An Autonomous Surface Vehicle for Profiling Freshwater Bodies Temperatures and Depths

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Introduction

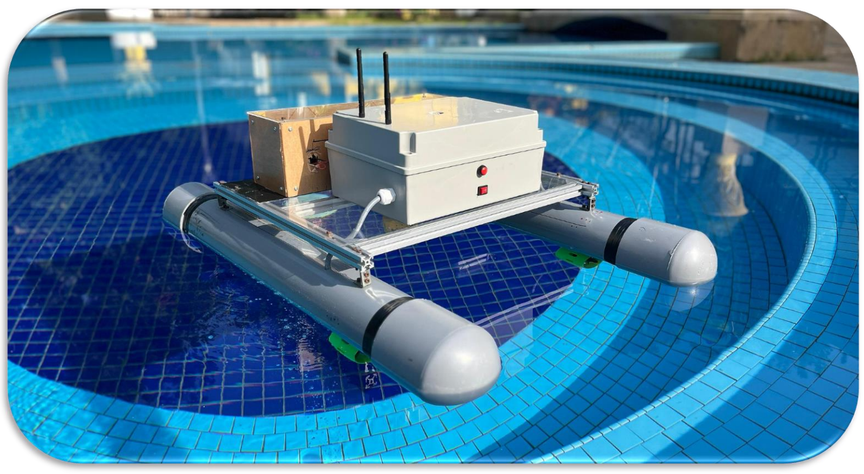
This study presents the design and development of an autonomous surface vehicle (ASV) tailored for measuring subsurface water temperature in freshwater rivers and lakes which directly impacts aquatic life. The ASV collects precise temperature data at three different depths (surface, midpoint, and river/lakebed), correlated with their location and time, offering valuable insights into aquatic habitat dynamics. ASVs reduce the risks for human surveyors, improving the efficiency of gathering data, while strengthening conservation initiatives.

Aim and Objectives

The aim of the project is to develop an autonomous vehicle capable of traversing rivers/lakes to obtain multiple subsurface temperature measurements. The objectives are as follows:

- Achieve temperature measurement accuracy of ±0.5°C, prioritizing data quality.
- Obtain three measurements: at water surface, surface bed, and halfway point up to 3m depth.
- Store temperature data with time, location, and depth, ensuring retrievability.

Methodology



User Interface and Data Storage

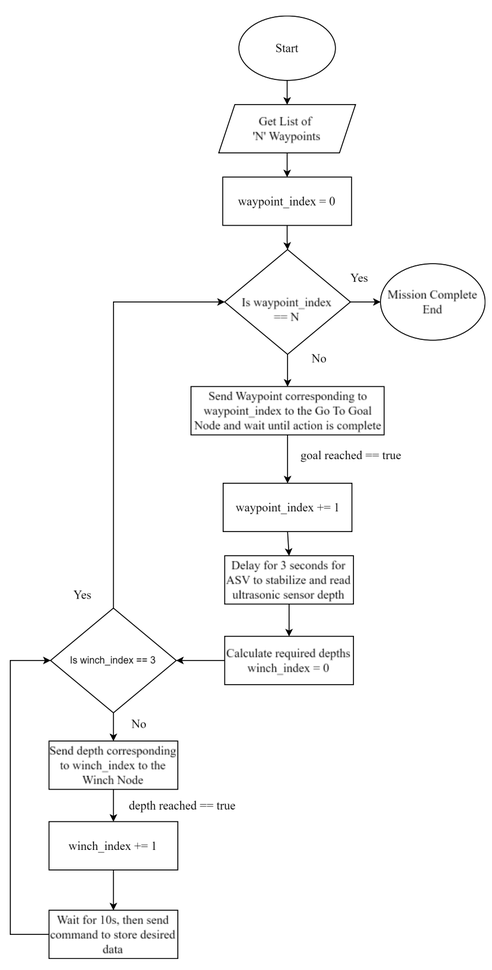
The user interface software is an added feature to the prototype ASV to make it more user friendly to operate. The user connects to the ASV using the telemetry radio plugged into USB port of laptop. The user the selects desired waypoints on the map and starts the mission. Once the mission is completed, the '.csv' file can be downloaded by the user. A local storage is also saved onto an SD card on the boat as a backup.

