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Development of Arduino-Based Panic Alarm with GPS and GSM Modules

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Abstract:- This research outlines the creation of a panic alarm prototype based on Arduino technology. An examination was undertaken to identify gaps in existing panic alarm systems. The data collected from this research gap analysis informed the development process, which followed the agile software development method. The development utilized C++ web technologies on a computer equipped with an i5 processor, 12GB DDR III RAM, a 250GB hard disk drive, and a 500GB solid-state drive.

The study successfully produced a prototype alarm featuring a GPS and SMS module, addressing the identified research gap in current panic alarms and offering an additional layer of security during travel. The GPS module demonstrated approximately 80% accuracy, acknowledging challenges in locating signals within buildings or residential areas. Testing involved five locations, including open spaces and indoor settings, with the prototype activated while the user moved. The SMS function operated concurrently with the GPS, sending messages to the registered user based on the prototype's location as determined by the GPS.

***Keywords**:- Alarm, Arduino, Prototype.*

I. INTRODUCTION

The COVID-19 pandemic exacerbated interpersonal violence, constituting a larger share of overall crime, primarily driven by firearms (Lalchandani 2022). In US cities, the pandemic resulted in a 15-30% surge in street crime victimization, even as violent crimes saw a decline, emphasizing the necessity for activity-adjusted crime rates to gain a more accurate understanding of public safety (Massenkoff, 2022). Lockdown restrictions during the pandemic contributed to decreased larceny and robbery rates, while homicide rates remained high and auto thefts increased (Meyer, 2021). Surprisingly, no single crime theory could provide a comprehensive explanation for all these varied outcomes. In Queensland, the pandemic led to lower rates of shop theft, other theft, and credit-card fraud, while property damage, burglary, and motor-vehicle theft remained relatively unchanged (Payne 2020). Meanwhile, New York City experienced a significant rise in grand larceny auto and gun violence crimes during COVID-19, whereas rape, other sex crimes, and other crimes showed a notable decrease (Esposito 2021).

Various alarms are available in the market, each serving distinct purposes, the common goal is to attract attention for assistance, protection, alerting, and warning. Smoke alarms, for instance, are obligatory for buildings, with manual and automatic options for activation. In contrast, Personal Alarms or Hand-Held Alarms are suitable for situations where deterring an attacker without causing harm is essential. The intention is to prevent users from facing scrutiny in case of a false alarm, ensuring that innocent individuals are not adversely affected. Recognizing the potential for self-defense devices to cause harm, the researchers aim to disguise these alarms as entertaining items, making them less conspicuous. This dual-purpose design allows users to stay entertained and calm while alone, whether traveling for work or spending time outdoors.

This study aims to reduce the likelihood of encountering crime or the need for self-defense in the current situation. Experiencing an attack, assault, or robbery is inherently terrifying. Having a straightforward device that can both deter potential attackers and summon assistance is significantly more effective than having no means of protection. As the pandemic gradually subsides and people strive to resume work to support their families, the necessity of travel becomes apparent, and the associated risks of traveling alone should not be underestimated.

The development of a panic alarm stems from the heightened urgency for enhanced personal and public safety, especially in the context of escalating interpersonal violence during the COVID-19 pandemic. As the pandemic contributed to a surge in various crimes, including street crime victimization and specific types of violent offenses, the need for proactive measures to address emergencies became evident. A panic alarm, designed to provide swift and accessible assistance, emerges as a crucial tool in such circumstances. The increased crime rates, unpredictable situations arising from lockdown restrictions, and the necessity for innovative solutions underscores the significance of developing a panic alarm system. Such a device can offer a rapid response mechanism, ensuring the well-being of individuals and communities facing emergent threats, thereby reinforcing the imperative for its development in the current socio environmental context.

II. SIGNIFICANCE OF THE STUDY

The development of panic alarms play a crucial role in enhancing security by offering a subtle and inconspicuous means to signal for help in emergencies. Their discreet nature is particularly advantageous in scenarios where maintaining a low profile is essential, preventing potential aggressors from realizing that an alert has been triggered. These discreet alarms can take various forms, including small, easily concealable devices or inconspicuous buttons integrated into everyday objects. The importance of panic alarms lies in their ability to provide a covert and swift response to emergencies without drawing unnecessary attention. This can be crucial in scenarios where overt signaling might escalate a situation or when individuals need to signal for help without others being aware. In personal safety contexts, discrete panic alarms are valuable for individuals facing threats or harassment, allowing them to quietly and swiftly alert authorities or security personnel. In commercial settings, these alarms are beneficial for employees in potentially dangerous situations, offering a low-key yet effective means of seeking assistance without attracting undue attention.

