Modern Applied Science; Vol. 16, No. 2; 2022
ISSN 1913-1844 E-ISSN 1913-1852
Published by Canadian Center of Science and Education

Development of A Smart Rescue Communication System for Drowning Personnel

Ifeoma B. Asianuba[1] & Kpegara N. Saana[1]

[1] University of Port Harcourt, Department of Electrical/Electronic Engineering, Choba Rivers State, Nigeria

Correspondence: Ifeoma B. Asianuba, Faculty of Engineering, Department of Electrical/ Electronic Engineering, University of Port- Harcourt, East/West Road, PMB 5323 Choba, Rivers State, Nigeria.

Received: March 11, 2022 Accepted: May 2, 2022 Online Published: May 5, 2022

doi:10.5539/mas.v16n2p41 URL: https://doi.org/10.5539/mas.v16n2p41

Abstract

Recently, there is an alarming increase in the number of deaths resulting from late rescue of drowning personnel falling overboard. Most mechanisms deployed are faced with the inability to detect the exact location of the drowning person especially when completely submerged in water. This paper therefore describes the development of a smart rescue communication system for drowning personnel. The developed system considered two major activities involved in drowning: the first scenario considers when the individual is completely submerged in water and the second; when the victim is struggling to survive. Thus, water and vibration sensors are useful input devices in actualizing the work. Arduino microcontroller was also used for the control system mechanism. For drowning and drowned situations which is detected and specified by the readings from the relevant sensors, an SMS (short message system) alert is communicated to the rescue personnel's phone indicating that there is an emergency. The exact location of the man overboard is also indicated in the SMS with the aid of the global positioning system (GPS) module. The SMS is sent at specified intervals to increase awareness of the current situation to aid fast rescue operation. The prototype is designed to be a wearable device.

Keywords: water and vibration sensors, GPS, Arduino micro controller, drowning personnel

1. Introduction

The need for smart emergency alert systems cannot be over emphasized in terms of personnel safety and security. One of the major safety concerns for offshore workers and sea travelers is preventing personnel from drowning in case of capsizing of the ship/boat. According to Case et al. (2018), it was recorded that between 2000 – 2016 unintentional falls overboard resulted in 204 fatalities, representing 27% work-related deaths in the industry. Ukoji & Ukoji (2015) recorded that within the period of 2006 to 2015, 180 boats capsized amounting to 1607 deaths. Identified human related and natural causes of such fatal boat accidents include overloading, carelessness, political instability, piracy, militancy, negligence and turbulent weather condition. From the aforementioned causes, late notification, inaccurate information about the incident and poor rescue time are factors that increase the high fatality rate.

Drowning has been one of the most devastating forms of death till date. International Lifesaving Federation (2007) showed that Drowning is associated with difficulty in breathing as a result of excess entry of liquid into mouth or nostrils. Nevertheless, there have been several efforts to cut down the number of deaths resulting from drowning. In most of these systems, a camera is deployed for monitoring the water body while in others a wearable device is worn to detect a drown situation and trigger an alarm to alert a lifeguard of the emergency situation. But in all of these the exact location of the victim is not usually communicated to the lifeguard through the alert system. This limitation introduces much delay in the rescue time, putting the victim in a more life-threatening situation. Thus, the need for a smart and more reliable drowning personnel alert system that can detect the location of the drowning person using GPS module in conjunction with other sensors and micro controller to notify a rescue team is presented.

The World Health Organization, WHO states that drowning is a public health challenge which claims more than 372,000 people a year worldwide. This scenario amounts to 90% death rate which is prevalent in low and middle income countries (World Health Organization, 2014).

Fatal drowning usually occurs when the individual is alone or the people in the same area with the drowning person are unaware of what is happening to the individual and are therefore unable to help out (Wikipedia, 2021). Rescued victims are most times faced with the challenges of associated health risks like respiratory distress, confusion, vomiting, aspiration and even unconsciousness. Drowning is associated with numerous risk factors such as epilepsy, inexperience and use of drugs (Handley, 2014). Drowning usually occurs in man-made and artificial water surfaces (Meck Manuals, 2017; Mott & Latimer, 2016).

