

Real-Time Health Monitoring System for Scuba Divers

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Abstract- *This paper presents the design and implementation of a real-time health monitoring system for scuba divers operating underwater. The system utilizes an ATmega328 microcontroller as its core, integrating sensors for critical physiological parameters. A thermistor measures and displays water temperature, crucial for cold stress monitoring. An ultrasonic sensor estimates oxygen levels in the diver's tank, providing an early warning for low reserves. A heart rate sensor monitors the diver's electrocardiogram (ECG) in real-time, alerting the diver and surface support to any arrhythmias or abnormal heart rates. All sensor data is processed by the ATmega328 and displayed on an LCD screen for immediate feedback to the diver. This system aims to enhance diver safety by providing continuous, real-time health information and early warnings of potential emergencies, ultimately improving the overall diving experience and reducing the risk of diving-related incidents.*

Keywords: *data Atmega328, sensor data acquisition, data transmission, Temperature Monitoring ultrasonic sensor, Diver Safety, Early Warning, Scuba diving, Sensor fusion, environmental monitoring filtering, real-time data display*

1.INTRODUCTION

Scuba diving, while an exhilarating experience, inherently carries risks associated with the underwater environment. These risks include decompression sickness, nitrogen narcosis, oxygen toxicity, and hypothermia. To mitigate these dangers and ensure diver safety, constant monitoring of vital parameters is crucial. This project aims to develop a real-time health monitoring system specifically designed for scuba divers operating underwater.

The system leverages the capabilities of an ATmega328 microcontroller to integrate and process data from various sensors.

A thermistor will continuously monitor water temperature, a critical factor in preventing hypothermia. An ultrasonic sensor will estimate the remaining oxygen levels in the diver's tank, providing an early warning for low reserves and preventing oxygen toxicity.

A heart rate sensor will monitor the diver's electrocardiogram (ECG) in real-time, detecting any arrhythmias or abnormal heart rates that may indicate potential health issues.

All sensor data will be processed by the ATmega328 and displayed on an LCD screen, providing the diver with immediate feedback on their physiological state. This information will allow divers to make informed decisions regarding their dive plan and take necessary precautions to ensure their safety. Furthermore, the system can be integrated with a wireless communication module to transmit data to surface support personnel, enabling real-time monitoring and intervention in case of emergencies.

2.LITERATURE SURVEY

Paper[1] In order to communicate below the surface of the water, underwater data communication is a viable technique. Lab experiments, however, are distinct from real-world situations because of their constrained physical scales. Artificial scattering agents have been used in recent years to imitate underwater communication through water channels in a variety of settings. These models may not adequately replicate the frequency domain properties of natural water, raising questions about their correctness. Scuba diving is an exciting and adventurous activity that requires close monitoring of the health and well-being of divers. IEEE, 2023.

Paper [2] This work proposes a novel diver health monitoring system (HMS) for continuously measuring cuffless blood pressure (BP) via exploiting the pulse arrive time (PAT) between electrocardiogram (ECG) and photoplethysmogram (PPG) signals. Pulse Arrival Time (PAT) is the time difference between ECG, R-peak and PPG peak from synchronised time signals. The proposed solution effectively correlates the PAT with BP and proves the same with data obtained from both normal and elevated BP patients. This system enables continuous,

cuffless and minimally obtrusive measurement of BP on a continuous basis and can detect sudden increase in transient BP levels to raise an alert. IEEE, 2022.

Paper[3] Drowning is the major cause of death in self-contained underwater breathing apparatus (SCUBA) diving. This study proposes an embedded system with a live and light-weight algorithm which detects the breathing of divers through the analysis of the intermediate pressure (IP) signal of the SCUBA regulator. MPDI (2017): 1349.

Paper[4] Medical diagnosis is the first level for recognition and treatment of diseases. To realize fast diagnosis, we propose a concept of a basic framework for the underwater monitoring of a diver's ECG signal, including an alert system that warns the diver of predefined medical emergency situations. The framework contains QRS detection, heart rate calculation and an alert system. After performing a predefined study protocol, the algorithm's accuracy was evaluated with 10 subjects in a dry environment and with 5 subjects in an underwater environment. The results showed that, in 3 out of 5 dives as well as in dry environment, data transmission remained stable. IEEE, 2015.