III. OBJECTIVES OF THE STUDY

The primary goal of this research is to create an Arduino-based panic alarm with gps and gsm modules. Specifically, it aimed for the following:

- Identify gaps on existing studies as basis for the development of the new panic alarm.
- Formulate the architecture for an Arduino-based panic alarm incorporating GSM and GPS modules.
- Create the algorithm for Arduino-based panic alarms equipped with GSM and GPS modules.
- Conduct thorough testing and evaluation of the novel panic alarm, assessing its accuracy and speed.

IV. SOFTWARE DEVELOPMENT FRAMEWORK

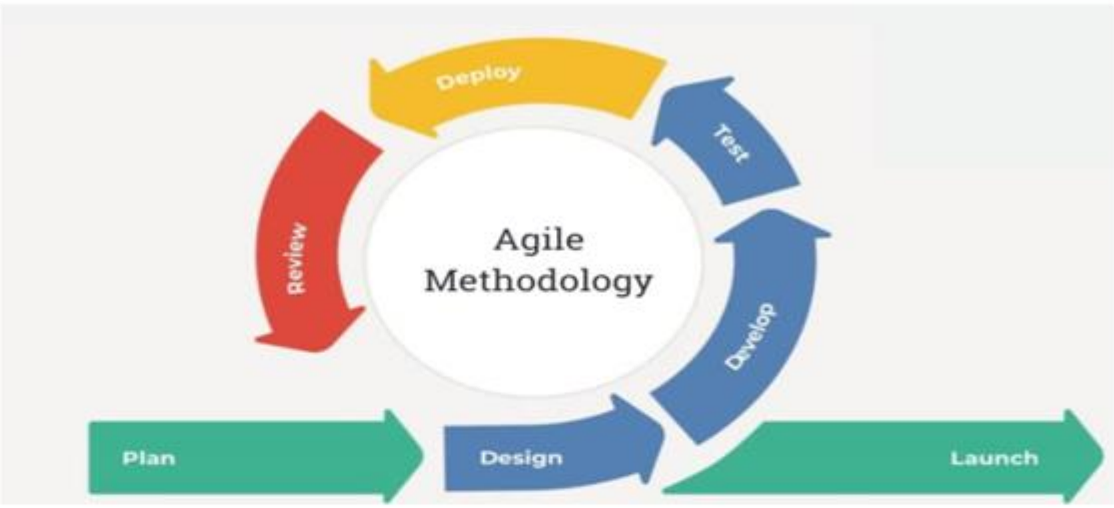


Fig. 1: Software Development Framework

This study adheres to the Agile Software Development Method, commencing with the identification of design requirements primarily based on the recognized research gap, specifically focusing on GPS (Global Positioning System) and GSM (Global System for Messaging Communication). In the design phase, the researchers systematically iterate through planning, execution, and evaluation cycles for the alarm until it successfully achieves its objectives and addresses the identified gaps. The technologies employed in this project include Arduino Nano, Arduino GPS & GSM modules, LED module, and a 130dB Speaker module. Utilizing these technologies, the researchers aim to create and develop the intended Panic Alarm, designated as the "Arduino-based panic alarm." The algorithm governing the device's functionality will be elucidated throughout the alarm's development. The agile development method is applied to both software and hardware development processes. This methodology involves breaking down features into sprints and developed it within short timeframes. Each sprint is integrated based on the existing panic alarms, as it addressed the identified research gaps. This iterative cycle, encompassing identifying requirements, designing, developing, testing, deploying, and reviewing, forms the fundamental framework for the evolution of the Arduino-based panic alarm.

