# Optimizing Underwater Depth Mapping through Sonar Technology


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# 1.Introduction

This project endeavors to advance the comprehension of underwater landscapes and weather patterns. Utilizing state-of-the-art sensor technologies and pioneering data collection methods, the primary objective is to generate intricate 3D maps of underwater terrains. By amalgamating GPS coordinates with sonar depth measurements, the aim is to precisely delineate the depths of various water bodies, including lakes, rivers, and seas.

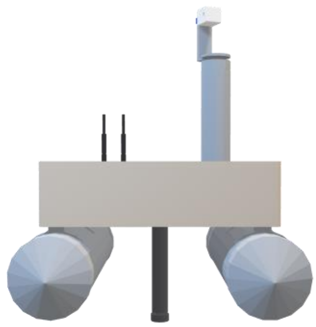

*Figure 1 - CAD Design of drone front view*

Beyond depth mapping, the project integrates additional sensors to concurrently capture crucial weather data. These sensors monitor humidity, temperature, air pressure, and light intensity. The holistic amalgamation of environmental factors with depth measurements promises to yield maps that not only portray underwater topography but also provide insights into concurrent weather conditions.

*Figure 2 - CAD design of drone*

The integration of these sensors with solar cells facilitates real-time data transmission to a ground station, ensuring uninterrupted monitoring of underwater and weather conditions during mapping expeditions.

The setup encompasses a self-guided system, a custom-built controller, and a versatile two-axis camera capable of transmitting live images from distances of 1 to 5 kilometers. This comprehensive approach aims to revolutionize underwater mapping techniques, promising diverse applications across scientific, navigational, and environmental domains.

# 2. Literature Review

To enhance underwater depth mapping, the integration of sonar technology and concurrent weather data collection is crucial. Sonar technology, when combined with other sensors, can provide accurate underwater mapping in challenging environments (Rahman et al., 2022). The fusion of scanning profiling sonar, visual, inertial, and water-pressure information in a non-linear optimization framework has shown promising results for small and large scale underwater mapping (Rahman et al., 2022). Additionally, the use of LiDAR and multibeam sonar has been investigated for benthic habitat mapping and underwater SLAM for Autonomous Underwater Vehicles (AUVs)

(Collings et al., 2020). This demonstrates the potential synergies between different technologies for underwater mapping.

Furthermore, the integration of sonar with visual and inertial sensors in a keyframe-based SLAM system has been proposed for underwater mapping, showing advancements in underwater domain localization technologies (Rahman et al., 2019). Additionally, the use of sonar systems in AUVs for tasks such as obstacle avoidance and seabed mapping has been highlighted, emphasizing the importance of sonar technology in underwater mapping applications (Fuchs et al., 2022).

Moreover, the challenges and opportunities in underwater wireless sensor networks (UWSNs) have been discussed, highlighting the importance of efficient communication and data collection in underwater environments (Awan et al., 2019). The use of UWSNs for collaborative monitoring and data collection tasks has been emphasized, indicating the potential for integrating sensor networks with sonar technology for comprehensive underwater mapping (Awan et al., 2019).

In conclusion, integrating sonar technology with other sensors and leveraging advancements in underwater wireless sensor networks can significantly enhance the accuracy and efficiency of underwater depth mapping. The fusion of different sensor modalities and the development of optimized localization systems for underwater environments are crucial for advancing underwater mapping capabilities.

## 3. Aims and Objectives

### 3.1 Aim

- Underwater Depth Mapping: Create accurate 3D maps using sonar sensors and MATLAB, with GPS for location and sonar for depth, allowing precise identification of depth ranges in lakes, rivers, or seas.

- Autonomous Navigation System: Build a self-guided system with a custom flight controller and two brushless motors, enabling autonomous and manual navigation modes.

- Enhanced Imaging: Equip the system with a movable camera transmitting live images up to 1-5 kilometers, providing real-time visuals during mapping.

- Practical Application: Design a user-friendly system capable of creating maps useful for identifying depth ranges in various water bodies, aiding in surveys of lakes, rivers, or seas.

### 3.2 Objectives

- Develop Precision Mapping Algorithm: Create a robust algorithm merging sonar and GPS data for accurate 3D underwater maps.

- Build Floating Board Drone: Engineer a drone with sensors for precise depth measurement upon water contact.

- Integrate Weather Data Collection: Incorporate weather data collection capabilities into the system for future research and environmental analysis.

## 4. Methodology

4.1. Algorithm Development:

- Gather and analyze sonar and GPS data to understand their integration possibilities.
- Design and develop an algorithm using MATLAB to merge and process the data for 3D mapping.

4.2. Drone Construction:

- Identify and assemble necessary components for the floating boat drone.
- Integrate sensors for precise depth measurement upon water contact.

4.3. Weather Data Integration:

- Select appropriate weather sensors (e.g., humidity, temperature) for integration into the system.

4.4. Testing and Calibration:

- Conduct initial testing to ensure accurate data collection and mapping functionality.

- Calibrate the system components for optimal performance in varied underwater environments.

4.5. Validation and Refinement:

- Evaluate the accuracy of the generated 3D maps through field tests in different water bodies.
- Refine the algorithm and drone mechanisms based on testing feedback for enhanced performance.

4.6. Documentation and Reporting:

- Document the methodology, findings, and any modifications made throughout the research.
- Compile a comprehensive report outlining the process and outcomes of the research endeavor.

## 5. Expected Outcomes

- Development of a robust algorithm enabling the creation of highly accurate 3D maps through the integration of sonar and GPS data.
- Construction of a specialized drone equipped with sensors capable of precise depth measurement upon contact with water surfaces.
- Integration of weather sensors into the system, enabling the collection and correlation of environmental data alongside mapping operations.
- Validation of the system's functionality and accuracy through testing in various underwater environments, ensuring reliable performance.
- Compilation of a detailed report documenting the research methodology, findings, and improvements made during the research process.

## 6. Time Frame

| | **November** | | | | **December** | | | | **January** | | | | **February** | | | | **March** | | | | **April** | | | |
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| Literature Survey | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Proposal Preparation | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | |
| Proposal Presentation | | | | | | ■ | | | | | | | | | | | | | | | | | | |
| Design & build drone | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | |
| Test device part by part | | | | | | | | | | | ■ | ■ | | | | | | | | | | | | |
| Make PCB and Assemble | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | |
| Field test | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | | | |
| Analyze data and visualize maps | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | | | |
| Debug and testing | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ |
| Final reporting | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ |

## 7. References

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