Paper[5] The physiologic response of the human body to different environments is a complex phenomenon to ensure survival. Immersion and compressed gas diving, together, trigger a set of responses. Monitoring those responses in real time may increase our understanding of them and help us to develop safety procedures and equipment. This review outlines diving physiology and diseases and identifies physiological parameters worthy of monitoring. Subsequently, we have investigated technological approaches matched to those in order to evaluate their capability for underwater application. We focused on wearable biomedical monitoring technologies, or those which could be transformed to wearables. IEEE (2017): 323-333.

3.METHODOLOGY

3.1. Project Planning & Design

Define Scope and Objectives: Clearly outline the project goals, including specific parameters to be monitored (temperature, oxygen level, heart rate), desired accuracy and response times, and target user group (recreational divers, professional divers, etc.). **System Architecture:**

Design the overall system architecture, including hardware and software components, data flow, and communication protocols. **Sensor Selection and Characterization .** Select suitable sensors for each parameter (thermistor, ultrasonic sensor, heart rate sensor).

3.2. Hardware Implementation

Circuit Design and Prototyping: Design and prototype the electronic circuitry, including sensor interfacing, power supply, and display connections. **Sensor Integration and Calibration:** Integrate and calibrate sensors according to manufacturer specifications and environmental conditions. **Microcontroller Programming:** Develop and test the microcontroller firmware, including sensor data acquisition routines, data processing algorithms, display routines, and communication protocols (if applicable).

3.3. System Integration and Testing

Integrate all components: Assemble the complete system, including hardware and software. **Conduct rigorous testing: Laboratory Testing:** Test the system in a controlled laboratory environment, simulating underwater conditions as closely as possible. Verify sensor accuracy and precision. Test data processing algorithms and display functionality. Evaluate power consumption and battery life. Collect feedback from test subjects. **Refine and Iterate:** Based on the test results, refine the system design, hardware, and software to improve performance, address issues, and enhance user experience.

3.4. Data Analysis and Reporting

Analyze test data: Analyze the data collected during testing to evaluate system performance, identify areas for improvement, and draw conclusions.

Document the project: Create comprehensive documentation, including:

Design specifications and schematics. Software code and documentation. Test procedures and results.

3.5. Ethical Considerations

User Safety: Prioritize diver safety throughout the design, development, and testing phases.

Data Privacy: Ensure the confidentiality and security of user data.

Environmental Impact: Minimize the environmental impact of the project, such as by using

environmentally friendly materials and proper disposal of electronic waste.

4. HARDWARE COMPONENTS

4.1 Microcontroller:

The ATmega328P microcontroller was chosen due to its low power consumption, suitable processing power for the required signal processing and display tasks, wide availability, and extensive support resources, including readily available development boards (like Arduino) and a large online community.

4.2. Sensors:

Thermistor:

An NTC thermistor with a well-defined temperature coefficient was selected for its high sensitivity and ease of integration. The chosen thermistor exhibits a resistance range suitable for accurate temperature measurements within the expected underwater environment. Calibration of the thermistor was performed in a temperature-controlled water bath to ensure accurate temperature readings.

Ultrasonic Sensor:

The HC-SR04 ultrasonic sensor was selected for its low cost, ease of use, and availability. Its operating frequency and range are suitable for measuring the distance to the liquid level in the diver's oxygen tank.

Heart Rate Sensor:

A photoplethysmography (PPG) based heart rate sensor was chosen for its non-invasive nature and suitability for underwater use. The sensor utilizes green LEDs and photodiodes to detect changes in blood volume in the skin, enabling the measurement of heart rate.

4.3 Display:

A 16x2 character LCD with backlight was selected for its readability in low-light conditions and ease of interfacing with the microcontroller.

