Unmanned Surface Vehicle

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Concept and Application

Concept:

Designing an affordable, safe and efficient autonomous USV with a purpose of wildlife monitoring, search and rescue, freight transportation, and data collection.

Objective tasks:

Our project demonstrates environmental monitoring through the integration of sensors for perception, communication, and the use of microcontrollers for motion control navigation.

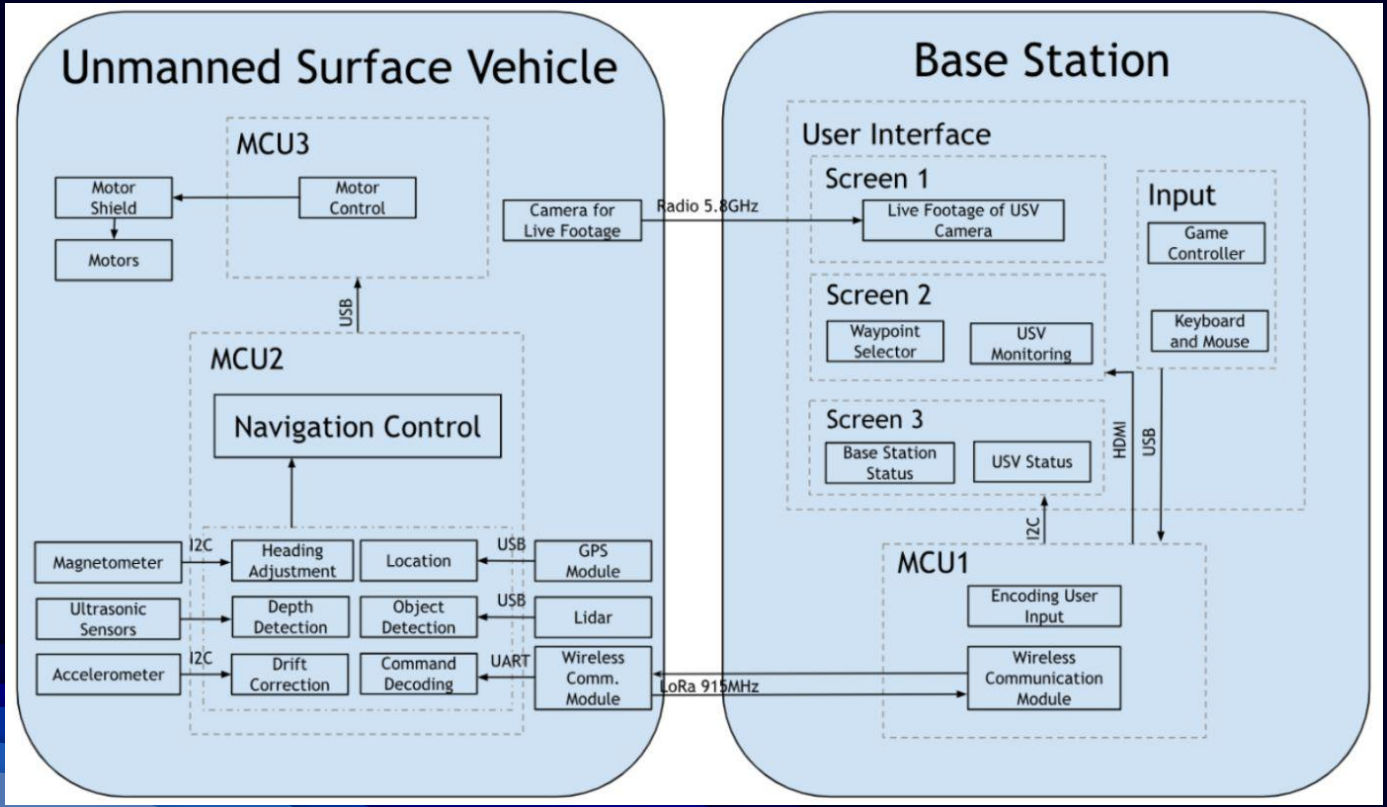
Relevant to control systems, signal processing, embedded systems, wireless communication, and power systems.

