturing and processing is around 2-4 seconds. Pictures have high-quality resolution enabling identification of surroundings and possible dangers.

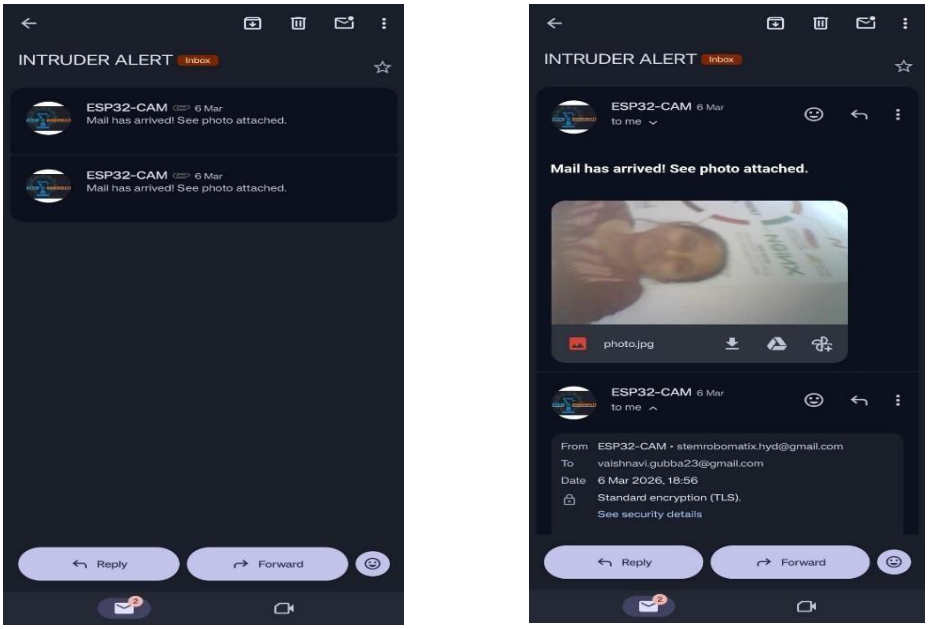

Fig 6: CAPTURED IMAGE

10. FUTURE ENHANCEMENT

Al While the proposed system operates efficiently, there are certain aspects where improvements can be made for future development. The integration with mobile apps and cloud services can provide real-time monitoring and database management facilities. The inclusion of an artificial intelligence component will aid in detecting any threats automatically. Further additions such as voice command and integration with wearable gadgets can facilitate its usage. In addition to this, enhancing the battery life and adding further sensors like motion or sound can add to its effectiveness and sophistication. These developments will immensely expand the application horizon of the system.

11. ACKNOWLEDGEMENT

In conclusion, the authors wish to convey their heartfelt thanks to their institution and the members of the faculty for all their encouragement and valuable suggestions provided in helping us complete this project successfully.

12. CONCLUSION

To summarize, the safety system using the Internet of Things technology with Raspberry Pi Pico and ESP32-CAM is one of the most effective solutions to improve the security conditions for women and children. The combination of GPS-based location monitoring, GSM-based SMS messaging, and voice calling, and the real-time image capture feature enables quick reaction in case of an emergency. The implementation of automatic voice calling to pre-selected phone numbers provides an additional means of instant communication with the help of voice calls, apart from text messages. Thus, the safety system is characterized by portability, affordability, and user-friendliness, which makes it applicable in everyday life. The experimental results have shown that the suggested safety system can provide an immediate response to emergency situations with a high level of accuracy. With future improvements, including cloud integration and threat detection capability, the developed solution has great potential for becoming popular among consumers.

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