digiRESCUE: A Smart Personal Emergency Rescue System

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***Abstract*—It is of no doubt that, emergencies occur without warning, and one does not predict the outcome. This paper seeks to design a personal emergency or panic alert system (digiRESCUE) to aid in inevitable and dangerous situations. The digiRESCUE system has two main parts: the embedded hardware and its associated software and a mobile software application. The hardware part is made up of a button embedded with a chip. This button when pressed triggers the chip, which then activates the software portion of the system to send an automated message including the individual's location to the selected contacts saved in the embedded software program. The user interface software (GUI) part of the system is in the form of a mobile application, which can be downloaded onto any mobile device. This GUI software would allow users to record or write an SOS message and input selected contacts (including friends, family, and authorities) who would be alerted of the user's predicament when the external button in pressed. This GUI software application can tap into the mobile device's GPS module to inform the selected contacts of the individual's location. The hardware would interact with the software application via Bluetooth connectivity therefore making the process of seeking for help, a lot quicker and easier. In situations where the individual is held as a hostage, he or she can easily call for help without drawing attention to oneself.**

Keywords—alert, emergency, notification, panic, rescue.

I. Introduction

From time immemorial, kidnappings, robberies, shoot out, accidents and some medical emergencies have resulted in loss of property, injuries and at worst loss of life. This loss could be avoided if only the authorities had been alerted or alarmed. Simply alerting the authorities about a situation does not guarantee the provision of assistance. Several other conditions must be met in other to reduce the percentage of casualties in such situations. When such situations occur, where victims have neither the liberty nor the time to actively pick up the phone to call for help, individuals need a portable panic alert system that can provide a very quick and efficient way to call for help. In today's world where kidnappings and robberies have become rampant, the first course of action the perpetuators of such crime take are to remove the victim's mobile phone. Similarly in emergencies perhaps medical, where a person cannot call for help due to the inability of that person to access his or her communication device, it becomes eminently necessary to provide an alternate and simpler solution for victims and patients to call for assistance.

In most emergency cases, distress signals from devices are directly channeled to rescue authorities. This often results in the over-dependence on rescue teams especially in cases where personnel are needed at several places at the same time. Emergency alert devices have at most 48hrs of continuous transmission of signals after which the battery becomes completely drained. This therefore implies that after this period, signal transmission is impossible irrespective of whether the transmitted signal has been received or not unsuccessfully transmitted due to terrible weather constraints. To minimize the over-reliance on rescue authorities and fast track rescue operations, this proposed prototype provides an option to store contacts of trustworthy relatives in addition to the default contact of nearby rescue authorities. The model described here is equipped with intelligent systems to enable automatic triggering, in case of fall detection via a fall sensor.

This project seeks to provide a quick, safe, and discreet avenue for individuals and groups like students, hospitality, industrial and corporate workers, victims of assault and kidnapping to call for help or assistance.

II. Related Works

Emergency alert and rescue systems have experienced an imperative transformation over the years due to technological advancements. Its relevance has led to a few innovative designs with variety of developed models centered at resolving challenges associated with search and rescue operations.

Several emergency locations beacons (ELB) and rescue systems exist and are primarily dependent on the type of emergency under consideration. Emergency Position Indicating Radio Beacon (EPIRB) was developed for emergencies predominantly in marine vessels. It provides an alert signal to search and rescue (SAR) authorities via satellite through a very high frequency (VHF) communication channel [1-3]. In [4], a low cost Cosmicheskaya Systyema Poiska Avariynyich Sudov-Search and Rescue Satellite Aided Tracking (COSPAS-SARSAT) transponder was developed. This EPIRB transponder model consists of a GPS (Global Positioning

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System), power module, crystal oscillator and modulator connected to a controller unit. When a button is pressed under emergency conditions, the EPIRB transponder is powered and a distress signal which contains the vessel's location is transmitted via GPS satellite communication. Although this beacon has a relatively longer operating time after been activated, the error range of the EPIRB transponder which is mostly affected by unstable weather condition was not accounted for.

[5-7], present the use of Emergency Locator Transmitter (ELT) in the aviation industry for locating manned aircrafts. There are a few ELTs that can either be activated manually or automatically by impact force based on the emergency condition. It incorporates transmitters which in the event of a crash on land emit VHF radio signals periodically depending on the strength of the power module (not more than 48hrs). The VHF radio signals are detected by satellite and the location subsequently estimated. Even though this system enables satellite communication, it is capital intensive, operational only in land crushes and in often cases are damaged upon impact.