Technical design objectives

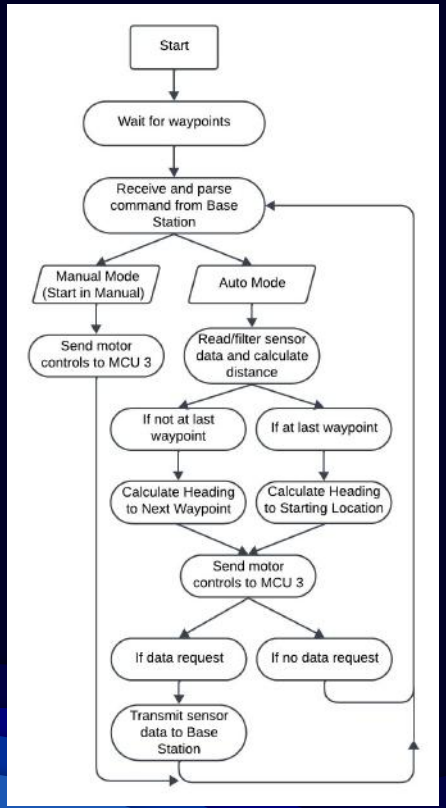
Requirements:

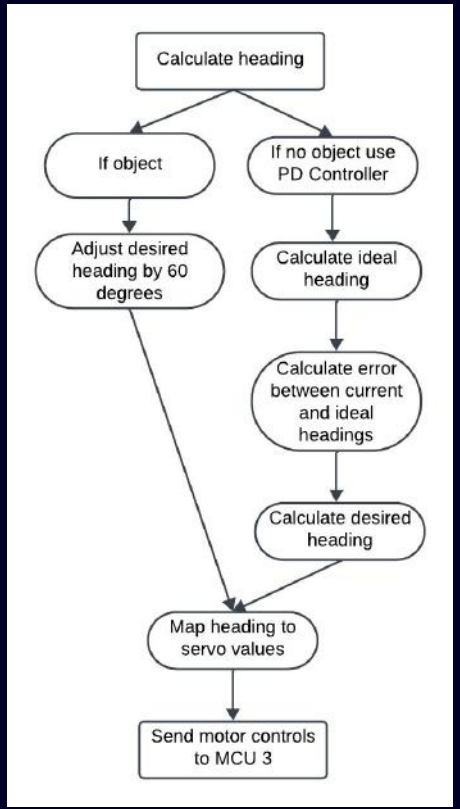
- Follow waypoints created by the operator.
- Sense objects and depth of water and respond accordingly.
- USV maximum range of 2 km
- USV maximum FPV range of 1km
- USV will move at 1m/s
- One hour operation time

Final high-level design(SBD)

