Project Mallard: Autonomous Floating Surveying Platform For Anomaly Detection

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BACKGROUND AND MOTIVATION

Problem:

- **89% of men** reported missing after a night out and subsequently found deceased are located in water [1].
- Traditional searches require massive manpower, multiple boats, and extensive time to cover areas of interest.
- Searches are limited, risking the loss of critical evidence

Approach:

- Adapting Unmanned Surface Vehicle (**USV**) technology manufactured to aid forensics/police
- Deploying a USV integrated autonomous navigation, high-resolution underwater mapping, and real-time anomaly detection.
- A faster, safer, and highly accurate method for surveying bodies of water, removing human error

OBJECTIVES

Project Mallard's objective:

- This project aims to develop an autonomous USV capable of providing a detailed "window" into bodies of water by identifying areas/objects of interest
- objects of interest include: *weapons, bags, discarded waste, vehicles, personal belongings, and, most critically, deceased persons or individuals requiring rescue.*
- Employing autonomous navigation to map an underwater terrain, the system reduces the potential for human error in search and analysis operations.

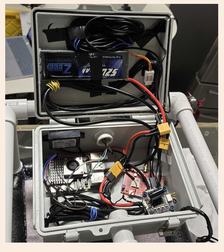
Materials

Computing & Control
- Raspberry Pi 5: main computer.
- SoloGood F722 Flight Controller + 4-1 ESC Stack

Propulsion
- 4× Brushless motors
- 3S battery

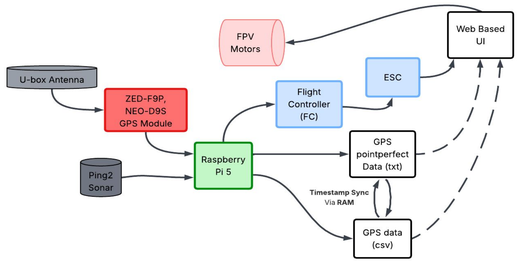
Sensors
- Ping2 Sonar
- GPS module

Hull & Structure
- PVC pipe frames
- Foam floats for buoyancy.

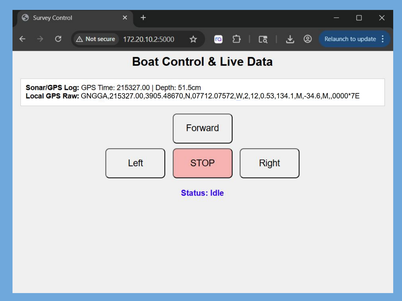


METHODOLOGY AND SYSTEM DESIGN

Data Flow Architecture:

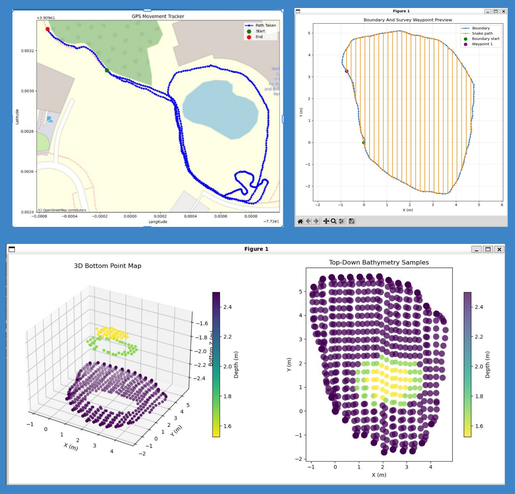


Motor/Sonar/GPS Webpage:



Simulation Testing:

- Gazebo environment used to validate navigation logic through GPS-based path simulation
- Waypoint-based control: turn, align, move forward.
- Simulated GPS used for realistic positioning
- Lawn mower path generated for full-area coverage

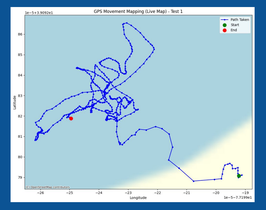


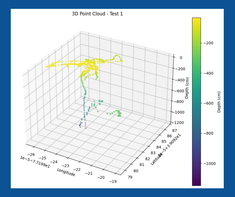
Real-World Application:

Field Validation & Results

The USV was deployed across two aquatic environments (USG Building 4 Lake and USG South Lake) for four rigorous performance trials.

- 100% confidence in sonar readings
- Captured vehicle movements and location data with centimeter-level precision.
- Motors maintained strong, stable directional movement despite headwinds
- The craft remained perfectly stable and buoyant under active deployment conditions.





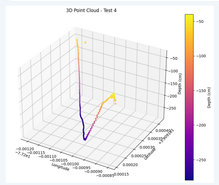
RESULTS AND ANALYSIS

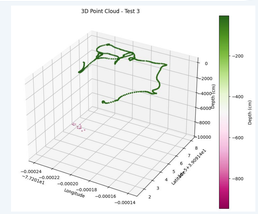
Propulsion
- 4-motor control validated in open water
- Forward, left, and right commands worked
- Platform remained stable and buoyant

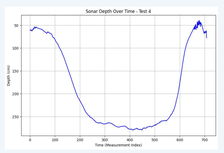
GPS Tracking
- GPS recorded platform movement across the test area
- Path data confirmed real-world deployment

Sonar
- Depth measured from ~40 cm to ~270 cm
- Readings supported underwater terrain mapping

Bathymetry
- GPS + sonar data fused by timestamp
- 3D bathymetric point cloud generated







- 4-motor control validated
- Depth range: ~40–270 cm
- GPS + sonar fused by timestamp
- Wind/water drift observed

CONCLUSION AND FUTURE WORK

Conclusion
- Developed and tested a floating USV for water surveying
- Validated 4-motor propulsion, GPS tracking, and sonar depth collection
- Generated 3D bathymetry using GPS + sonar data
- Simulation validated autonomous survey path planning

Future Work
- Transfer autonomous navigation from Gazebo simulation to physical platform
- Replace WiFi hotspot with LoRa radio for extended, low-latency communication range
- Improve robustness against wind drift and water disturbances
- Refine GPS + sonar timestamp synchronization for higher-accuracy bathymetric mapping
- Integrate underwater camera and anomaly detection algorithm for forensic search capability

References

[1] Lorna Dennison-Wilkins, Lucina Hackman, Masoud Hayatdavoodi, The Body Recovery From Water Study: The application of science to missing person search, *Policing: A Journal of Policy and Practice*, Volume 17, 2023, paad037, https://doi.org/10.1093/police/paad037

[2] Shubo Xu, Minghua Zhang, Wei Song, Haibin Mei, Qi He, Antonio Liotta, A systematic review and analysis of deep learning-based underwater object detection, Neurocomputing, Volume 527, 2023, Pages 204-232, ISSN 0925-2312, https://doi.org/10.1016/j.neucom.2023.01.056.

[3] Sotelo-Torres F, Alvarez LV, Roberts RC. An Unmanned Surface Vehicle (USV): Development of an Autonomous Boat with a Sensor Integration System for Bathymetric Surveys. Sensors (Basel). 2023 Apr 30;23(9):4420. doi: 10.3390/s23094420. PMID: 37177623; PMCID: PMC10181514.