Personal location beacons (PLB) and satellite emergency notification devices (SEND) regarding emergency alert and rescue systems have experienced significant improvements especially in health care [8,9], indoor and outdoor navigation and security [10-12]. In relation to the work conducted in [9], the proposed PLB model consists of fix and wearable Bluetooth low energy (BLE) sensors inter-linked to a wireless sensor network. A sensor attached to a patient sense, records, and monitors the patient's vitals and ambient conditions. The recorded data are sent to a processing unit, synchronized with local servers, and stored in a cloud-based storage via BLE and wireless fidelity (Wi-Fi). A location-based service is utilized to facilitate real-time transfer of the data to monitoring authorities for action. Though this model enables easy location of patients, improves information management, and saves time, it is however capital intensive, and requires routine maintenance checks.

In [13], a trauma detection personal location beacon was proposed. This model employed a pulse oximeter module, electrodermal activity module, freefall and impact detection module and body temperature module connected to a microcontroller unit. These modules comprise of different sensors which are used to measure and continuously monitor a user's distinct physiological parameters (pulse rate, sweat level, injuries from impact and body temperature). The recorded data is processed by a microcontroller and the health condition of the user is estimated. The PLB is automatically activated, and an alarm is set off if trauma is detected based on exceeded thresholds. This model is cost effective, energy saving and user friendly nonetheless it does not enable immediate transfer of distress signals to search and rescue authorities.

Personal distress-based services integrated in smart phones cannot be overlooked in both indoor and outdoor localization [14]. Smart phones with high processing and sensor capabilities enable localization through, GPS, RFID, ambient and artificial intelligence. Although it provides easy and faster navigation and location via wireless communication standards, it however may require addition of external devices or hardware especially for outdoor localization. Table I contains some portable emergency alert systems available on the market in some developed countries.

TABLE I. SOME PORTABLE EMERGENCY ALERT DEVICES

Device	**Description**
Silent Beacon (2019) [15]	This is a device that beeps and glows when pressed to call for help. The features: • Call for help without touching your phone • Send location instantly when in need of help via GPS.
Silva Consultant (2020) [16]	This device is like the Silent Beacon but can silently call for help in an event of emergency. It was created for a wide range of people including receptionist's desk in building lobbies, security station and checkpoints, shipping/receiving areas, customer service counters etc.
SureSafeGo (2020) [17]	A fully mobile personal alarm for the elderly and those with disability but can be repurposed for anyone. It offers protection both at home and outdoors. It includes a two-way communication talking pendant, call, text alerts, a 'find me' feature and automatic fall detection.
V. ALRT (2019) [18]	A wearable help button that can be carried discreetly in a pocket or a bag, worn on the wrist, or around the neck as a pendant. The V. ALRT uses Bluetooth SMART technology in association with a mobile application, to initiate calls and text messages from a smartphone. With the push of the V. ALRT help button, your smartphone sends a personalized text message and GPS location to three pre-selected contacts.
Kintronic Panic Button (2019) [19]	A personal security alert system, which allows for help in emergency situations no matter where you are. The push of a button on the mobile panic button sends an alert through the system.
Vega Panic Button Alert (2020) [20]	This device was developed for people with dementia or other cognitive impairment to allow them to live a more active, and safer life. The features are a GPS and GSM positioning modules. The Vega GPS watch wearer can move freely within a pre-configured safe zone. Family members or caretakers of emergency services are alerted every minute to follow the wearer, via computer, smartphone, or a tablet.

Although existing emergency alert devices provide signaling to nearby rescue authorities or rapid response teams, most of these devices are manually triggered. Thus, implies that they are mostly activated by a self-conscious individual in distress. However, in circumstances of sudden unconsciousness, it therefore means that sole activation of these devices is difficult to achieve. Hence, the model proposed in this paper integrates a fall detector to the system to ensure automatic activation of the device. To bridge the gap in transmission of distress signals in situations of unexpected falls and sudden loss of consciousness, this model was developed to improve existing emergency alert devices.

III. METHODS

In this paper, a portable, tiny but smart rescue device was designed, prototyped, and implemented. The system architecture, system block diagram and system workflow as well as system rescue scenarios are described in detail in different subsections.