Navigation Software and Hardware

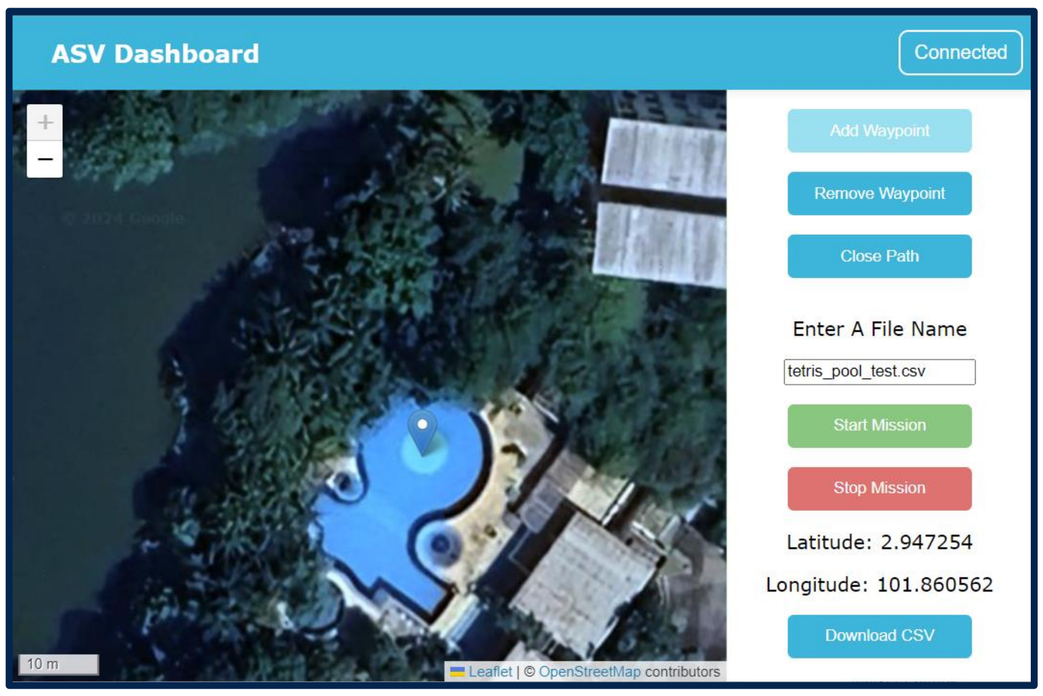
The navigation software stack, based on ROS2, runs on Ubuntu 22.04 on a Raspberry Pi 4B. This high-level mission controller communicates with the sensor subsystem (based on the Raspberry Pi Pico) which contains a GPS and IMU sensor for localization. The navigation commands are sent to the actuator subsystem (based on the Arduino Uno) which controls the ASV thrusters.

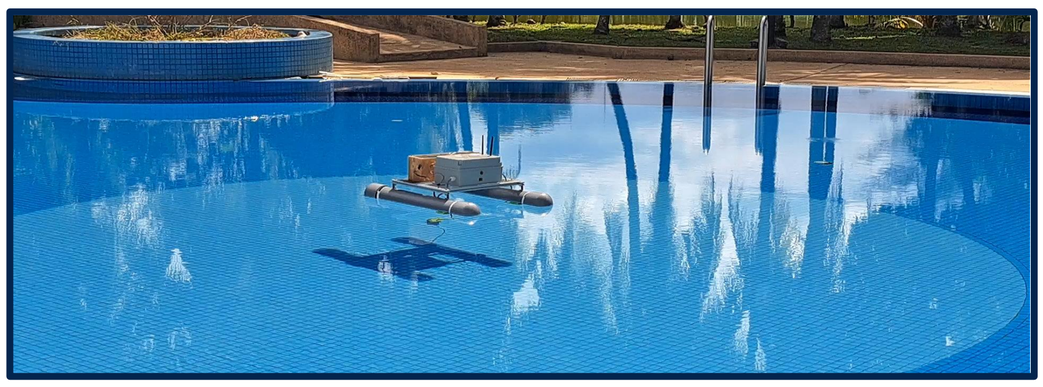
Payload System

The payload subsystem integrates a winch to lower and lift a PT100 temperature probe for measuring water temperatures at the water surface, waterbed, and the midpoint up to a maximum depth of 3m. The system ensures ±0.5°C accuracy. An ultrasonic sensor measures water depths and provides feedback to the winch system for precise depth control.



Results





Date	Time	Latitude	Longitude	Depth/mm	Temperature/°C
27/4/24	14:34	2.947274	101.8605	998	34.3
27/4/24	14:34	2.947278	101.8605	501	34.2
27/4/24	14:35	2.94728	101.8605	72	34.2

The results illustrate the functionality of the ASV prototype, demonstrating that once the user selects their desired waypoint(s) on the software interface, the ASV accurately navigates to the designated location. Subsequently, the temperature readings at various depths are recorded which were also validated with a thermometer, reflecting the successful execution of the intended operation. Thus, this proves that the project objectives have been met.

Conclusion and Future Improvements

The ASV prototype achieves project goals by accurately sampling water temperatures and autonomously navigating to user-defined waypoints, capturing surface, midpoint, and bottom temperatures within ±0.5°C accuracy up to 3m depth. Waypoints are set via a user interface, and data including temperature, depth, location, date, and time are stored on an SD card for download**.** Future improvements include improving GPS accuracy with an RTK system, increasing maximum depth for larger water bodies, implementing obstacle avoidance for autonomy, upgrading winch mechanisms for efficiency, refining user interface software for added features like battery monitoring and manual winch control, and enhancing station-keeping algorithms to mitigate drift during data collection in challenging environments.