Functional Specification

Year: 2018 **Semester:** Fall **Team:** 6 **Project:** Garbage Collecting Boat
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Assignment Evaluation:

Item	Score (0-5)	Weight	Points	Notes
Assignment-Specific Items				
Functional Description		x3		
Theory of Operation		x3		
Expected Usage Case		x3		
Design Constraints		x3		
Writing-Specific Items				
Spelling and Grammar		x2		
Formatting and Citations		x1		
Figures and Graphs		x2		
Technical Writing Style		x3		
Total Score				

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

1.0 Functional Description

The Garbage Collecting Boat features the function of collecting floating garbage on the water. The project has two parts, a boat collecting garbage on the water, and a user interface which allows the user to control and monitor the movement and the working environment of the boat.

In the front of the boat, there is a conveyor belt catching the floating garbage, and transferring them to a specially designed storage box, whose filling situation is monitored. The boat is navigated through signals and commands transmitted from the user interface through cellular radio data. The power usage of batteries equipped within the boat is monitored carefully, and the batteries are recharged through the solar panels mounted on the roof of the boat or by an external charger. The position of the boat is monitored by the Global Positioning System (GPS), and the coordinates of the boat are transmitted to the user interface. The user can obtain the location of the boat and therefore control the route of the boat, either manually or by presetting the path. The camera on the boat will send back pictures to the user interface to report the environment in front of the boat.

2.0 Theory of Operation

The Garbage Collecting Boat, driven by motors, works on the water with wide area radio control. Control signals are issued by the Graphical User Interface (GUI) on a computer and those signals are communicated through the cellular network such as General Packet Radio Service (GPRS), and Long-Term Evolution (LTE). The GPS module is used to receive GPS coordinates and report the coordinates back to the user interface.

The microcontroller will issue commands to the waterproof Electronic Speed Control (ESC) which controls the speed of motors to navigate and steer the boat. All electrical power is provided by a group of Lithium battery with the appropriate voltage, and solar panels and inverter are used to charge the battery. An auxiliary charging port will also enable charging the onboard battery with a charger when needed.

To collect the garbage, a conveyor belt is used to catch the floating objects and transfer them to the storage room. On the top of the storage room, infrared sensors are used to monitor whether the room is filled, and once full, the boat will send a proper signal to the user interface.

3.0 Expected Usage Case

The Garbage Collecting Boat will be used in inland lakes to collect floating garbage on the water surface. The Garbage Collecting Boat is targeted for park operators, National Park Service, and other government departments that maintain public parks. It is also targeted at private park owners, golf course staff, and other commercial areas that have lakes. The users are expected to operate the boat through a user interface installed on a computer, charge the batteries before usage, and clean out the storage box when necessary. The graphical user interface is designed to be user-friendly and easy to use so that any person with the knowledge of using a computer should be able to operate the boat after reading the user manual with minimal training.

4.0 Design Constraints

4.1 Computational Constraints

The primary computational functions of the Garbage Collecting Boat will be:

- Comparison of coordinates from the GPS module and the preset path
- The battery voltage monitoring system
- Motor speed control
- Sensor input signals analysis
- Image transmission

The design has three separate computational systems: a microcontroller located on the boat, a camera module with data transmission ability, and a software interface on a computer. The interface on the computer communicates with the other two systems over cellular radio data to exchange necessary information.

The comparison of coordinates from the GPS module is done on the computer. The path inputted by the user through coordinate points will be calculated by the interface and converted to direct commands to transmit to the microcontroller on the boat. The camera module will have a built-in data transmission capability and send real-time images to the computer interface continually. The microcontroller is responsible for all the other computations. The main algorithm on the microcontroller will be a state machine. The power usage will be carefully monitored, and the sensor input signals will be interpreted. According to the signals received from the user interface through cellular radio data, the motor speed will be determined and modified.

Given the fact that the microcontroller does not have a high computation requirement, the memory of the microcontroller is not an essential aspect of the project. A typical microcontroller from STM32 family features 1 Mbyte of Flash memory and 320 Kbytes of RAM [1], which is enough for the purpose of this project.