A. digiRESCUE System Architecture

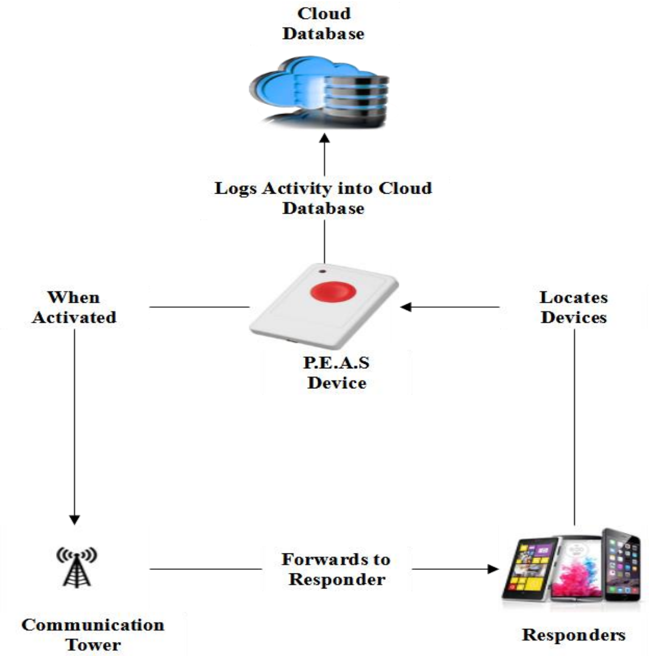

Fig. 1. digiRESCUE system architecture

The digiRESCUE system architecture is as shown in Fig. 1. The device (PEAS) is very tiny and can be used as key holder or on a necklace. There is only one knob or button which interface directly with the central intelligent unit CIU of the system. The knob has three (3) press and activate functions namely **single press**, **double press**, and **triple press.**

Upon activation by pressing the knob, the embedded microcontroller in the CIU queries the SD-card and collects stored SOS messages and automatically request from the GPS module location information and build a message package ready for transmission via the GSM module. The data package is transmitted via GSM to the communication tower for forwarding to known respondents stored in the SD-card and or SIM chip. For further references all activities are logged in a cloud database and the stored data can be retrieved later and use as evidence in criminal rescue cases.

B. digiRESCUE System Block Diagram

As shown in the digiRESCUE system block diagram in Fig. 2, the device can be activated in two ways: either manually by the press of a button or automatically by a fall detector sensor. Upon activation, the central intelligence unit CIU detects, receives and process input and output signals. The CIU request for and receives a GPS link from the GPS tracking chip. It also requests for and receives the contacts of respondents from the SIM card. It concatenates everything into an SOS message and sends out an SOS signal. The signal is picked up by a communication tower which then transmits it to the intended respondents. The respondents can then take appropriate action. The main hardware components as shown in Fig. 2 are: GPS module, SD card module, Pushbutton, Fall-sensor, and the Central Intelligent Unit CIU equipped with GSM module.

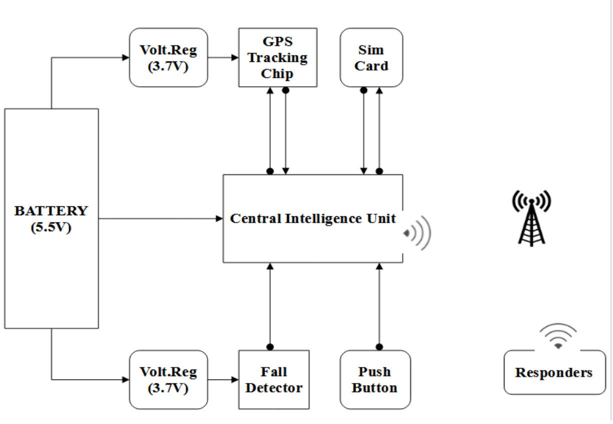

Fig. 2. digiRESCUE system block diagram

Fig. 3 illustrates the system activation via the fall detection sensor. In case of a fall detection by the fall sensor, an interrupt is sent to the CIU for validation. If validation fails or system was unintentionally activated, the process is abandoned, and a dummy message is sent to respondents to ignore activation and not to take any further action. Upon a successful validation of an alert notification, the CIU puts together a message package for further transmission. This message package contains among others, a SOS message, and the GPS location of the holder of the rescue device.

