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UNMANNED SURFACE VEHICLE FOR BATHYMETRIC MAPPING OF SHALLOW WATER BASINS

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Abstract

This paper introduces a mobile ground control station designed for unmanned surface vessels (USVs), which can operate either autonomously or be remotely controlled without human crew aboard. USVs are versatile machines equipped with a variety of sensors, propulsion systems, and communication devices, serving purposes like scientific research, environmental monitoring, and maritime security. A USV is being designed for the purpose of monitoring the parameters of Local river. Anacostia river flows through the District of Columbia and passes through urban areas. This has created an atmosphere of pollution and sediments. This USV is expected to explore the depth, location, and volume of contaminants. The Ground Control Station (GCS) is a vital component for USV operations, facilitating remote control and monitoring, thereby enabling autonomous or semi-autonomous functions. The portability of the GCS is highlighted, allowing operators to transport the system to remote or challenging-to-reach locations, expanding the range of environments and conditions in which USVs can operate. This paper outlines the hardware architecture of the system, with a particular focus on the navigational sensors used for guidance and control. Hardware elements encompass controllers, communication gear, and sensors like GPS and sonar. These sensors furnish real-time data about the USV's position, speed, and surroundings, which are crucial for informed navigation and control decisions. The software component comprises control algorithms, user interfaces, and data processing tools that empower operators to oversee and direct the USV's activities. In summary, the paper offers insights into the design and deployment of a system for commanding USVs, with an emphasis on hardware, user interface, and mission planning.

Motivation and Research Problem

The motivation for employing Unmanned Surface Vehicles (USVs) in bathymetric mapping of shallow water basins arises from various factors.

- Firstly, traditional surveys using manned vessels or aircraft are costly, time-consuming, and risky, especially in challenging environments. USVs mitigate these risks by eliminating the need for human presence, making surveys safer and more cost-effective.
- Secondly, USVs, equipped with advanced sensors, offer precise data collection, surpassing manual methods, particularly in shallow waters where accuracy is vital.
- Thirdly, USVs reduce the environmental impact associated with manned vessels, crucial for preserving delicate ecosystems. Moreover, USVs navigate close to shorelines, capturing detailed data overlooked by larger vessels, enhancing our understanding of underwater topography.

The primary research problem involves optimizing USV methodologies to enhance survey efficiency, accuracy, and safety [1]. This includes designing USVs with appropriate sensors, developing algorithms for data processing, and integrating environmental monitoring capabilities.

"Research efforts focus on challenges such as outer optimization, data acquisition time reduction, sensor calibration improvement, and data fusion techniques[4]". Ultimately, the goal is to establish USVs as reliable platforms for bathymetric mapping, supporting various applications like navigation and environmental monitoring while aiding in the conservation of shallow water ecosystem.