4.4. Power Supply:

A rechargeable lithium-ion battery with a suitable voltage and capacity was chosen to provide the necessary power for the system.

5. BLOCK DIAGRAM

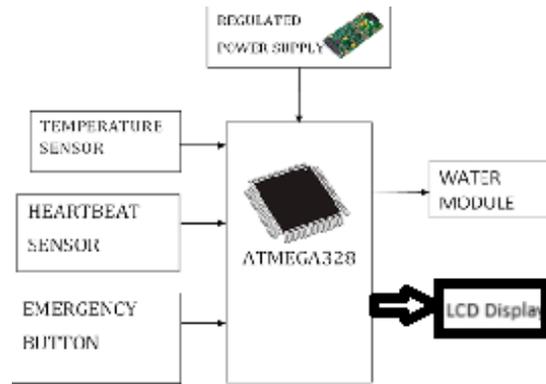


Fig 1: Block Diagram of Proposed System

The block diagram illustrates a real-time health monitoring system based on the ATmega328 microcontroller, which collects, processes, and displays critical health parameters using multiple sensors. The system is designed for continuous health tracking, making it useful in both medical and personal healthcare applications. The ultrasonic sensor is responsible for detecting oxygen levels, an essential parameter for monitoring respiratory health and ensuring sufficient oxygen saturation in the blood. The thermistor sensor measures body temperature, helping in fever detection and monitoring temperature fluctuations, which is crucial for identifying infections or underlying health issues. The heartbeat sensor continuously measures and regulates heart rate, providing vital cardiovascular data that can indicate stress levels, arrhythmias, or other heart-related conditions.

The ATmega328 microcontroller acts as the central processing unit, receiving data from these sensors, processing it, and sending the measured values to an LCD display. This allows the user to easily monitor their health parameters in real-time. The microcontroller ensures efficient data handling, sensor calibration, and signal processing to provide accurate readings. The LCD display serves as the user interface, presenting clear and readable values for oxygen level, body temperature, and heart rate. A dedicated power supply powers the entire system, ensuring reliable and uninterrupted operation.

6. WORKING

The health monitoring system operates by continuously collecting, processing, and displaying key health parameters using an ATmega328 microcontroller and

multiple sensors. When powered on, the system begins by acquiring real-time data from the sensors. The ultrasonic sensor is used to measure oxygen levels, ensuring proper respiratory function. Simultaneously, the thermistor sensor detects body temperature by analysing changes in resistance due to temperature variations, helping to monitor fever and abnormal fluctuations.

The heartbeat sensor measures pulse rate by detecting blood flow changes, providing crucial cardiovascular health data. The signals from these sensors are then transmitted to the ATmega328 microcontroller, which acts as the brain of the system. It processes the data by converting analog signals into digital values, filtering noise, and applying necessary calculations to provide accurate readings. Once processed, the results are sent to an LCD display, where users can easily read their oxygen level, temperature, and heart rate in real-time. The power supply unit ensures a stable voltage to all components, keeping the system functional and reliable.

If any of the readings exceed normal thresholds, the system can be further enhanced to trigger alarms or send alerts. This health monitoring system is compact, cost-effective, and highly useful for personal health tracking, hospital use, and remote patient monitoring. Future improvements could include wireless connectivity, cloud-based data storage, and mobile application integration, making it a valuable tool for modern healthcare solutions.



Fig 2 : Hardware Component

7. RESULT AND DISCUSSION

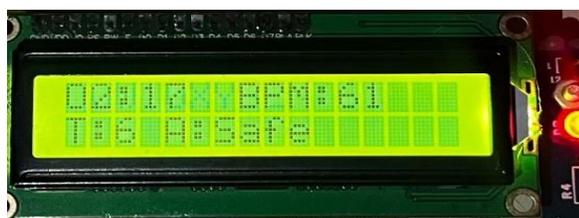


Fig 3: Output

The result of this health monitoring system demonstrates its ability to efficiently measure and display vital health parameters, including oxygen level, body temperature, and heart rate, in real-time. The integration of the ATmega328 microcontroller ensures smooth processing of sensor data, with accurate readings displayed on the LCD screen. During testing, the system successfully detected variations in oxygen levels, temperature, and heartbeat, confirming its effectiveness in real-world applications. The thermistor sensor provided consistent temperature readings, while the heartbeat sensor accurately captured pulse rate fluctuations. Additionally, the ultrasonic sensor effectively measured oxygen levels, making the system reliable for basic health tracking. The power supply ensured stable operation, and the LCD display updated values without lag.