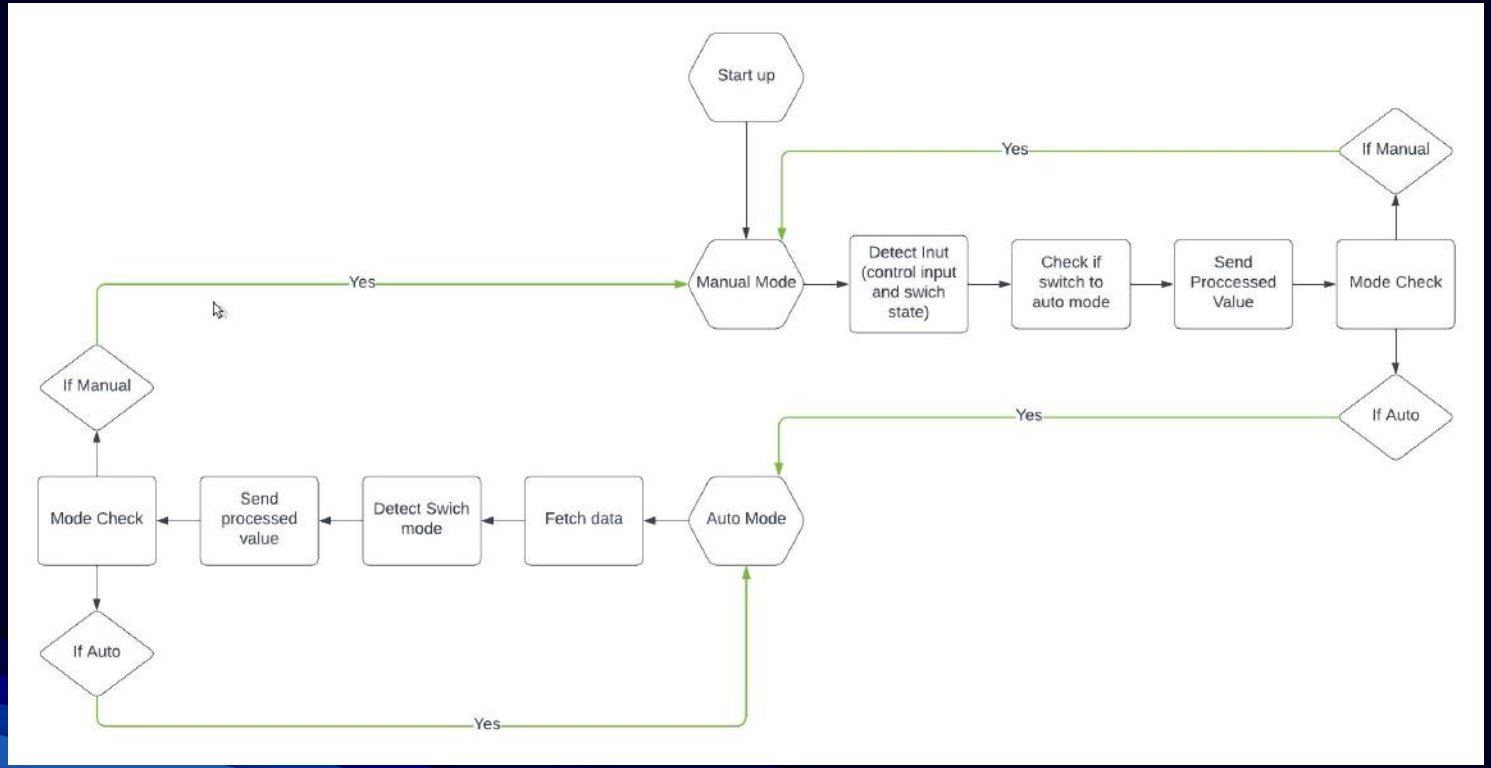


Low-level design USV



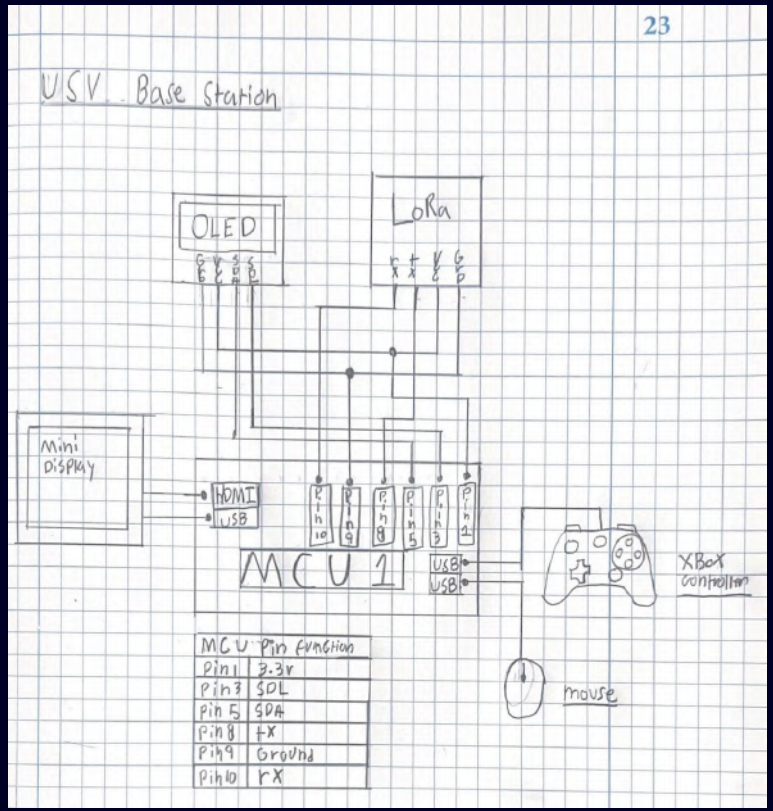


Low-level design Base Station



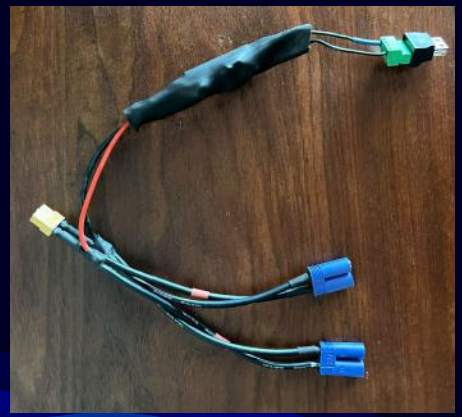
Schematics (Base station)

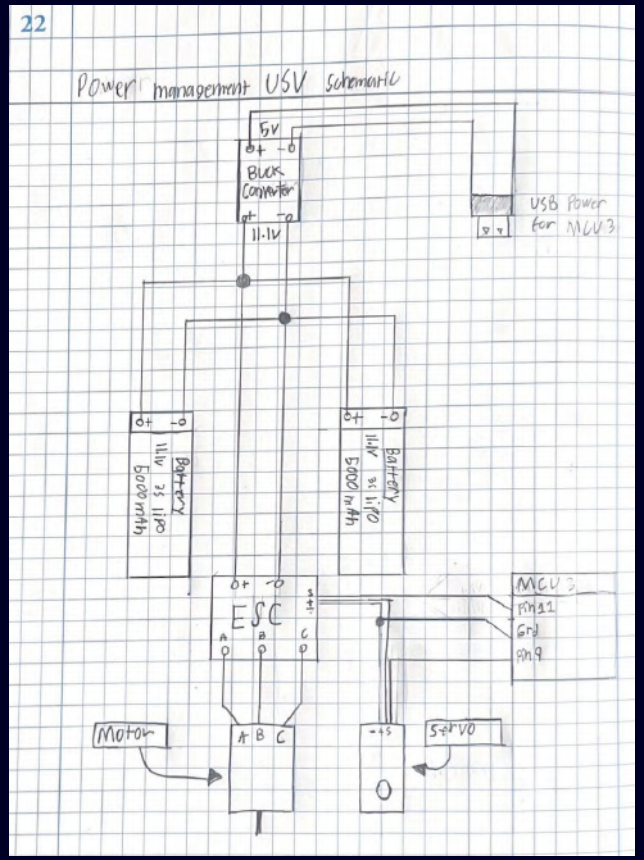
- Base station interprets data sent from controller to be sent via lora to USV
- OLED displays modes
- In Auto mode OLED displays fetched Latitude, Longitude, and heading.
- Mini display is used for setting waypoints and viewing map



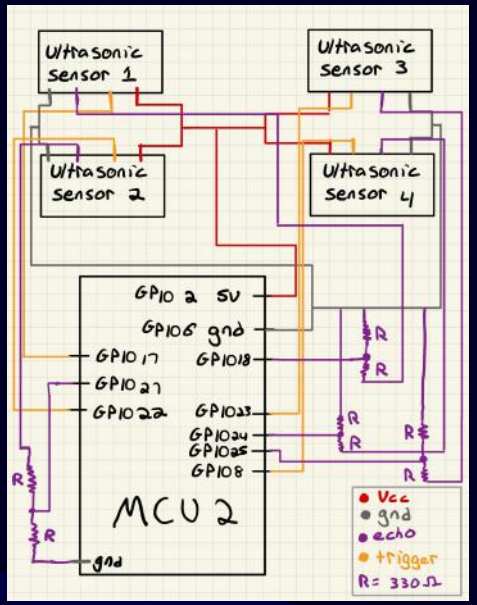
Schematics (USV Power)

