Autonomous Sailboat

Austin Glass
Devansh Damani
Michael Sutanto

Team 24
TA: Koushik Udayachandran
Prof: Dr. Fliflet

Table of Contents

1. Introduction:

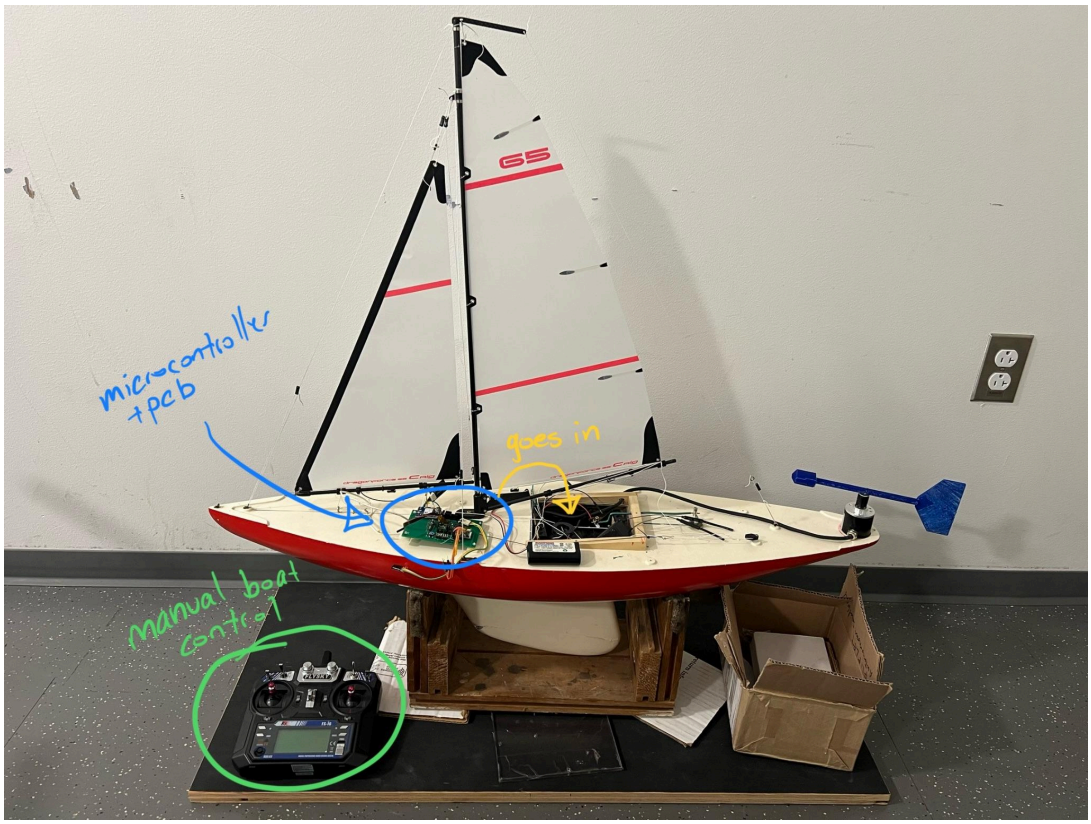
1.1 Problem:

Given a starting point, destination, path, and environmental factors such as wind speed or water current, a boat can travel both autonomously or remotely. We aim to improve the performance achieved by an earlier iteration of this project, as well as demonstrating new capabilities. One major improvement is streamlining the autonomous controls, and making the transition between autonomous and remote user control seamless. We also aim to introduce ease of life features like battery indicators, simpler charging / batteries, and an autonomous return to user mode.

1.2 Solution:

To complete this project, we will need to redesign a new PCB to accommodate new functionality, such as the speedometer and battery charging capabilities. We will be able to iterate on both the PCB and code libraries using the resources already available to us from the previous semester work, rather than starting from the ground up. Our main focus will be on streamlining the software side of the project, and optimizing our systems to work best in a physical environment.