V. REVIEW OF THE RELATED LITERATURE AND STUDIES

The studies used in this paper share a common theme of designing security and alarm systems based on GSM and GPS technologies. A communication equipment alarm system utilizing a GSM module was utilized to connect various modules for sending short messages and giving voice alarms in the event of equipment breakdown using ARM chip LPC2103 as the main control circuit (Xuan, 2010). While GPS and GSM modules, a microcontroller, and a mobile client, automatically send GSM short message alerts and report the vehicle's position when an alarm threshold is breached (Ye, 2013). This research used the same technologies for vehicle positioning and anti-theft alarm systems and was proven effective in providing real-time alarms and post-theft location tracking. Similar to this, the integration of GSM/GPRS, GPS, and Bluetooth modules established a comprehensive car anti-theft and navigation system. With features like vibration sensors and real-time GPS positioning, this system achieves global car alarm functionality. (Xiao-Ming, 2011). In addition, utilizing a mature and reliable GSM mobile network as a community alarm system with MCU AT89C52 series as the core, the system employs infrared monitoring, and LCD alarms for timely accident handling. (Wang, 2015) Moreover, a car security alarm system network design based on GSM/GPS, utilizing AVR microcontroller Atmega128 for control and various sensors for real-time security monitoring. It introduces a high-precision network-based anti-theft and anti-hijacking system. (Peng Wei, 2011) Also, a versatile security and alarm system for individuals, corporations, and establishments is proposed. This system, using an ATmega16 microcontroller, GSM SIM900A module, and two Android applications, ensures a cheap yet reliable security solution. It sends emergency messages with GPS locations, providing a swift and simple means of obtaining help during emergencies. (Chaundry, 2015) The device, cost-effective and versatile, can be deployed anywhere with mobile network connectivity. In terms of remote home security alarm systems using WSN and GSM technology equipped with the C5081F310 single chip, CC1100 wireless chip, and SIMENS TC35 GSM module, detects theft, gas leaks, and fires, sending alarm messages remotely. (Lili, 2009)

VI. RESEARCH METHODOLOGY

This study aimed to address existing problems. The initial phase involved an extensive literature review, where researchers explored reference materials on various alarm types and their applications. Subsequently, an examination of different alarms available in the market was conducted to understand their functionality and inform the development of a prototype. The prototype incorporates insights from the identified research gaps presented in the paper "Real-time Alarm, Dynamic GPS Tracking, and Monitoring System for Man Overboard" [Sheu, 2020] to address the GPS research gap, and to address the GSM gap found in the study of Design of Intelligent Fire Alarm System based on GSM network [C.-y Lian, 2011]. Following the product development, the researchers will conduct tests to assess the accuracy of the GPS and GSM systems in the developed panic alarm.

VII. INSTRUMENTS USED

- Materials

Fig. 2: Arduino UNO R3

The microcontroller or the brain of the device where it will be the one controlling the other components attached to it.

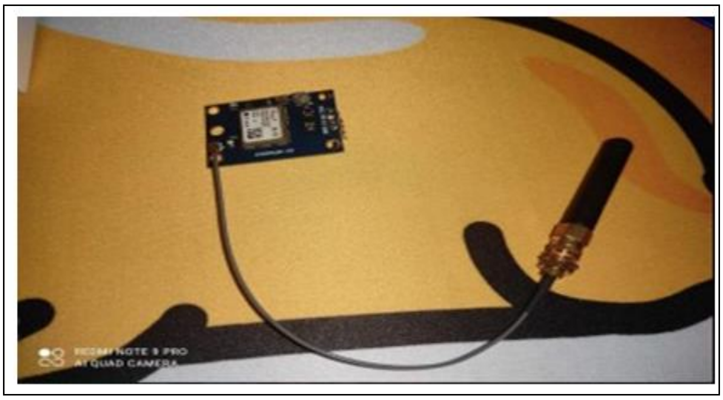


Fig. 3: GY-NE06MV2 GPS Module

The chip module that will provide the location of the prototype.

Fig. 4: SIM800L GSM Module

The chip module that will provide the capability of the prototype to send messages.

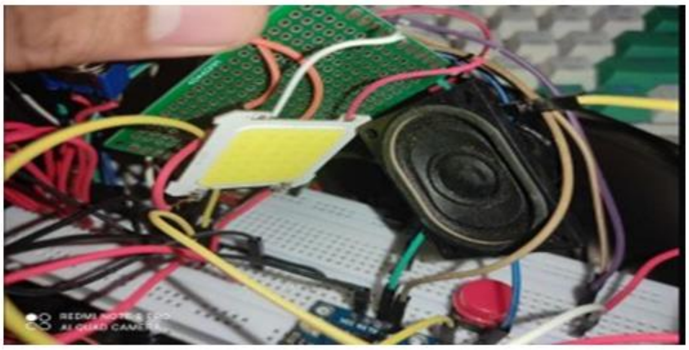


Fig. 5: LED Light and Speaker

The components responsible for providing additional functionality to the prototype that makes up the alarm; make up the sound of the prototype with the press of the button along with an LED Light.