Research Objectives

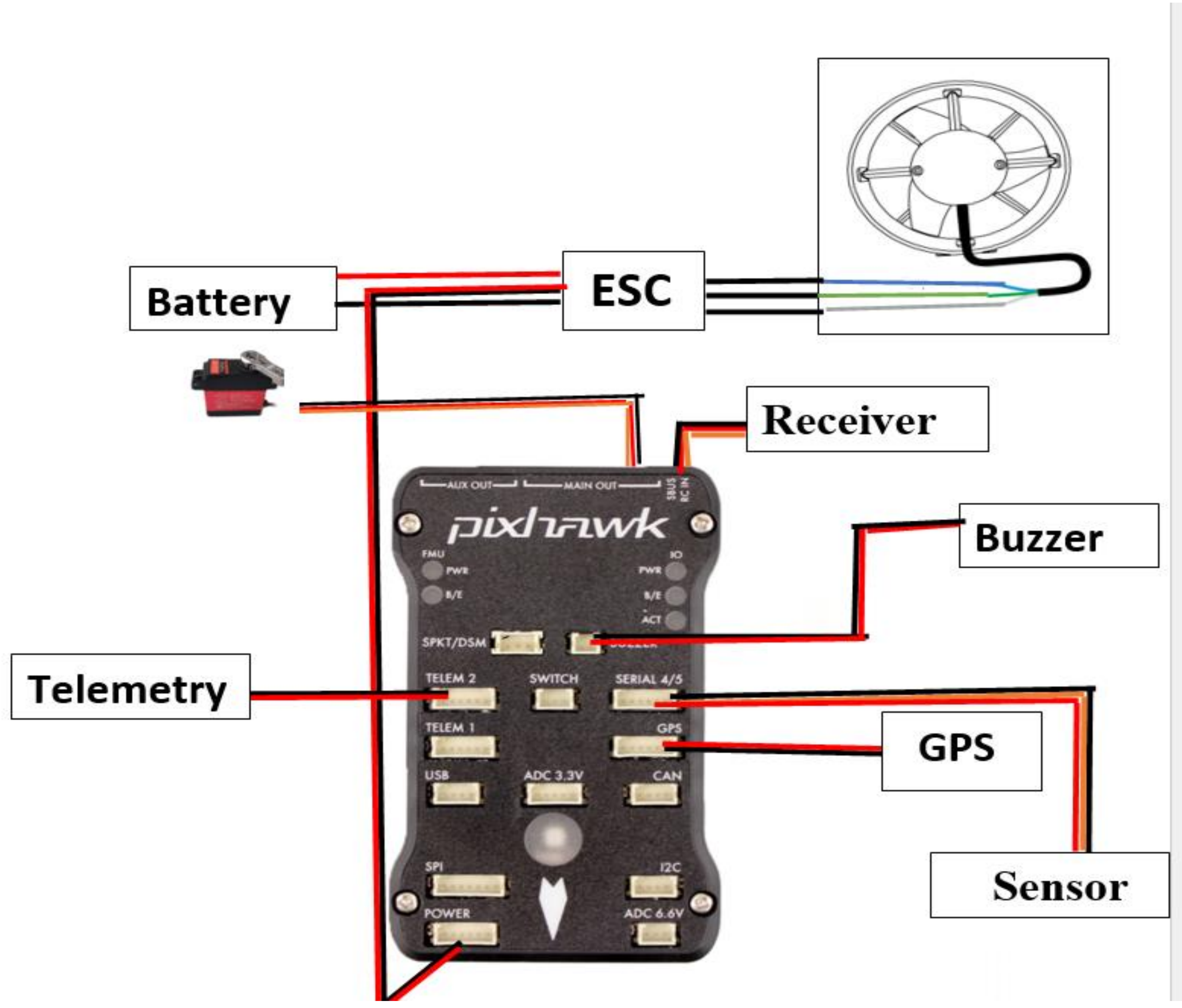
The purpose of this project is to demonstrate that a high-resolution bathymetric map can be constructed using the in-house developed USV using open-source hardware and software. We are focused on developing a cost- effective USV which will capture the depth and bathymetric profile of shallow water basins using echosounder.

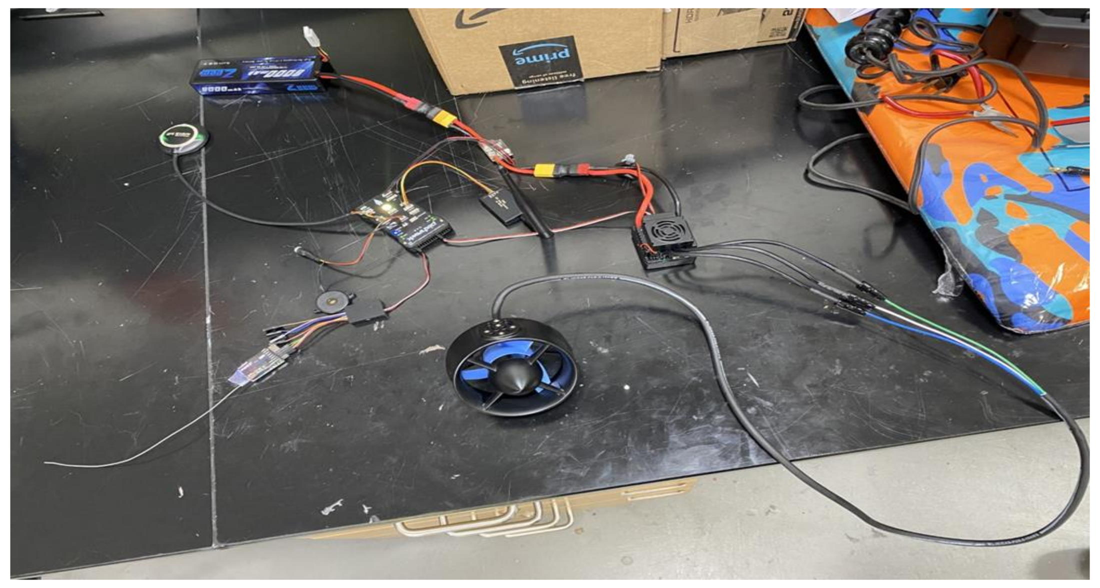
Research Methodology

"Despite notable research progress[1,3], USVs in Search and Rescue missions continue to face technical challenges." For instance, establishing the boundaries of the maritime search area or the practical and careful allocation of the target areas for USV search, efficiently coordinating search and rescue operations by USVs, and optimal alignment between USV and search missions. To do so, our focus will be on:

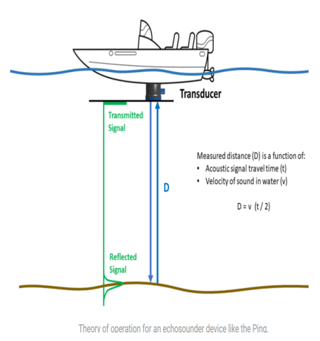
- Defining the boundary of the search area using mission planner
The USV will only map the defined search area.
- Be able to control the USV remotely from the ground.
The USV will be remotely controlled from the ground station.
- Be able to obtain the topographic map of the search area from the USV.
This will be generated using the ping sonar emitting and receiving signal..

Wiring Diagram Circuit

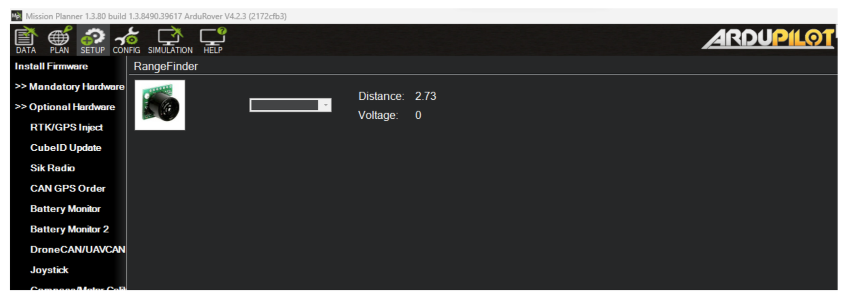




Analysis and Results
Sensor(Ping Sonar)



Poll Depth Measurement



The results we were able to obtain from the testing we did are displayed below in the pictures. We were able to receive data back from mission planner. The first test was in the 8ft – 7in part of the pool, the ping read back 2.73 meters which is roughly 8ft – 9in

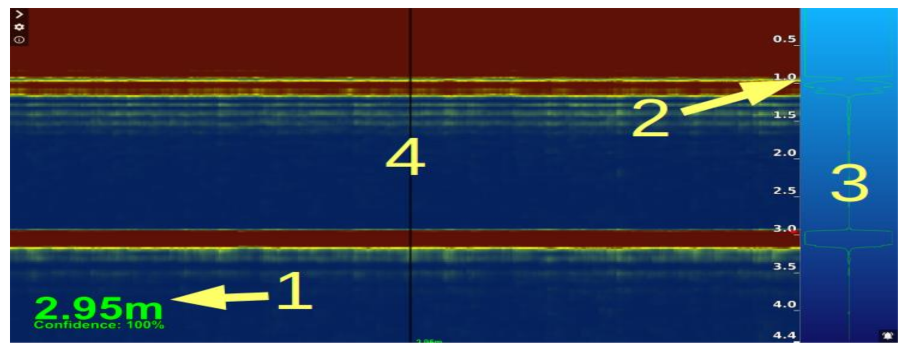
Mission Planner

The mission planner allows the calibration of the Radio, GPS and Telemetry.

Ground Station

The GCS is the hub of the USV's communication network, control and provides the operator with real-time information about the UAV's status, location, and mission performance.

Ping Viewer



Conclusion

Within this project we built a prototype Unmanned Surface Vehicle (USV) using bathymetric surveys to accurately map marine environments, provide real-time transmission of processed data. We used the UDC Athletic Pool to conduct the testing of the USV. After multiple different research approaches consideration, we decided to implement the following main components Pixhawk PX4 as the microcontroller, T2OO underwater thruster (propeller), 25Kg servo driving the thruster, 4068/1700KV brushless motor with ESC as the USV speed controller, 8000mAh Lipo power supply and GPS/Compass, Echo-sounder sensor ping sonar providing 2D pictures of the sea floor . The Pixhawk microcontroller controls and manages the electrical system of the USV.

Acknowledgment

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