4.2 Electronics Constraints

The major components the boat will utilize are as follows: a microcontroller, a GPS antenna, a cellular radio module [1], brushless dc motors, lithium batteries, solar panels, solar panel inverters, camera module, sensors and other supplemental modules. Depending on the components selected, the devices will utilize a selection of UART, SPI, I2C, PWM interface. In order to perpetuate the durability of the components, major electronic components should either be waterproof or securing in a location where the water will not damage those components.

4.3 Thermal/Power Constraints

The design has high power consumption as the design needs to use several brushless DC motors to drive the boat and the conveyor belt. Considering relatively high friction and water drag, the use of brushless DC motors is reasonable for the needed torque and speed. Since the design is

current demanding, a battery group will be used to drive the motors and other onboard components. Solar panels will enable the boat to be charged in case of the remaining battery life is not enough for the boat to drive back. When the battery level is too low, the microcontroller will power down all motors to save power for the microcontroller and communication to the user. The life of lithium-based batteries in most consumer products is between 300 and 500 discharge/charge cycles [2]. A 6-watt solar panel can charge a 4,000mAh, 3.7V lithium-based battery to 90% of full capacity in 4 hours [3]. Therefore, a lithium-based battery group is a reasonable power source for the boat.

4.4 Mechanical Constraints

The primary mechanical constraints of the Garbage Collecting Boat are the size of the boat, the design of the storage room, the angle and the material of the conveyor belt, and the ability to protect the major electrical components from water damage. The size of the boat should be portable so that the boat could be managed and operated by a single operator. The storage box for storing garbage should be designed primarily for the operator to remove from the boat, and the cleaning with a box should be with ease since the manual engagement between the boat and the operator is required. The boat will be designed to be waterproof and prevent water from entering the chamber where the electronic components located. The box will also be designed to allow water to exit the storing unit so the water will not be trapped in the unit and causing the boat to sink. The dragging caused by the water is another mechanical constraint for the design. To ensure the boat to overcome the dragging force of the water and move in a relatively fast pace, the boat should be equipped with two brushless DC motors which enable the boat to steer its direction and move forward. A third motor is used to drive the conveyor belt in a relatively slow pace. The design of the conveyor belt includes the angle of the slope and the material of the belt. The belt should be slightly inclined, and the material should have high friction to prevent objects from slipping of the belt.

4.5 Economic Constraints

There is currently no commercial product on the market which is identical to the Garbage Collecting Boat with its size. Most of the garbage collecting boats in the market is operating at a much larger scale, with onboard manual control, pricing around $30000 to $100000 [4,5]. The Garbage Collecting Boat has a cost of around $700, and the cost of each component is relatively around $100. Thus, the economic constraint is not very tight on the project. However, to find each relevant component still in production is necessary.

4.6 Other Constraints

As the nature of the boat, the design needs to have enough buoyancy to float on the water successfully. The weight of the boat should be symmetrically distributed such that the center of the mass locates at the geometrical center of the boat. The GUI designed for the boat should be user-friendly and must be easy to install. Along with the user manual, a user should be able to know the usage of the boat and the interface quickly.

5.0 Sources Cited:

[1] STMicroelectronics. (2018) *LTE Cellular to Cloud Pack with STM32L496AG MCU*. [Online]. Available: https://www.st.com/en/evaluation-tools/p-l496g-cell02.html [Accessed: 30-Aug-2018]