Spending substantial time with respiratory parts of the human body in water results in reduced amount of oxygen and large amount of carbon dioxide in the blood. The latter triggers increased breath issues which gives rise to physical anomalies (North, 2002).

1.1 Review of Related Work

Video based drowning monitoring systems was proposed in How-Lung et al. (2008) but the technology is very prone to visual and sensor disturbances especially when the pool or water-body is crowded. In B. Dhande et al. (2018), a comprehensive survey on different drowning and rescue system was considered ranging from the concept of image processing, pressure and motion sensing, heartbeat sensing etc. The issue of drowning can also be handled with internet of things application (Mohammed et al., 2018), by sending signals received from a pulse sensor to rescue hub. Samuel et al proposed a wrist wearable device which measures the heartbeat and blood pressure of victims and alerts a rescue team. Stauffer and Grimson 2000 adopted learning patterns of activity for real time tracking systems. John et al. (2019) also proposed a rescue alert system to prevent drowning in victims. Sentag (2021) proposed a safety solution for swimming pools to monitor the depth of individual in water, motion of the individual and time spent. The wearable device is given to the individual prior to using the pool.

1.2 Statement of the Problem

Most deaths recorded from drowning of personnel overboard and boat accident is as a result of the inability to timely locate the victim due to poor communication process. With the knowledge that drowning is a situation that takes life very quickly, it is expected that a swift response from the rescue team is required to save lives. In this work, a smart system is developed to monitor near drowning situation that occurs before drowning actually take place. The hardware developed will help reduce deaths by developing a system which can communicate the exact location of the drowning personnel within a short time interval. The smart system is also designed to reduce false alarm since some of the existing rescue systems are faced with the challenges of false alarm. This is because unnecessary panic resulting from false alarm in some emergency alert systems have also posed much danger than the actual drowning process.

2. Methodology

The methodology adopted in the design is made up of the software and hard ware aspects. The hardware component is made up of water and vibration sensing module, Arduino microcontroller, GPS module, DC battery.

2.1 Hardware Design

The Water sensing module's Digital Output pins (DO) is connected to the Microcontroller's Digital pin 7 (D7). The VCC and GND pins of the microcontroller are connected to the 5V and GND pins respectively. The module's Digital Output pin for the vibration sensor is connected to the Microcontroller's Digital pin 9 (D9). The power supply of the microcontroller board was attached to the power and ground pins of the GPS module which is further interfaced with the Transmitter (Tx) and Receiver (Rx) terminals of the GPS to the microcontroller digital pins 4 and 5 respectively. The SIM800 also takes this interfacing pattern with GSM Transmitter to Arduino digital pin 2 and GSM Receiver to Arduino digital pin 3.

A 5v DC battery connected to the power input of the Arduino Mini will adequately run the designed system effectively. The circuit Diagram for the entire hardware is shown in the Figure 1 below.