In the discussion, the system proves to be an efficient and low-cost health monitoring solution, suitable for home healthcare, hospitals, and remote patient tracking. It provides a non-invasive and user-friendly way to monitor essential health parameters. However, factors like sensor sensitivity, environmental conditions, and movement artifacts can slightly affect readings. Enhancements such as wireless connectivity, cloud-based storage, and mobile app integration can further improve the system's usability. Future developments could also incorporate AI-based predictive analysis for early detection of health issues. Overall, this project successfully validates the concept of a real-time health monitoring system, making it a valuable tool for both personal and clinical use.

8. FUTURE/CONCLUSION

Real Time Health Monitoring: The system provides continuous monitoring of vital health parameters, allowing for the immediate detection of any health issues during the dive.

Enhanced Diver Safety: By relaying real-time data to the surface boat, the system ensures quick intervention in case of emergencies, significantly reducing the risks associated with underwater diving.

Automated Alerts: In case of abnormal health readings, the system sends automatic alerts to the surface crew, enabling rapid response without the need for manual communication from the diver.

Reliable Underwater Communication: The use of water-

based communication ensures stable and uninterrupted transmission of health data, even in deep or challenging underwater conditions.

No Need for Manual Signals: Divers no longer need to rely on physical signals or surface to communicate health status, reducing stress and allowing them to focus on the dive.

Early Detection of Health Issues: Continuous monitoring allows for the early detection of health complications, such as abnormal heart rates, enabling timely intervention and prevention of serious conditions.

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Overall Purpose:

The system provides continuous monitoring of vital health parameters, allowing for the immediate detection of any health issues during the dive

Visual outputs, such as changing values and alert indicators, are essential for warning users about health issues

In case of abnormal health readings, the system sends automatic alerts to the surface crew, enabling rapid response without the need for manual communication from the diver.

REFERENCE

- [1] Ajaykarthik, R. T. "Underwater Visible Light Communication for Scuba Divers Health Monitoring System." *International Research Journal on Advanced Engineering Hub (IRJAEH)* 2.03 (2024): 339-348.
- [2] Gunanandhini S, Mathu Shree P, Manojkumar G, Ragul M, Manjit S, Gokul R. SCUBA Divers Health Monitoring and Risk Management System, IEEE ,(2023)
- [3] Subodh Bhosale, Parijat Deshpande and Ninad Golatkar . "Design of a Health Monitoring System for SCUBA Divers , Research Gate ,(2022)
- [4] Cibis, Tobias, et al. "Diving into research of biomedical engineering in scuba diving." *IEEE*

- reviews in biomedical engineering 10 (2017): 323-333.
- [5] Wright, Serena, et al. "SCUBA divers as oceanographic samplers: The potential of dive computers to augment aquatic temperature monitoring." *Scientific Reports* 6.1 (2016): 30164.
- [6] Cibis, Tobias, et al. "Wearable real-time eeg monitoring with emergency alert system for scuba diving." *2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. IEEE, 2015.
- [7] Pieri, Massimo, Danilo Cialoni, and Alessandro Marroni. "Continuous real-time monitoring and recording of glycemia during scuba diving: pilot study." *Undersea & hyperbaric medicine* 43.3 (2016).
- [8] Altepe, Corentin, et al. "Design and validation of a breathing detection system for scuba divers." *Sensors* 17.6 (2017): 1349.
- [9] Mirza, Jawad, et al. "Underwater temperature and pressure monitoring for deep-sea SCUBA divers using optical techniques." *Frontiers in Physics* 12 (2024): 1417293.