DESIGN AND DEVELOPMENT OF SMART SWIM TUBE FOR AUTOMATIC DROWNING DETECTION

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Introduction

1. Drowning is a serious public safety issue and one of the leading causes of accidental death in places like swimming pools, lakes, rivers, and coastal areas. Many drowning incidents happen because of sudden health problems, exhaustion, panic, or a lack of timely help. In most cases, the victim cannot call for assistance, and rescue teams might struggle to find them quickly. This creates a need for a smart safety system that can automatically spot drowning situations and provide immediate rescue support.
2. The project, “Smart Swim Tube for Automatic Drowning Detection,” is a wearable safety device designed to track a swimmer’s vital signs, including oxygen saturation (SpO_2), heart rate, and body movement using sensors. The system relies on an ESP32 microcontroller to constantly process sensor data and identify abnormal conditions that may signal a drowning scenario. When it spots a dangerous condition, the system first gives a warning through vibrations and sound. If the swimmer does not respond, the system automatically inflates the swim tube using a servo-controlled CO_2 mechanism.
3. The system also has a GPS tracking module and a wireless monitoring setup based on Internet of Things (IoT) technology. The swimmer’s health data, system status, battery level, and GPS location are shown on a web-based dashboard accessible through a mobile phone or laptop. This helps rescuers keep track of the swimmer in real time and quickly pinpoint their location during an emergency.
4. The main goal of this project is to create a low-cost, portable, and dependable drowning detection and rescue system that can enhance water safety and lessen the chances of drowning incidents. This system can be used in swimming pools, water sports, and rescue operations to improve swimmer safety.

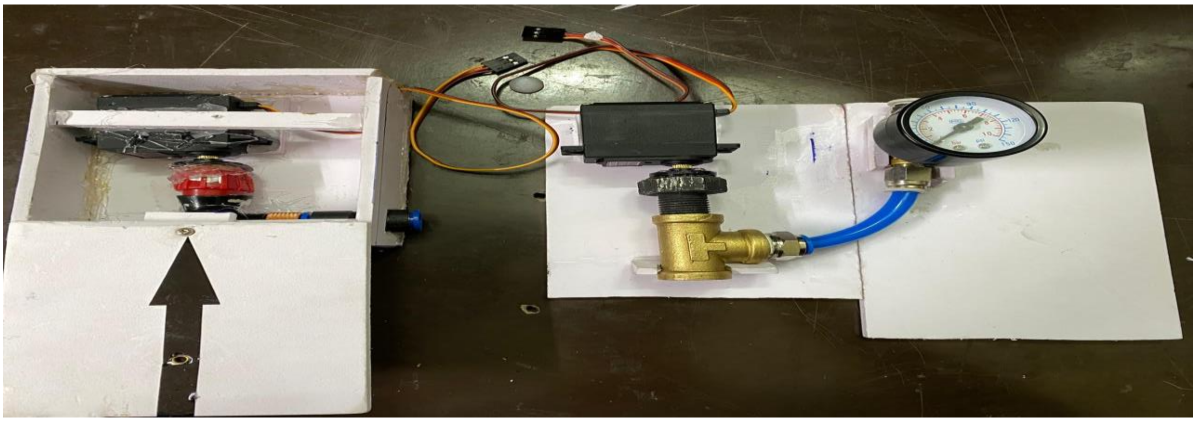

Figure 1: Tube inflation mechanism setup

Figure *2:* Picture of inflation tube present in the Jacket

Objectives:

1. The main goal of this project is to design and develop a Smart Swim Tube system that can automatically detect drowning conditions and provide immediate rescue support. This system aims to improve swimmer safety by continuously monitoring health signals and offering automatic flotation support during emergencies.
2. The first goal of the project is to detect drowning conditions by tracking the swimmer's vital signs, such as oxygen saturation (SpO_2), heart rate, and body movement using sensors. The system collects sensor data continuously and processes it with the ESP32 microcontroller to spot abnormal situations. Low oxygen levels, irregular heart rates, or lack of movement may suggest a drowning incident.
3. The second goal is to create an automatic inflation mechanism that can inflate the swim tube in emergencies. When the system identifies a dangerous condition, it first issues a warning through a vibration motor and buzzer. If the swimmer does not respond, the system activates a servo motor that triggers the CO_2 cartridge to inflate the swim tube and keep the swimmer afloat.

4. The third goal is to establish a wireless monitoring system using Internet of Things (IoT) technology. The ESP32 microcontroller runs a web server that shows key information, such as SpO_2 level, heart rate, battery level, system status, and GPS location. This web dashboard is accessible via a mobile phone or laptop, allowing real-time monitoring and helping rescuers locate the swimmer quickly during an emergency.
5. The final goal of this project is to create a low-cost, portable, and reliable drowning detection and rescue system that can be used in swimming pools, lakes, rivers, and water sports activities to improve safety and reduce drowning-related accidents.