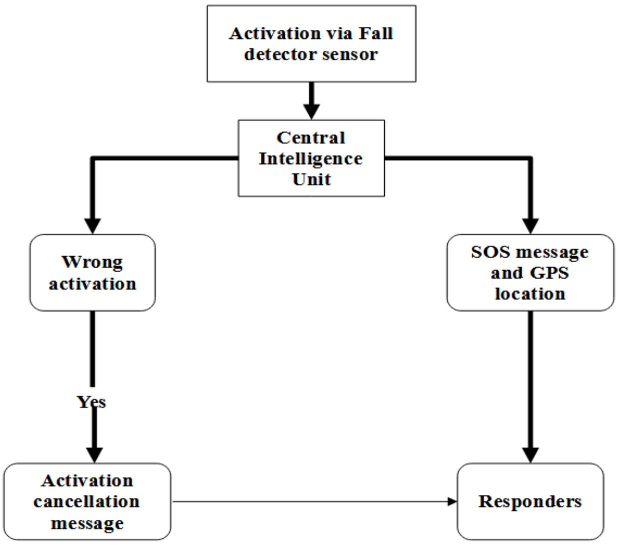

Fig. 3. digiRESCUE fall detect workflow

C. digiRESCUE System Rescue Scenarios

The digiRESCUE system implements three (3) rescue scenarios, namely **SCENARIO 1: physical attack**, **SCENARIO 2: health attack** and **SCENARIO 3: stranded situation**. Table II contains the various scenarios and actions to be taken in case of activation.

TABLE II. DIGIRESCUE SYSTEM SCENARIOS

Case	Action
SCENARIO 1 Physical Attack	A person is being attacked by a criminal or a dangerous person. In this case, the person under duress immediately presses the panic button. Upon pressing the button, the device is activated. There is an in-built sim card that gets its connection from a nearby communication tower. An SOS or a pre-set message on the rescue device is then sent to the respondents (friends and family) as notification message on their mobile device or smartphones informing them about the situation and asking for assistance where possible. During the device activation, all information and any other messages are sent to the cloud database to track or record any alert and activities.
SCENARIO 2 Health Attack	The *health attack* is the second scenario for a person under a medical attack, e.g., an asthmatic, cardio attack etc. Activation process is initiated automatically with the aid of the fall sensor without user interaction.
SCENARIO 3 Stranded	Being stranded_is the third instance where the person can activate the system to notify close relations for assistance of some defined kind which must be already configured and stored on the SD card storage

D. digiRESCUE System Workflow

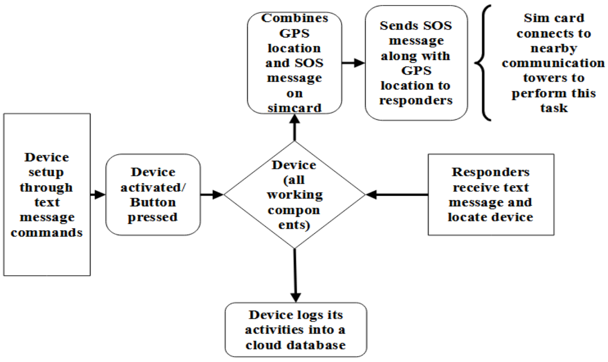

Fig. 4. digiRESCUE system workflow

The system workflow is as illustrated in Fig. 4. The digiRESCUE smart device can be set-up and configured via text message or SMS commands received via the smartphone. Activation is triggered by the press of a button interfaced with the CIU of the system. The embedded microcontroller which serves as the brain of the system is responsible for all data reception, processing, and further transmission. The microcontroller unit interface seamlessly with the GPS module, GSM module and the SD card.

IV. RESULTS AND DISCUSSION

The functionality and reliability of the digiRESCUE portable device was set-up and tested using the designed system prototype shown in Fig. 5. Results obtained are discussed below in this section.