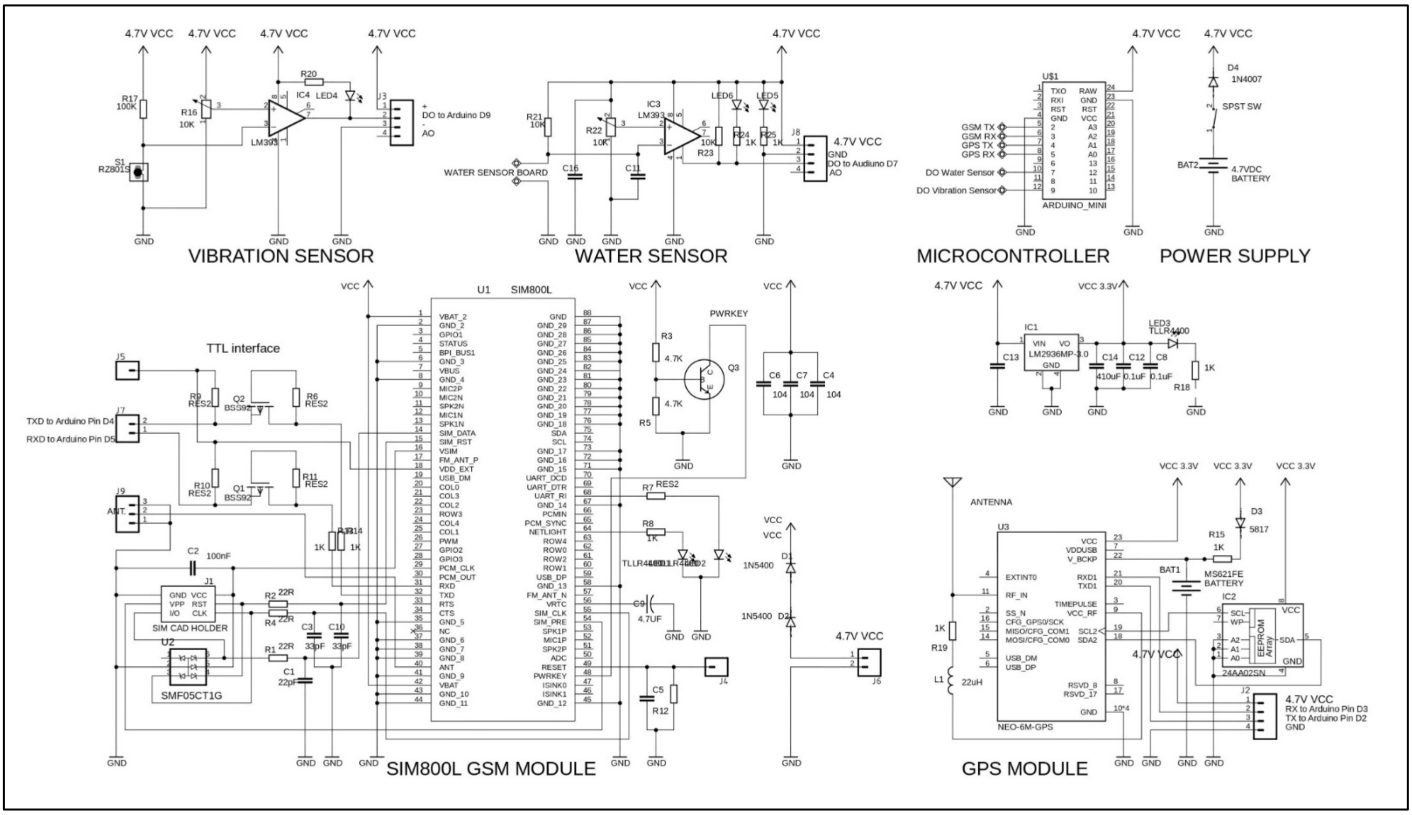

Figure1. Circuit Diagram of the Smart Rescue communication System for Drowning Personnel

2.2 System Software

The Arduino Board is interfaced with the ATMEGA328P microcontroller. The latter can therefore be programmed with a computer using the Arduino IDE compiler.

2.2.1 Arduino IDE

The Arduino Software (IDE) consist of, but not limited an information field for messages, text console, text editor for code writing, a toolbar for basic functions, and a set of menus. It interfaces with the Arduino Microcontroller hardware and uploads programs to it.

Sketches are the names given to programs created with the Arduino Software (IDE) stored as files with the extension ‘. ino’. Cutting/pasting, as well as searching/replacing text, are all possible in the editor. The message region shows errors and provides input when saving and exporting. The Arduino Program (IDE) outputs text to console which contains full error messages and other information. The designed board and serial port are shown in the window's bottom right corner. Verify and import programs, make, view, and save drawings, as well as opening the serial monitor are all possible with the toolbar buttons.