Methodology

1. The Smart Swim Tube system utilizes a methodology of continuously monitoring swimmers using sensors, processing their data, generating alerts, and automatically rescuing them from dangerous situations. This is accomplished through the use of multiple sensors, microcontroller(s), and wireless communications to detect the conditions under which someone is drowning and provide the necessary support for immediate rescue.
2. During the first phase of operation, various environmental sensors are used to collect data and send it to the main processing unit, or ESP32. These sensors include: MAX30102 (measures oxygen saturation (SpO_2) and heart rate); MPU6050 (detects body movement and tilt); and GPS Module (used to track the location of the swimmer). Data will be collected from each of the sensors regularly and sent to the ESP32 for processing.
3. In the second phase of operation, the data sent from the sensors will be processed and compared against predetermined or threshold values. For example, if the SpO_2 value falls below a safe threshold, the heart rate becomes abnormal, or there is no detected motion for a specified duration, then this condition would be identified as a potential drowning event. The system would change its operational status from safe to warning.
4. The third phase of operation is triggered when an identified warning condition is detected.

Result and Conclusion

To quickly identify drowning incidents and provide automated rescue support, a system known as the Smart Swim Tube was developed and created. The system underwent extensive testing through a variety of different environments to determine how well the system's sensor technologies, inflation capability, visual alert, GPS location capabilities, and IoT dashboard worked together.

The SpO_2 and heart rate functionality was provided by the MAX30102 sensor. The MPU6050 sensor measured both movement and tilt of the user's body. All the sensory data collected was processed through the microcontroller called the ESP32. The ESP32 microcontroller regularly compared the incoming sensor data to predetermined threshold values in order to identify whether or not a dangerous condition existed. If a dangerous condition existed, such as an SpO_2 reading below a certain level, and/or no movement detected, the system would provide an initial warning through vibrating the vibration motor. If the user did not respond, the system would activate the servo motor and inflate the Smart Swim Tube. The emergency alert feature was also successfully tested, through auditory notification with a buzzer.

The GPS provided accurate latitude and longitude coordinates, and the web server hosted on the ESP32 provided health statistics, battery status, and system status and location on a web dashboard viewable via WiFi from a smartphone or laptop. The battery level provided confirmation to the user as to whether or not the system was operable. Overall, the testing of the Smart Swim Tube demonstrated that all aspects of the system were working as anticipated.

References

1. [1] A. Alghamdi, M. Qureshi, and S. Khan, "Drowning Detection Wearable Using AI and Sensors," *IEEE Sensors Journal*, vol. 22, no. 11, pp. 14560–14568, 2022, doi: 10.1109/JSEN.2022.3147895.
2. [2] M. Razzak, H. Ahmed, and R. Patel, "Smart Life Jacket with Pressure and Motion Detection," *International Journal of Scientific Research (IJSR)*, vol. 10, no. 5, pp. 1024–1028, 2021
3. [3] L. Chen, X. Zhao, and Y. Wang, "Depth and Temperature-Based Inflatable Safety Vest," *Sensors and Actuators A: Physical*, vol. 351, p. 114056, 2023, doi: 10.1016/j.sna.2023.114056.
4. [4] Kingii Technologies, "Kingii Wearable Inflatable Device," Kingii Official Product Documentation, 2022. [Online]. Available: https://www.kingii.com
5. [5] Edge Impulse, "Embedded ML for Sensor Applications," Edge Impulse Documentation, 2024. [Online]. Available: https://edgeimpulse.com
6. [6] Blynk IoT Platform, "BLE-Based IoT Communication for Embedded Systems," Blynk Developer Resources, 2024. [Online]. Available: https://blynk.io
7. [7] P. Zhang, J. Lin, and C. Wei, "IoT-Based Real-Time Drowning Detection and Alert System," IEEE Internet of Things Journal, vol. 10, no. 4, pp. 3501–3512, 2023, doi: 10.1109/JIOT.2023.1002568.
8. [8] S. Banerjee, K. Das, and R. Ghosh, "Design of a Wearable Safety Device with Health and Location Tracking," 2022 IEEE International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2022, pp. 912–917, doi: 10.1109/ICOSEC56436.2022.9954741.
9. [9] M. Ali, N. Yousaf, and R. Ullah, "Development of Smart Wearable Devices for Emergency Detection Using Machine Learning," Journal of Ambient Intelligence and Humanized Computing, vol. 15, no. 2, pp. 2417–2430, Feb. 2024, doi: 10.1007/s12652-023-04762-z.