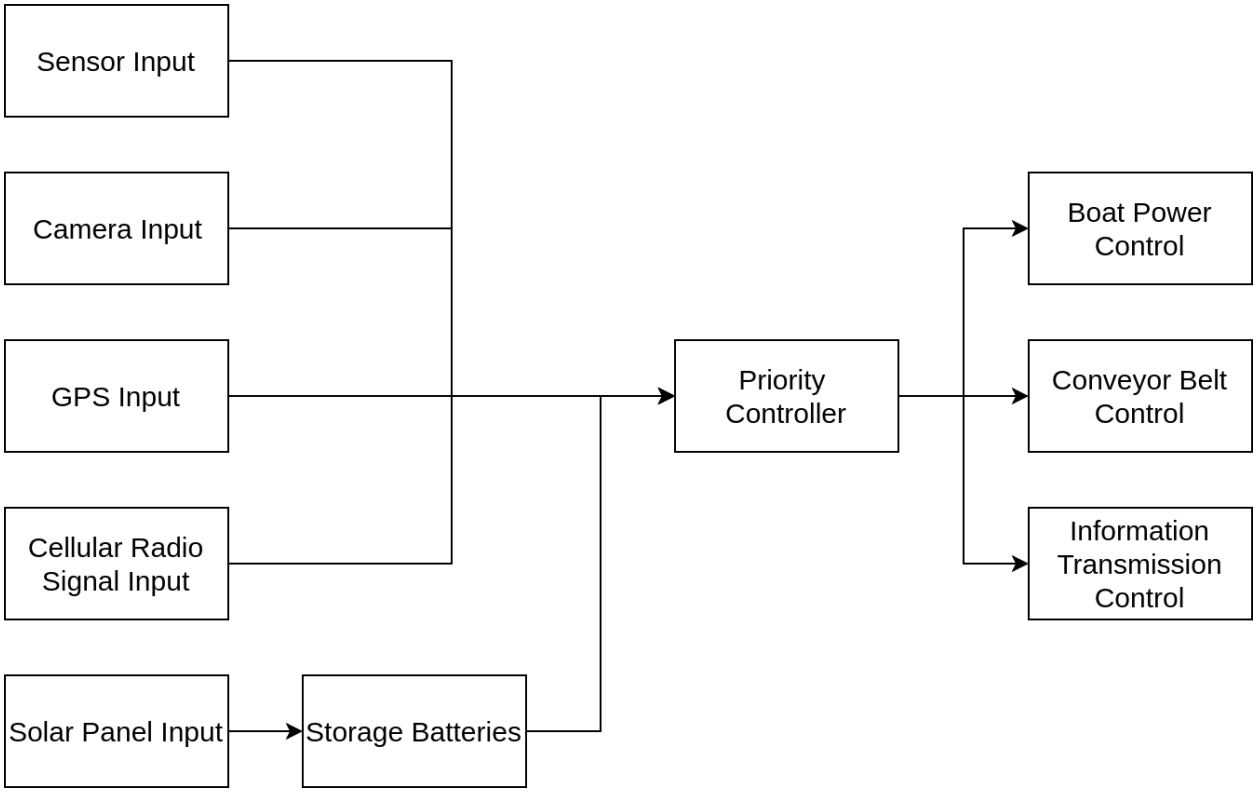
[2] Battery University. (2018) *How to Prolong Lithium-based Batteries.* [Online]. Available: https://batteryuniversity.com/learn/article/how_to_prolong_lithium_based_batteries [Accessed: 30-Aug-2018]

[3] Voltaic. (2017) *Estimating Solar Charge Time For Batteries.* [Online]. Available: https://www.voltaicsystems.com/blog/estimating-battery-charge-time-from-solar/ [Accessed: 30-Aug-2018]

[4] "High-quality River Garbage Collection Boat/trash Skimmer For Lake Cleaning - Buy Collecting River Boat For Sale, High-Quality River Garbage Collection Boat, Trash Skimmer For Lake Cleaning Product on Alibaba.com," *www.alibaba.com*. [Online]. Available: https://www.alibaba.com/product-detail/High-quality-river-garbage-collection-boat_60760094026.html?s=p. [Accessed: 04-Aug-2018].

[5] "Julong Aquatic Weed Harvester/ River Cleaning Boat /garbage Collecting Ship For Sale - Buy Julong Aquatic Weed Harvester, High-Efficiency River Algae Cleaning Boat, Low Price Lake Plants Harvester Product on Alibaba.com," *www.alibaba.com*. [Online]. Available: https://www.alibaba.com/product-detail/JuLong-Aquatic-Weed-harvester-River-Cleaning_60744874257.html. [Accessed: 04-Aug-2018].

Appendix 1: Functional Block Diagram



Appendix 2: Concept Sketch