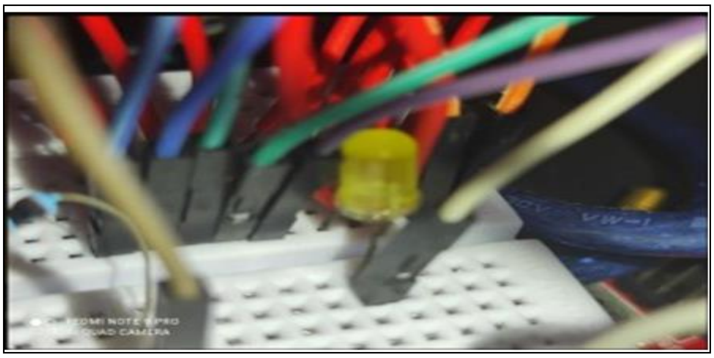


Fig. 6: Wires

Responsible for the connection of the components.

Fig. 7: Switch

Capable of turning the prototype on/off depending on what function is needed.

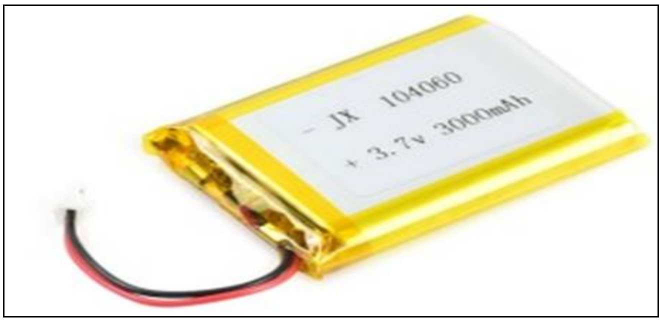


Fig. 8: LiPo Battery

The LiPo Battery is used to give some power to other components of the prototype such as the LED lights, modules, etc.

VIII. RESULTS AND DISCUSSION

A. Accuracy Test

The GPS coordinates for Location 1 (14.562113, 121.000724), Location 2 (14.5539, 121.0180), and Location 3 (14.5536167, 121.0220008) precisely correspond to the actual locations of Boyle St., Makati, Washington Sycip Park, and Greenbelt 5 Valet Parking, respectively, as verified on Google Maps. However, the GPS coordinate for Location 4 (14. 33 7632121 01 24.096) does not align with the Google Maps location of EDSA bus station SM. Additionally, the GPS coordinate for Location 5 (14.560416, 121.065354) is considered invalid according to Google Maps. In summary, the GPS module accurately provided location data for the first three test locations when compared to Google Maps, while for Locations 4 and 5, the GPS coordinates did not match the actual location names according to Google Maps. This section of the study addresses the outcomes of the accuracy testing conducted on the components employed in the research. It is crucial to note that the researchers operated within limited resources, and there is room for enhancement by subsequent researchers with a more comprehensive understanding and additional resources. With this acknowledgment, the first criterion in Reliability testing pertains to the GPS Signal Strength. When testing the GPS module (GY-NE06MV2), several advantages and disadvantages became apparent.

Table 1: Accuracy Test Results

GPS Module Testing	Google Map Location	Actual Location	Result
1	Location 1: GPS Coordinate 14.562113,121.000 724 Boyle St., Makati	Boyle St., Makati	Yes
2	Location 2: GPS Coordinate 14.5539, 121.0180 Washington Sycip Park	Washington Sycip Park	Yes
3	Location 3: GPS Coordinate 14.5536167,121.02208 Greenbelt 5 Valet Parking	Greenbelt 5 Valet Parking	Yes
4	Location 4: GPS Coordinate 14. 33 7632121 01 24.096 Landmark Makati	EDSA bus station SM	No
5	Location 5: GPS Coordinate 14.551818, 121.022960 Residential Area	Makati Avenue	no

Starting with the disadvantages, the module is not well-suited for indoor use, as its antenna necessitates a direct satellite signal to receive GPS data. Another limitation is its reliance on a wide and unobstructed skyline for data reception, making it ineffective in areas surrounded by tall buildings. Furthermore, it requires 10-20 minutes to establish a signal, even if all prerequisites are met. On the positive side, the module demonstrates consistency in sending data to the serial monitor and operates without disturbance when the necessary conditions are met. Additionally, the GPS accuracy is commendable, but further details on this aspect will be discussed subsequently.

The SMS Signal Strength, akin to the GPS module, exhibits both advantages and disadvantages. Notably, one of its strengths is the consistent delivery of SMS messages. Another advantage lies in its superior signal strength compared to the GPS, enabling it to transmit SMS even in areas with poor reception, while the GPS may provide inaccurate or no results. Conversely, a drawback is the potential sudden loss of signal. Another disadvantage is the absence of an indication when the SIM card has no load.