When a sketch is submitted, the Arduino boot loader is used, which is a simple program loaded on the board's microcontroller. It enables the upload of code without the need for any extra hardware. On resetting the board, the boot loader within a few seconds is made active before starting whatever action that must have been sent to the microcontroller. When the boot loader finishes, i.e., after the board had reset, the LED of pin 13 will blink. The IDE's interface is seen in Figure 2.

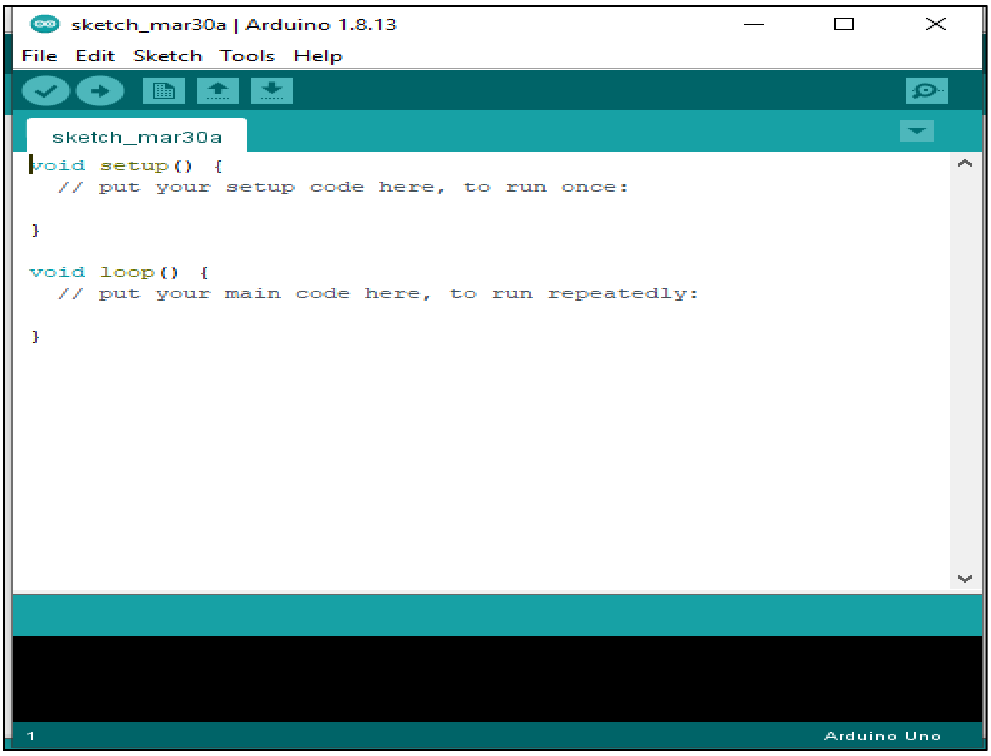

Figure 2. Arduino IDE environment

The Arduino IDE is a platform where the codes that serve as the intelligence of the system are written, compiled and sent to the Arduino board. The overall algorithmic progression of the intelligence is however discussed as follows:

2.2.2 Algorithm of the System

The following steps are used to describe the algorithmic process of the system design.

1) Start
2) Initialize system and set all microcontroller pins to the right pin Mode.
3) Check SIM800 Connection and set to Text Mode.
4) Receive User number and set it for communication.
5) Set pins to receive Water and Vibration Sensor readings.
6) Check Water Sensor modules for data set transfer.
7) If data set from Water module signifies high presence of water, then go to 8; else, return to 5.
8) Check Vibration sensor module for data set transfer.
9) If data from Vibration Sensor signifies high amount of movement, then got to 10; else return to 5.
10) Initiate GPS module for localization operation
11) Extract location of user from GPS module
12) Initiate SIM800 to send an emergency SMS alert and GPS location to designated rescue contacts
13) Initiate system rest/standby for a designated period of time.
14) Check Water Sensor modules and Vibration Modules again for data set transfer.
15) If data set from Water module signifies NO presence of water, then go to 16; else, return to 13.
16) If data from Vibration Sensor signifies NO movement, then go to 17; else return to 13.
17) Initiate SIM800 to send a clear alarm SMS alert.