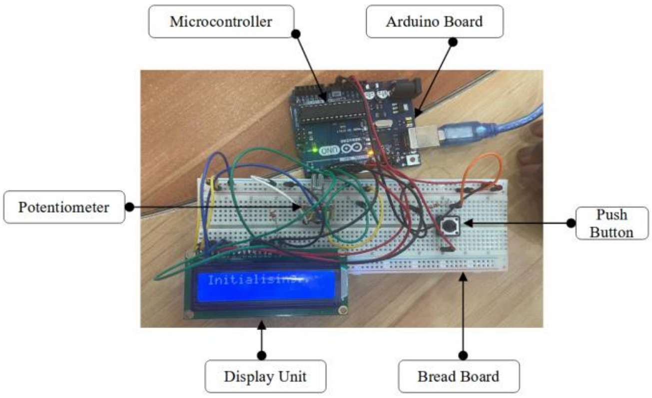

Fig. 5. digiRESCUE system initialization

The system was tested according to the three (3) case scenarios as indicated in Table II: Key press once, twice and trice. Table III contains expected actions or outcomes after key press. Fig. 6, 7 and 8 contains screen shots of the test scenarios 1, 2 and 3.

The SCENARIO 1, as depicted in Fig. 6 a, b and c, is initiated by pressing the button once (single-click), the LCD then displays the text “Scenario 1 Activated”. The microcontroller unit in the embedded hardware gets stored information from the SD-card, package it and prepare data for transmission. After which time, the LCD displays “sending notifications to close relationships and messages are transmitted in the background.

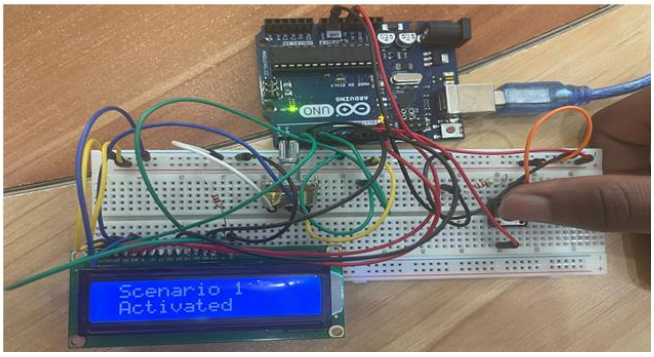

Fig. 6. digiRESCUE scenario 1 activation

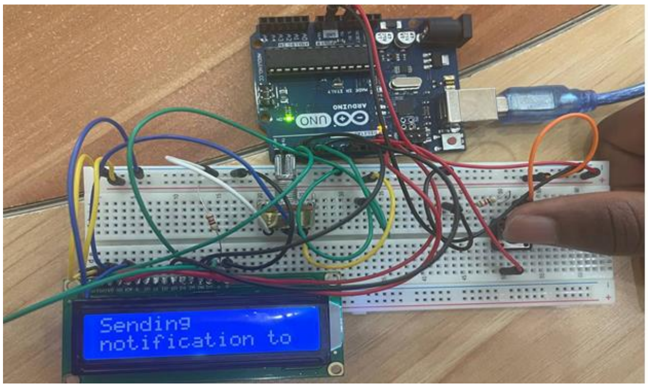

Fig. 6. digiRESCUE scenario 1 sending notification

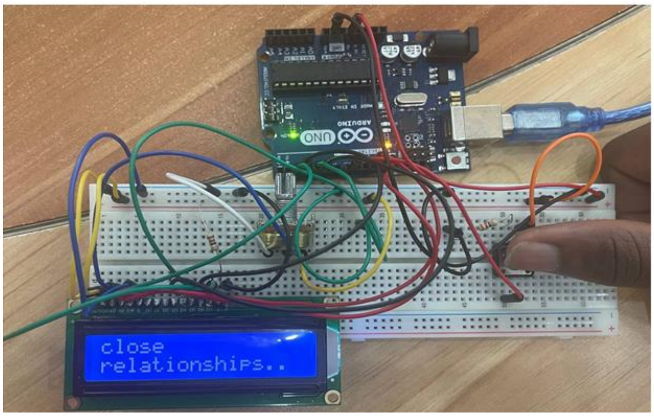

Fig. 6. digiRESCUE scenario 1 relation notified

The SCENARIO 2, as depicted in Fig. 7 a, and b, is initiated by pressing the button twice (double-click), the LCD then displays the text “Scenario 2 Activated”. The microcontroller unit in the embedded hardware gets stored information from the SD-card, package it and prepare data for transmission. After which time, the LCD displays to the user, “Sending notifications to close and extended relationships and security.