B. Speed Test

Table 2: Speed Test Results

GSM Module Testing	Button	Time (+ 2)	Speed
1	21.686	23.732	2.046
2	03.247	03.292	2.045
3	22.306	22.353	2.047
4	14.814	14.860	2.046
5	32.334	32.380	2.046
Average			2.046

The evaluation involved a series of tests wherein a button connected to the GSM module was pressed, and the subsequent measurement of time intervals was recorded. The test encompassed five instances, each revealing specific details:

- Press 1 initiated at 21.686 seconds and concluded at 23.732 seconds, resulting in a time interval of 2.046 seconds.
- Press 2 commenced at 3.247 seconds and terminated at 3.292 seconds, yielding a time interval of 2.045 seconds.
- Press 3 was initiated at 22.306 seconds and concluded at 22.353 seconds, resulting in a time interval of 2.047 seconds.
- Press 4 commenced at 14.814 seconds and concluded at 14.860 seconds, yielding a time interval of 2.046 seconds.
- Press 5 began at 32.334 seconds and ended at 32.380 seconds, resulting in a time interval of 2.046 seconds.

The interval time between the button presses is very consistent, around 2.046 seconds for each one. This indicates that the GSM module is reliably detecting the button presses and accurately reporting the timing. The consistency of the intervals shows precise performance of the GSM module in detecting a triggered input event.

Overall, based on the consistent button press intervals, the GSM module appears to be functioning properly in detecting digital input signals and reporting the timing. The test shows reliable performance of the input signal detection on the GSM module across multiple button presses.

C. Sound Attenuation Result

The diagram illustrates the outcomes of the speaker's sound test, where SPL stands for Sound Pressure Level, representing the measurement of sound loudness in a specified area [Svantek, 2023]. R1 and R2 denote the distances from the sound source. As anticipated, there is a decrease in Sound Pressure Level (SPL) as the measurement distance extends from the source, indicating sound attenuation over distance. Specifically, at 5 meters, the SPL is 13.98 dB lower than at 1 meter. The attenuation effect becomes more pronounced with increasing distances: at 10 meters, the attenuation is 20 dB, at 15 meters, it is 23.52 dB, at 20 meters, it is 26.02 dB, and at 25 meters, the attenuation reaches 27.96 dB. There is an exponential relationship between distance and sound attenuation - the farther from the source, the greater the sound level drops off. This is expected due to the geometric spreading of acoustic waves. A clear trend is seen of increasing sound attenuation at larger distances from the source, verifying the principle of sound amplitude reduction over distance. The results align with typical expectations for acoustic propagation and drop-off. The data indicates consistent and appropriate functionality of the sound measuring system used in this test.

Table 3: Sound Attenuation Results

Trial	R1	SPL 1 (dB)	R2	SPL 2 (dB)	Difference in SPL
1	1 meter	90	5 meters	76.02	13.98
2	1 meter	90	10 meters	70	20
3	1 meter	90	15 meters	66.48	23.52
4	1 meter	90	20 meters	63.98	26.02
5	1 meter	90	25 meters	62.04	27.96

D. Development Process

The team underwent a total of four development cycles for the panic alarm. The initial cycle primarily focused on designing and researching the desired panic alarm, as well as planning the components required to be compatible with the Arduino-Uno, which serves as the central processing unit for the device.

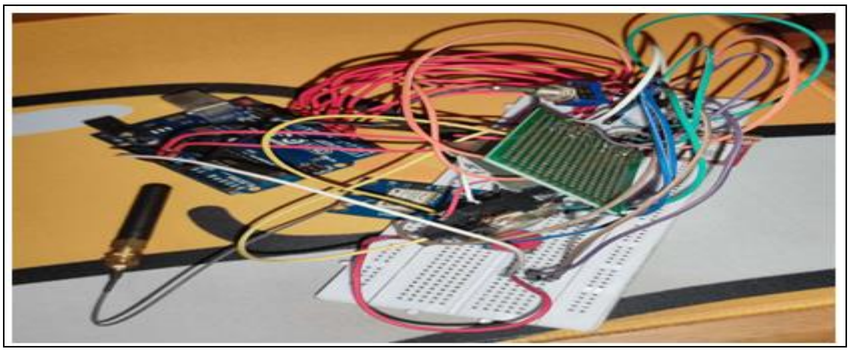


Fig. 9: Digital Mockup of the Alarm

The provided illustration depicts the digital mockup of the panic alarm created through TinkerCad. It's important to note that certain components, namely the GPS and GSM modules, are not available in TinkerCad and have been substituted with placeholders. Following the assembly of the identified components, Cycle 2 commences. In the initial stages of Cycle 2, the team initiates the construction of the first iteration of the prototype, focusing on implementing the speaker and the LED light. Regarding the LED light, discussions centered on determining the duration of its blinking, with the light intensity set at 500 lumens. Concurrently, the speaker settings were configured to emit sound at 90 decibels, alternating between frequencies of 2000 and 5000 hertz