1.3 Visual Aid:

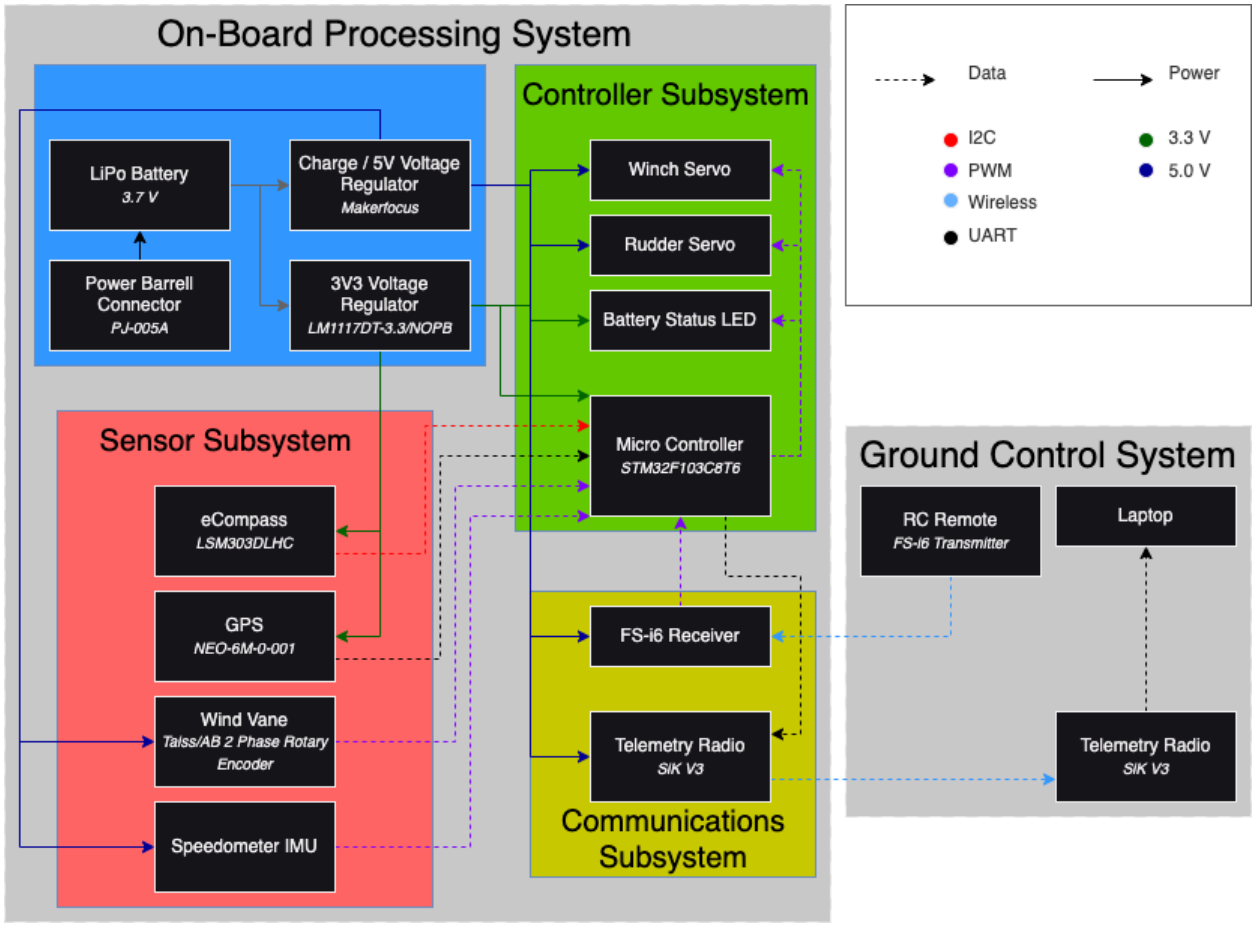


1.4 High Level Requirements:

1. Sailboat is capable of both autonomous control using sensor data and desired path, as well as user defined control through a remote.
2. Sailboat is capable of transmitting sensor data to remote clients for collection and processing.
3. Boat is capable of returning to a defined base from any location with a direct path.