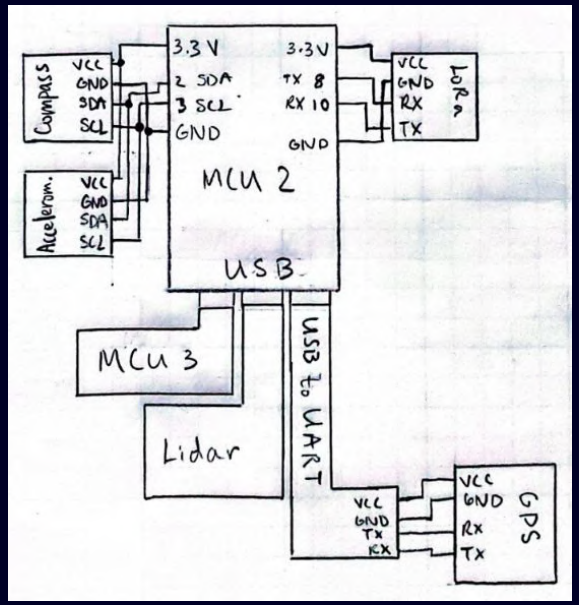
- Power management circuit
- Entire USV powered controles uses 11.1v for brushless motor, 5v usb power for raspberry pi arduino and sensors, 6v for servo power.
- 10 amp hours of capacity
- Allows all electronics to be powered off main power supply





Schematics (USV Sensors)





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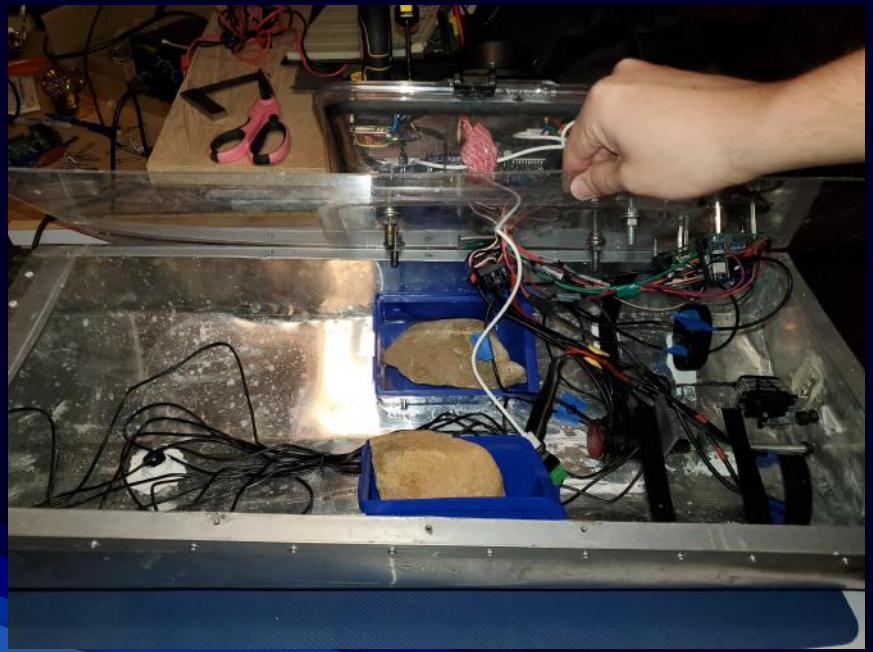