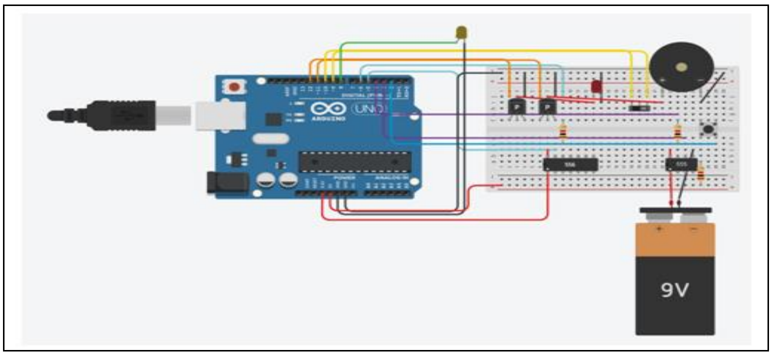


Fig. 10: First physical prototype

The picture displayed is the initial tangible representation of the prototype. In the photograph, only a standard LED is affixed to the device, as the COB LED had not been received at the time the photo was taken. Following a thorough testing and program review, the team proceeds to Cycle 3. Cycle 3 marks the initiation of incorporating the GPS and GSM modules into the prototype.

The inclusion of these modules also involves integrating their respective codes, and facilitating communication between the microcontroller (Arduino) and the modules themselves.

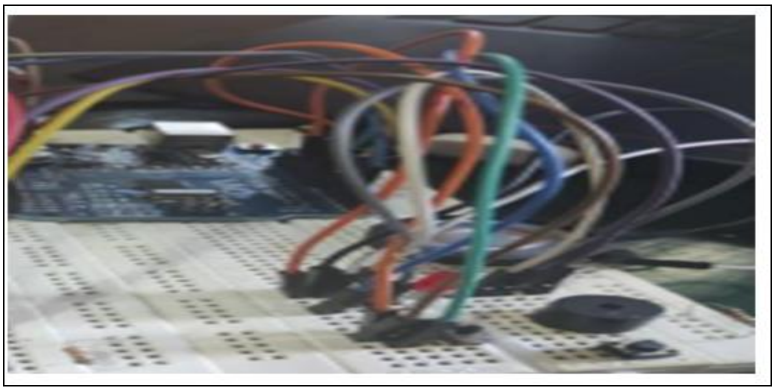


Fig. 11: Final Prototype of the Panic Alarm

Upon completing the assembly of the physical components of the GPS and GSM modules, along with their corresponding code integration, the team progresses to testing in Cycle 4. This phase involves comprehensive testing of the prototype's functionalities. Initial tests include examining the speaker and light functions, which can be performed at any location. The team initiated the first round of testing for the GPS and GSM modules in their initial state. As the prototype advanced, actual on-site tests were conducted. The subsequent image illustrates the operational states of the prototype: turned on, idle, and in the off mode.