The Flowchart for the above Algorithm is shown in the Figure 3 below.

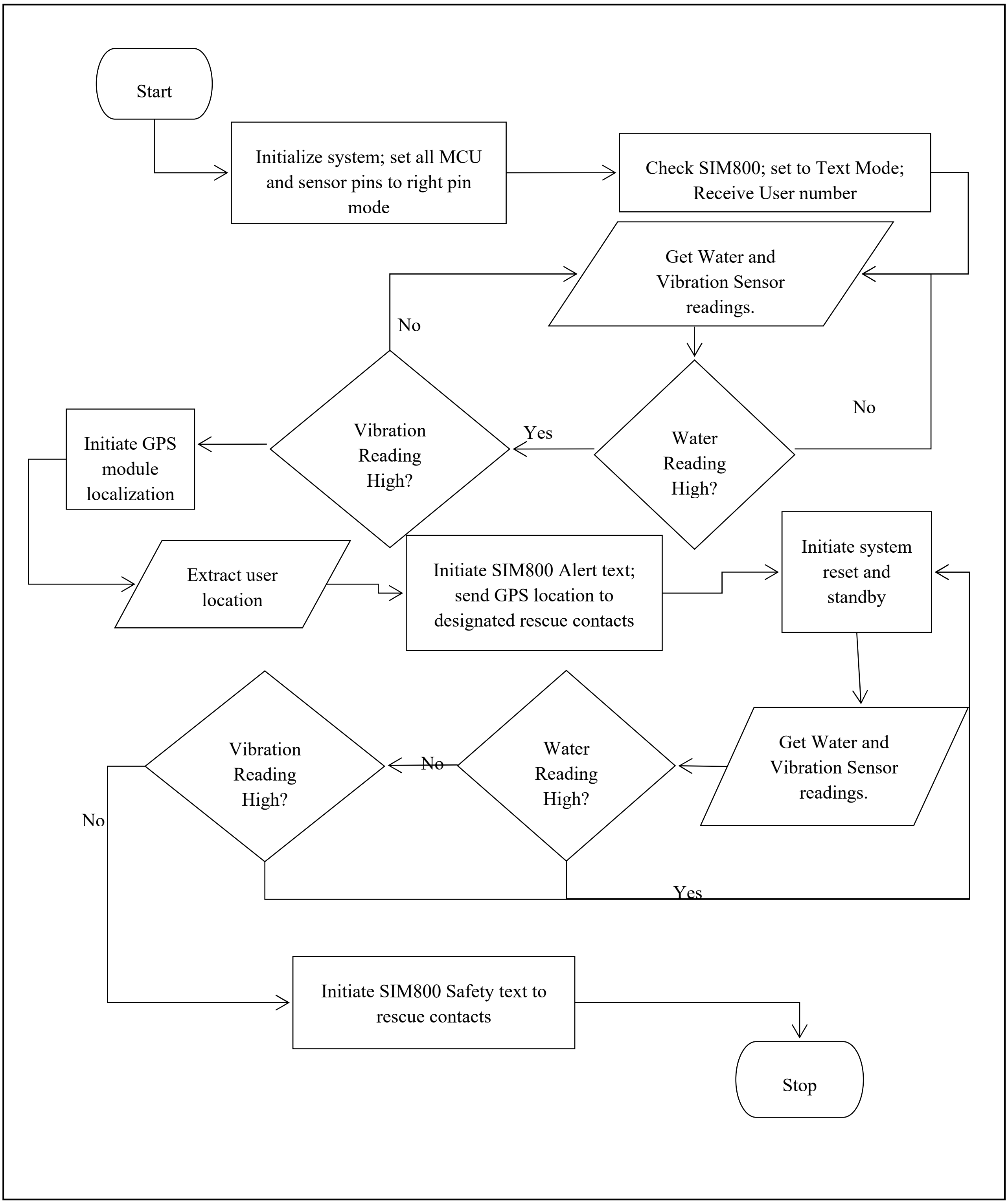

Figure 3. Flowchart of Designed System

3. Result

Series of tests were carried out to determine the efficiency of the designed system. Modifications were made according to discovered errors and limitations that were experienced during the test. These modifications are however very small and do not affect the proposed system design. These changes are usually concerned with the manner of execution of certain functions which could be changed without causing major design drifts. The tests carried are as follows:

Table 1. Table showing Test results of Water sensor

Water Level	Conductivity Range	Resistance Level (ohms)	Microcontroller Output
Dry (no water)	0 – 300	1000 – 10000	LOW
Humid (partially immersed in water)	300 – 700	100 – 1000	LOW
Wet (fully immersed in water)	700 – 950	1 – 100	HIGH

Table 1. Table Showing Vibration Sensor Test results

Scenario	Threshold	Triggered Result
Measured movement	< 50mV/g	LOW
Continuous and energetic movement	>50mV/g	HIGH

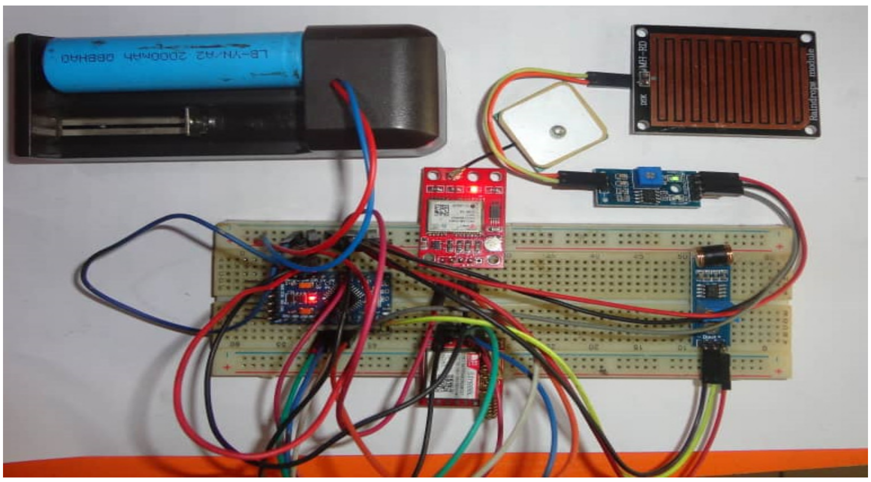

Figure 4. Setup for testing the GPS and SMS Module

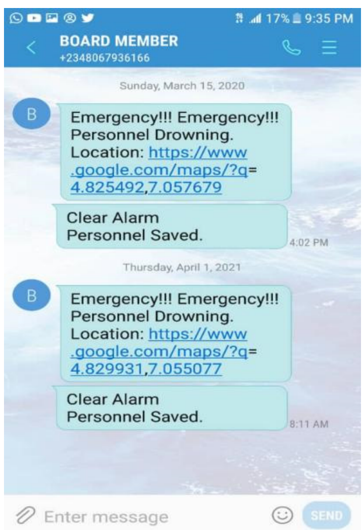

Figure 5. Result of successful GPS and SMS Module test

The Proposed system was designed to combine two of the most prevalent components in a drowning situation: One is total immersion in water and the other is continuous energetic movement of the victim. The Arduino mini microcontroller is chosen for its acceptable processing speed and negligible size and weight. When both sensors give corresponding data readings to the microcontroller which signify a drowning situation, the microcontroller is required to respond to the situation. The appropriate response is to initiate the SMS alert system which is driven by the SIM800 module. The SIM800 is programmed to send an SMS alert to designated rescue contacts warning them about the system user's imminent demise. This work also takes a further step to ensure the rescue of the system's user by incorporating a GPS module which will aid the rescue team in finding the user. This is possible through the capability of the GPS module to triangulate the location of the user based on a Global Position evaluation within permissible error levels. The proposed system was successfully designed and implementation proved successful with results to validate claim.