2. Design:

2.1 Block Diagram:



2.2 Subsystem Overview:

2.2.1 Controller Subsystem:

The control subsystem is central to both operation of the sailboat in autonomous mode and manual mode. It is the heart of the sailboat's functionality and is what allows the sailboat to move and function. It fundamentally interfaces with the Power Subsystem to provide power for the microcontroller and the rudder and winch servos.

a) Microcontroller:

In autonomous mode, the microcontroller takes data from the Sensor Subsystem (eCompass, GPS, WindVane, Speed Sensor) and uses that data to calculate the appropriate angles for the winch and rudder servos. The correct movement of these servos is essential to keeping the sailboat in its course and in upright position

In manual mode, the microcontroller interfaces with the Ground Control System through wireless receivers and the Telemetry Radio. It will adjust the angles of the servo and rudder servos based on the input received from the transceiver.

Requirement 1: We should be able to adjust servo angles with a tolerance of ±3°.
Requirement 2: The processor should be able to calculate the position, heading, wind speed and direction with a maximum of 5% error.

b) Winch Servo

The winch servo serves the purpose of rotating the sails of the boat according to the instructions of the microcontroller, which would allow us to change the angle of the sails to maneuver the sailboat. It is powered with 5V by the Charge/Voltage Regulator from the Power Subsystem.

c) Rudder Servo

The rudder servo is used to rotate the rudder of the boat according to the instructions of the microcontroller, which would allow us to steer the boat. It is powered with a 5V supply by the Charge/Voltage Regulator from Power Subsystem.

d) LED

The LED will be mounted on the top of the sail, or any other visible location, and will indicate the remaining battery life of the boat.

2.2.2 Power Subsystem:

a) Battery (3.7 V LiPo):

The battery will be wired to a 3.3V and 5V Voltage regulator, which will in turn power all of the Control, Sensor, and Communication Subsystem.

b) 5V Voltage Regulator (Makerfocus)

The 5V Regulator will supply constant power for the Winch Servo and Rudder Servo from the Controller Subsystem, the Wind Vane Encoder and Speedometer from the Sensor Subsystem, and the Telemetry Radio and Receivers for the Communication Subsystem.

c) 3.3V Voltage Regulator (LM1117DT-3.3/NOPB)

The 3.3V Regulator will supply constant power for the Microcontroller from the Controller Subsystem and the eCompass and GPS from the Sensor Subsystem.

d) Power Barrel Connector (PJ-005A)

The Power Barrel Connector would be used to set up the battery charging port to allow for ease of use for charging.

2.2.3 Sensor Subsystem:

a) eCompass and Accelerometer (LSM303DLHC)

The eCompass will send the direction of the boat's travel to the microcontroller in order for the system to control itself and correct its path if it deviates from the desired direction. The LSM202DLHC also has a built-in accelerometer which we will use to calculate the speed of the boat.

Requirement 1: The eCompass should be able to monitor the direction of travel with a tolerance of ±10°.

Requirement 2: The accelerometer should be able to detect acceleration with a tolerance of ±1 m/s^2

b) GPS (NEO-6G)

The GPS will keep track of the boat's position. It will send position data to the microcontroller which will be used to implement a "return back home" feature which would enable the boat to autonomously navigate back to its starting position.

Requirement 1: The GPS should be able to ±2.5m

c) Wind Vane (MA3 Miniature Absolute Magnetic Shaft Encoder)

The wind vane will inform the microcontroller of the direction of the wind.

Requirement 1: The MA3 should be able to measure the direction of wind within a tolerance of ±10°.