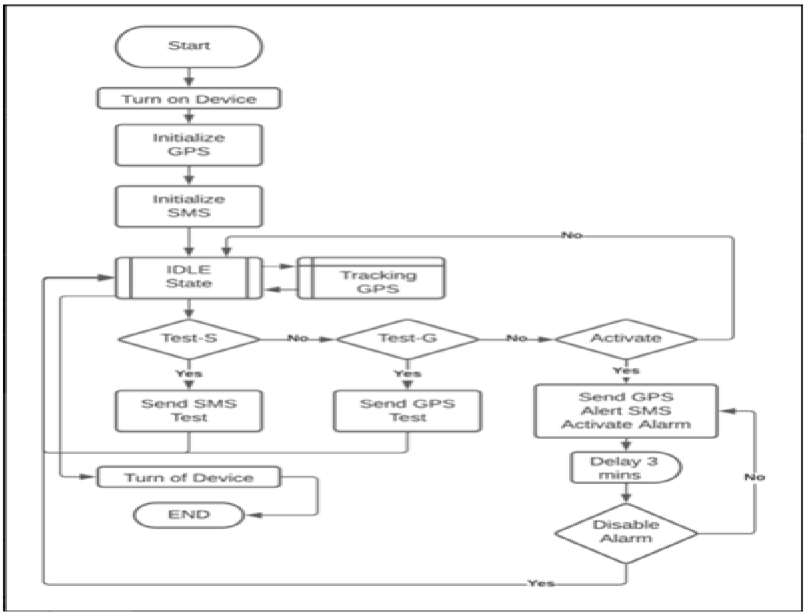


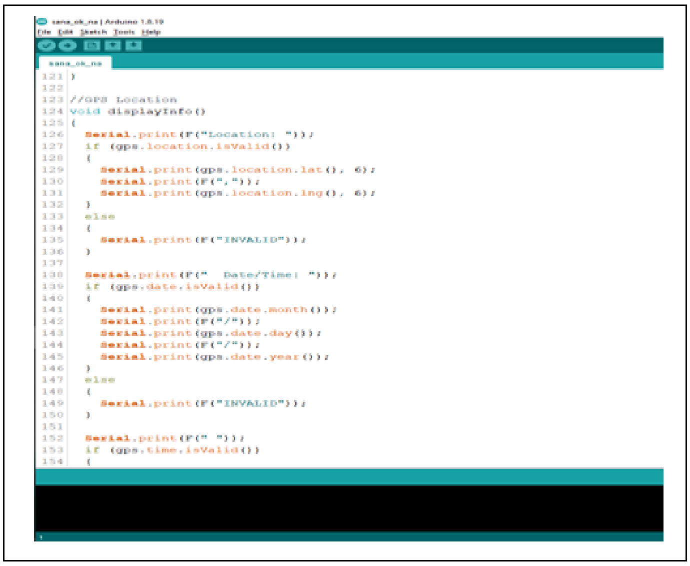
Fig. 12: Prototype Flowchart

Upon activation of the prototype alarm, it initiates the GPS module followed by the initialization of the GSM module. Subsequently, the alarm enters an IDLE mode, continuously monitoring its location via the GPS module. While in idle mode, the system responds to user commands. If the user inputs the command "Test-S" or "S," the system triggers a corresponding message to the user-entered number, thus testing the SMS module. Similarly, upon entering the command "Test-G" or "G," the system sends a corresponding message containing the GPS location of the alarm to the user-inputted number, thereby testing the GPS module. If the user activates the alarm, it dispatches a message to the specified number, activates the LED light, and initiates the speaker, alerting those in proximity. The activation includes a 3-minute delay; if the alarm is not deactivated within this time frame, the system sends another message to the designated number, and the cycle repeats until the alarm is turned off.

E. Technical Requirements

The Arduino-based panic alarm is a blend of software and diverse hardware technologies. In the programming aspect of the panic alarm development, C++ was employed for coding on the Arduino Uno, and the Arduino IDE served as the software for compiling and communicating with the Arduino Uno. In terms of hardware, the prototype alarm utilized the following components: GY-NE06MV2 for the GPS module, SIM800L for the GSM module, a 4-ohm 2W Speaker, 6W OCB LED light, Mts-103 3 feet 3 files Switch, 3000mAh 3.7V LiPo battery. Additionally, for the development of the device, tools such as a computer equipped with an i5 processor, 12GB DDR III RAM, 250GB hard disk drive, and 500GB solid-state drive were utilized.

F. Program Code



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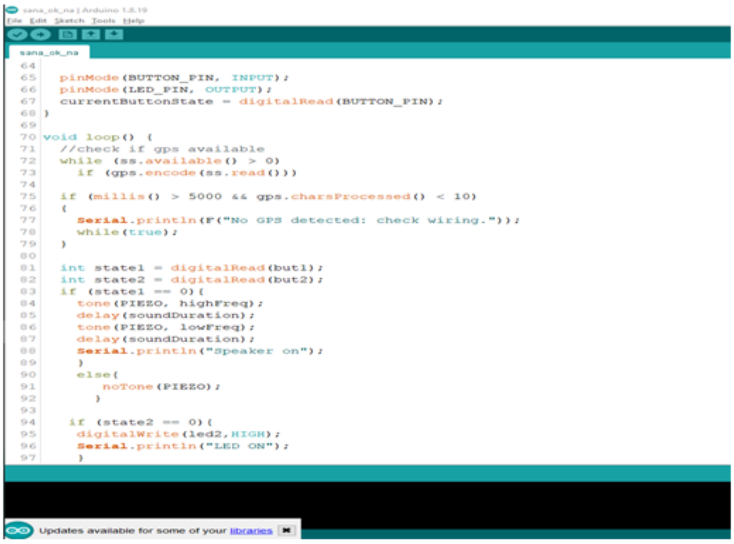