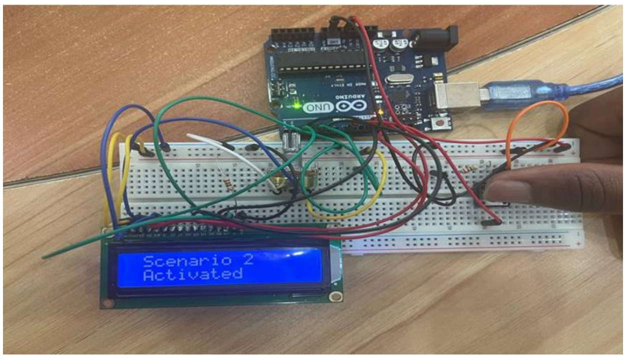

Fig. 7. digiRESCUE scenario 2 activation

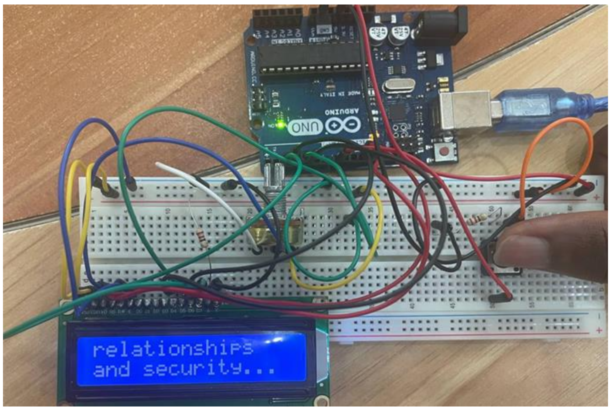

Fig. 7. digiRESCUE scenario 2 relationships and security notification

The SCENARIO 3, as depicted in Fig. 8 a, b and c, is initiated by pressing the button thrice (triple-click), after which time, the LCD displays the text “Scenario 3 Activated”. Action performed by the intelligent unit same as explained in scenarios 1 and 2. The LCD then displays to the user, “Sending notification to close relationships, security and telco networks and data exchange done automatically in the background.