2.2.4 Communication Subsystem:

The communication subsystem is to transfer data to and from the Ground Control Subsystem.

a) Telemetry Radio (SiK V3)

The Telemetry Radio is used to transfer data about the servo, sensor, position, and microcontroller calculations to the Ground Control Subsystem. It operates at 915MHz.

b) FS-I6 Receiver

This wireless receiver would be used when the boat is in manual mode. It receives the user control input which it will then delegate to the microcontroller to control the servos. It also receives the boat autonomous mode ON/OFF signals and “return to base” signal to do these appropriate actions. It operates at 2.4GHz, and has 5 channels.

2.2.5 Ground Control Subsystem:

The ground control subsystem is used to manually control the sailboat when in manual mode and to activate the “return to base” function when needed. It is also used to track the data on servo, sensor, position, and microcontroller calculations through the data it receives from the Telemetry Radio.

a) FS-16 Transmitter

The wireless transmitter sends user commands from the control panel to the onboard processing system when the boat is in manual mode. It also forwards signals to activate or deactivate autonomous mode and initiates the "return to base" command to the onboard system. It operates at 2.4GHz, and has 5 channels.

b) Telemetry Radio Receiver

Receives data from the Telemetry Radio Transmitter in the communication subsystem. It operates at 915MHz, and communicates with a laptop via a UART connection.

2.3 Tolerance Analysis:

One risk that we will be addressing in this iteration of the project is real world testing. When running tests on certain functions of the boat in the lab, such as testing sensors or motor response to sensor input, results may vary from real world testing. We hope to identify any issues caused by an imperfect environment, such as varying wind and surface current. This requires us to get the boat up and running early on so we have ample time to perform tests, and optimize based on results.

3. Ethics and Safety

3.1 Ethics

This project is a follow-up project to the Autonomous Sailboat senior design project done in 2022, furthermore it is definitely not the first Autonomous Sailboat project published throughout the internet, this brings the concern of originality and accreditation. An ethics policy that will be heavily taken into consideration is Section 7.6 of the IEEE Code of Ethics I.5 states, “to seek, accept, and offer honest criticism of technical work… and to properly credit the contributions of others” [1]. We will ensure to credit and cite any resources from previous projects and online and/or offline resources we use.

Furthermore, through our goal of making a seamless system of dual-mode control, we aim to adhere with the first IEEE Code of Ethics “to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;"[1]. By enabling a dual-mode capability, the project aligns with this ethical guideline by ensuring that users can take control in situations that may require human judgment or intervention, thereby protecting the public and the environment from potential harm.

Finally, one of the mission and goal of this project, which is to create a user-friendly and more affordable autonomous sailboat, strongly addresses the fifth IEEE code of ethics, "to improve the understanding of technology; its appropriate application, and potential consequences;"

3.2 Boat and Team Safety and Data Privacy

Since the boat is a water-based mode of transport, our team must ensure the safety of the electrical systems by encasing it within a waterproof section of the boat- so as not to ruin the machinery and circuitry and not pose any shocks of electrocution to our team and others using the boat. We will also ensure that the wiring connecting the servos to our casing will be protected against water damage, vibration and rolling.

We will follow the Lab Safety guidelines while working on the boat in the Senior Design Lab rooms while testing our circuits, sensors and soldering.

Our ground control system will allow users to monitor sensor data such as GPS coordinates. The ethical concerns about that would be that the user’s GPS coordinates would also be recorded as the “home base”, which would pose a risk to the controller’s privacy. In order to ensure that there are no privacy violations, we will protect and not monitor user data and uphold the IEE code I.1; “to hold paramount, the safety, health, and welfare of the public... and to protect the privacy of others” [1].

References

[1] “IEEE code of ethics,” IEEE, Jun-2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 8-Feb-2024].
[2] Baker, Riley, et al. 2022, *Autonomous Sailboat*.