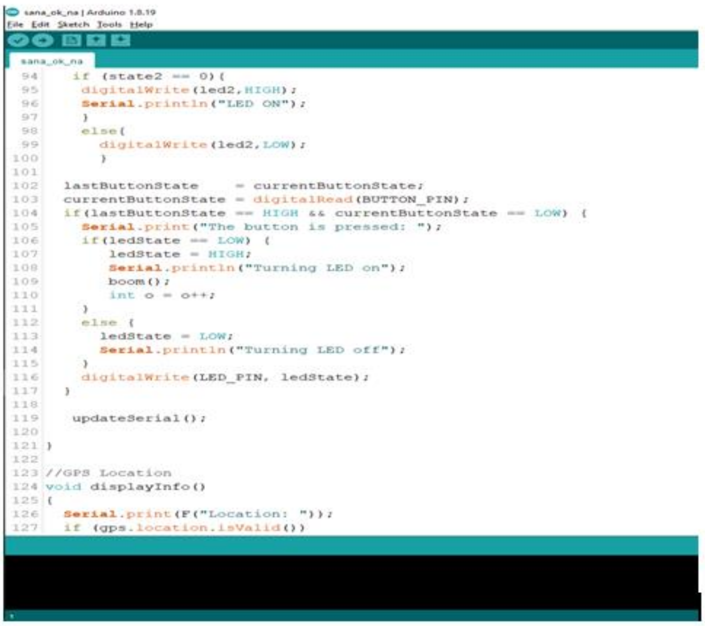

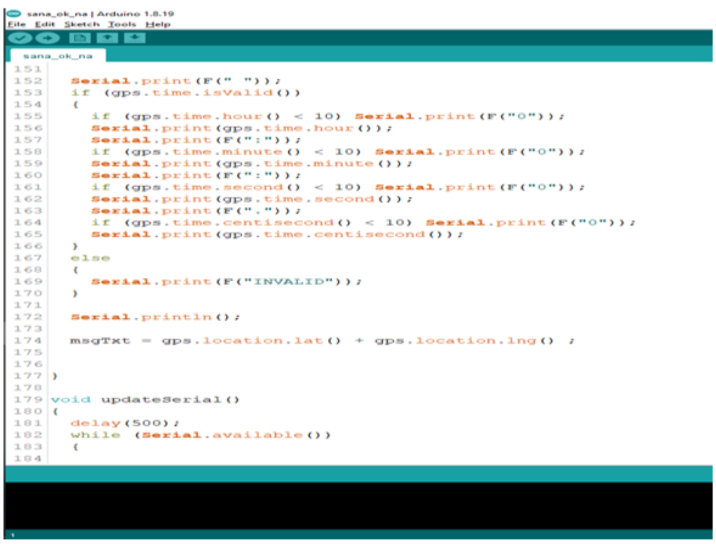

IX. CONCLUSION

The developed system, established as the foundation of this study, addresses the identified research gap. This Arduino-based Panic Alarm goes beyond the conventional alarm by focusing on enhancing its functionality. While the prototype retains its fundamental alarm features, such as generating sound and, at times, light, it introduces additional capabilities. Specifically, the device is designed to transmit the user's location and an SMS to a designated number. The Arduino-based Panic Alarm ensures accurate location transmission, depending on the pressing location, and users can access these locations through Google Maps. The researchers conducted on-foot testing of the prototype in diverse settings, including densely built areas and open spaces. Notably, being within a building at the time of activation may affect location accuracy, but the SMS function remains operational as long as a signal is present.

X. RECOMMENDATIONS

The results of the studies highlighted new features and enhanced aspects of the prototype during development. Consequently, the following recommendations are proposed for the implementation of the prototype:

- Consideration of an upgraded GPS module to enhance accuracy.
- Evaluation and potential enhancement of the SMS module for increased speed and reliability.
- Consideration of utilizing a Printed Circuit Board (PCB) instead of cables for a more organized arrangement of components.
- Exploration of superior battery options to achieve extended and more efficient battery life.
- A focus on designing the prototype to be inconspicuous, preventing individuals from recognizing it as a panic alarm.

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