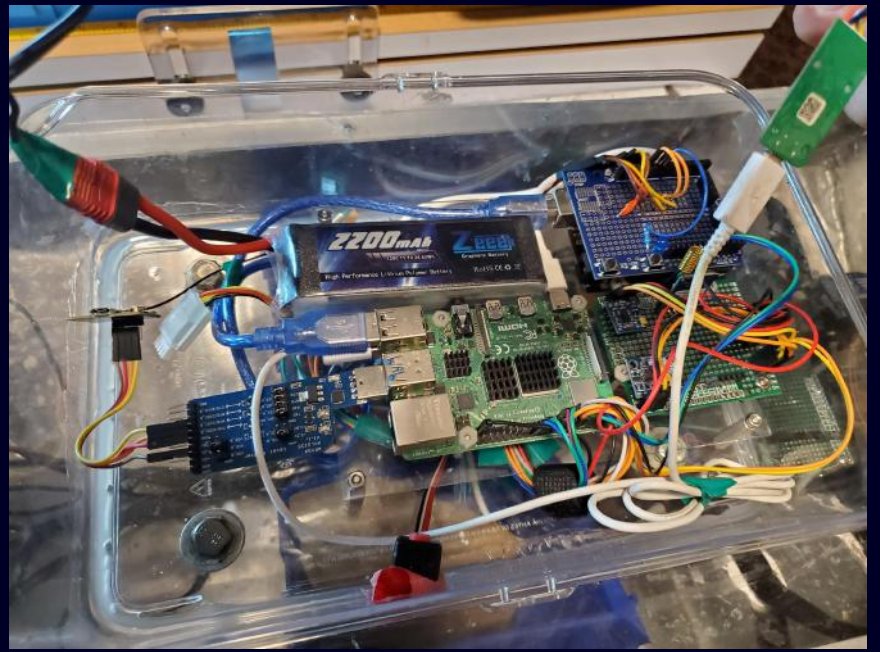

Technical challenges

- Communication Speed
- PD tuning
- Sensor calibration
- Waterproofing
- Finding testing locations
- Optimizing object detection algorithms
- User input with controller
- Communication reliability between MCU1 and MCU2
- System integration

Major components of the design and implementation

Overview:

Alyan: Lidar, ultrasonic sensors, accelerometer, and magnetometer.

Max: PD, LoRa communication, waypoint creation, GPS Module, sensor board, full software integration.

Daniel: Control interface, LoRa communication, FPV for video data, servo and motor control, power management, and aluminum hull, sensor mounting.

Design considerations

Realistic Constraints

- Run Time: One hour
- Organized electronics and wire management
- Power Consumption: have capacity for 1 hour runtime
- Weight: USV is 15.8 lbs
- Size: USV dimensions around 1 meter in length and 1/3 meter in width.
- FPV Memory: 32Gb
- Total Cost: $1000

Design considerations

Industry Standards

- LoRa - 915MHz (FCC) regulates the use of radio frequency devices
- surveillance on government-owned property needed approval based on the California Consumer Privacy Act (CCPA)
- The Local Lake Perris Regulations: Specific rules and regulations established by the management authority for Lake Perris, which include restrictions on the operation of the USVs, speed limits, and designated operating areas.

Communication Protocols

- I2C
  - Accelerometer and magnetometer
- USB
  - Lidar sensor and GPS module
- UART
  - LoRa module, Lidar sensor, and GPS module

Test report

- USV tested in multiple aquatic settings
- Lake Perris and home pools
- Manual control usable for positioning
- Auto mode had issues with compass calibration and GPS resolution
- Tested many days due to weather and bug fixes

Demo Video

https://youtu.be/K6GloAeiloA

Summary

- Our Unmanned Surface Vehicle (USV) project aimed to develop an autonomous boat capable of navigating to waypoints, avoiding obstacles, and collecting survey data.

- The project taught us about integrating various sensors and control systems, managing power consumption, and optimizing communication between components.

- Through this experience we faced many challenges such as waterproofing the electronics/boat, fine-tuning the control algorithms, and ensuring reliable communication in complex environments.

- Moving forward, we envision our project expanding the possibilities of a reliable and cost efficient USVs, incorporating more advanced obstacle avoidance algorithms, integrating machine learning for decision-making, and improving communication models of the USV for longer ranges of environmental monitoring.

Acknowledgments

Faculty in Charge: Roman Chomko

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Family and Friends

Online Tech Creators

Classmates

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