Most research works on emergency alert systems for a drowning person focuses on creating awareness of the emergency situation with little or no attention to the exact location of the person. In this research work, a smart rescue system has been developed with effective communication through low powered electronic circuit to indicate exact map location in the rescue alert system.

4. Conclusion

The design and development of a smart rescue communication system for detection of drowning personnel was achieved in this paper. The work is aimed at developing a means to ensure the safety of users within the proximity of large water bodies since the safety of personnel off the shores is vital and of critical concern. The Drowning Detection System is based on the combined information provided by the water sensor, vibration sensor and other relevant components that were deployed to achieve this device. It is recommended that other communication module operating in dedicated channel can be implemented for further use.

References

Bhavesh, D., Yash, K., Abhishek, K., & Anjali, A. (2018). Comprehensive survey of Drowning detection and rescue techniques. *International Research Journal of Engineering and technology, 5*(3).

Case, S. L., Lincoln, J. M., & Lucas, D. L. (2018). Fatal Falls Overboard in Commercial Fishing — United States, 2000-2016. *Morbidity and Mortality Weekly Report, 67*(16), 465-469. https://doi.org/10.15585/mmwr.mm6716a2

Handley, A. J. (2014). Drowning. *BMJ (Clinical Research Ed.)*, 348. https://doi.org/10.1136/bmj.g1734

How-Lung, E., Toh, K., Yau, W., & Wang, J. (2008). DE WS: A Live Visual Surveillance System for Early Drowning Detection at Pool. *IEEE Transactions on Circuits and Systems for Video Technology, 18*(2), 196-210. https://doi.org/10.1109/TCSVT.2007.913960

International Life Saving Federation. (2007). International Life Saving Federation World Drowning Report 2007. *International Journal of Aquatic Research and Education, 1*(4). https://doi.org/10.25035/ijare.01.04.08

John, S. N., Godswill, J. U., Osemwegie, O., Onyiagha, G., Etinosa, N. O., & Okpujie, K. (2019). Design of a drowning rescue alert system. *International Journal of Mechanical Engineering and Technology (IJMET), 10*(1), 1987-1995. Retrieved from https://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=10&IType=01

Merck. (2018). *Drowning-Injuries; Poisoning, Merck Manuals Professional Edition.*

Mott, T. F., & Latimer, K. M. (2016). Prevention and Treatment of Drowning. *American Family Physician, 93*(7), 576-582.

Muhammed, M. R., Mohammed A., Eberechukwu, P., Kamaludo, M. Y., Ghazli, N. E., & Samura, A. (2018). An early drowning detection system for internet of things (IoT) applications. *TELKONIKA (Telecommunication Computing Electronics and Control), 16*(4), 1870-1876. https://doi.org/10.12928/telkomnika.v16i4.9046

North, R. (2002). The pathophysiology of drowning. *South Pacific Underwater Medicine Society Journal.*

Samuel, N. J., UkpabioImelda, G., Omoruyi, O., Godfrey, O., Etinosa, N., & Kennedy, O. (2019). *International Journal of Mechanical Engineering and Technology, 10*(1), 1987-1995.

SenTag. (2018). Drowning Detection System. *Sentag Pool Safety Drowning Detection*. Retrieved from https://www.sentag.com

Stauffer, C., & Grimson, W. E. (2000). Learning patterns of activity using real time tracking. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 22*(8), 747-757. https://doi.org/10.1109/34.868677

Ukoji, V. N., & Ukoji, V. U. (2015). Boat Accidents in Nigeria: General Trends and Risk Factors (June 2006-May 2015). *ADR Journals 2015*. Retrieved from https://www.nigeriawatch.org/media/html/Ukoji2015.pdf

Wikipedia. (2021). *Man Overboard*. Retrieved from https://en.wikipedia.org/wiki/Man_overboard

World Health Organization. (2014). *Global report on drowning: preventing a leading killer Australian Policy*. Retrieved from https://apo.org.au/node/423502014