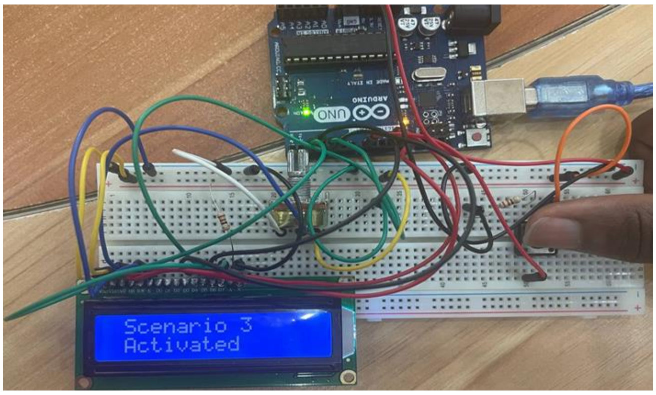

Fig. 8. digiRESCUE scenario 3 activation

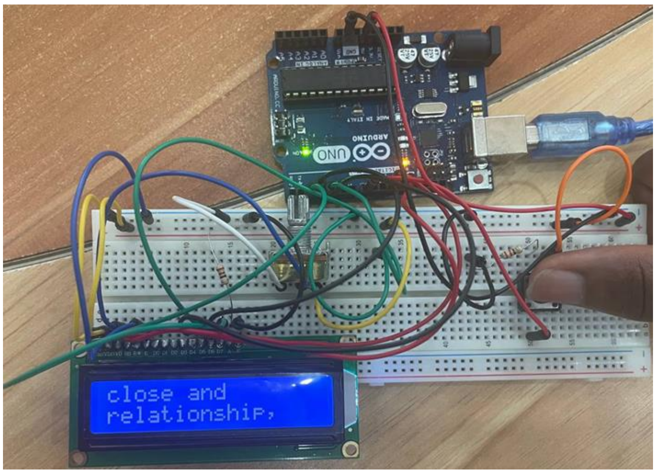

Fig. 8. digiRESCUE scenario 3 relationship notification

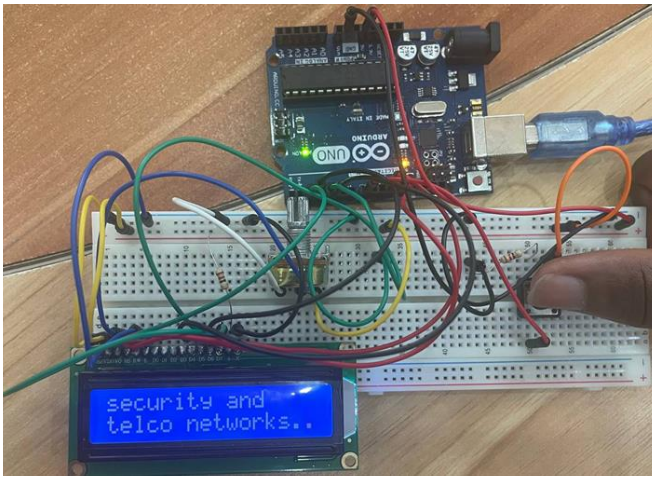

Fig. 8. digiRESCUE scenario 3 security service and telco notification

All the three (3) system scenarios and corresponding actions to be taken are again summarized in Table III. Fig. 9 and 10 contains some self-explanatory messages and screen shots of the digiRESCUE graphical user interface (GUI) mobile software application test and results obtained thereafter.

TABLE III. DIGIRESCUE SYSTEM KEY PRESS

BUTTON PRESS	FUNCTIONALITY
ONE PRESS **SCENARIO 1**	Used when the victim wants to signal or send a message to primary respondents (family or friend).
TWO PRESSES **SCENARIO 2**	Used when the victim wants to send an alert message to all respondents (family and friends).
LONG PRESS **SCENARIO 3**	Used when the victim wants to send an alert message to cancel an accidental activation of the button, by informing respondents of the accidental activation.

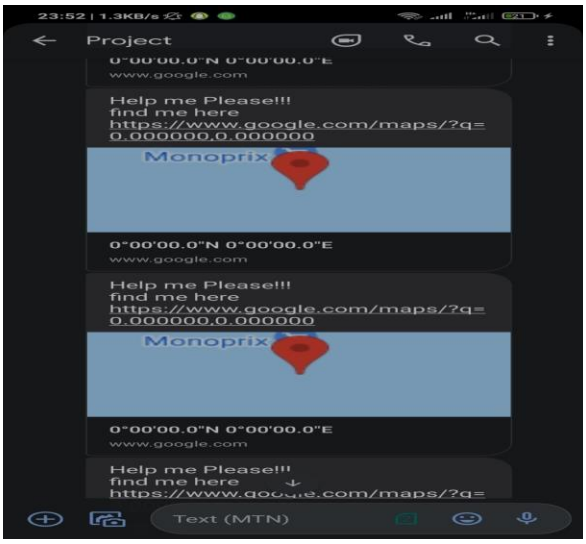

Fig. 9 digiRESCUE GUI mobile application

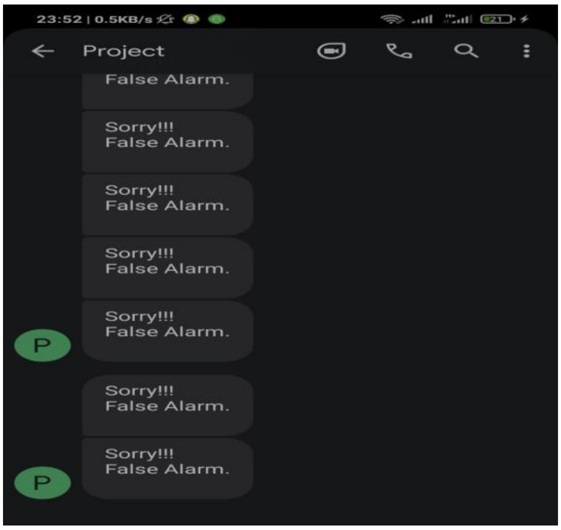

Fig. 10. digiRESCUE mobile app error message

V. CONCLUSION

In this paper, the design of a tiny but smart personal emergency alert system (digiRESCUE) has been proposed and implemented. Controlled by GPS location and GSM communication technologies, the digiRESCUE system has a real time functionality which provides accurate SOS and geo-location data. The system covers a wide range of individuals irrespective of age and health. The performance of the proposed system was examined, and it provided good results regarding real time notification and established communication between the relevant stations. The portable and smart proposed system can therefore serve as an economical and highly efficient personal emergency alert solution for any individuals. Additionally, its efficient power management system prolongs battery longevity as opposed to existing models. Thus, its small package produced with readily available and economical materials would provide a portable and cost-effective rescue beacon or alert device for users of all groups.

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