Autonomous Aquatic Drone

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Summary

The proposed project is to construct a small solar powered paddle boat capable of navigating itself using GPS waypoints. The boat will be versatile, designed to be flipped 180 degrees in any direction and still function as intended. This involves applying solar panels to both the top and bottom of the boat to ensure the onboard systems have power at all time. In order to implement these specifications, hardware such as GPS, accelerometers, magnetometers, and batteries will be required. Tests will be conducted on small bodies of water such as swimming pools or small lakes like Lake Padden. The end goal will be for the boat to travel Lake Whatcom, launching from Bloedel Donovan Park, circumventing Reveille Island, and finishing in South Bay. Success in navigating Lake Whatcom will demonstrate the capability of a small watercraft to travel a great distance without direct human control.

Features

The following is a prioritized list of features we plan to implement for our device. The list is prioritized where the lower the number coincides with the higher priority.

1. <u>Watertight buoyant chassis</u>

   In order for this drone to be able to handle extreme conditions, like waves and splashes, the chassis needs to be watertight and buoyant. If the chassis is not watertight, we risk exposing the electronics inside to water, which could critically damage the craft and render it inoperable. We also need to ensure that the chassis is sufficiently buoyant so that it can traverse across rough waters without sinking, which would result in the complete loss of the craft.
2. <u>Paddle wheel propulsion</u>

   Paddle wheel propulsion comes from our constraint for the device to be able to travel over surfaces like floating kelp. If the craft was propellor driven, we would risk debris getting tangled in its only source of propulsion. Paddles also posses the capability to traverse land, which most likely would be the smooth surface of a beach or sandbar. This would decrease the likelihood of the craft becoming stuck by having its propulsion buried in sand.
3. <u>Solar powered battery array</u>

   The boat needs a source of power generation and storage if the trip is to go on for an extended period of time. Since bodies of water are usually prone to sun exposure, the most practical way to generate power for our drone is via solar panels. In order for our system to be efficient, we need batteries to store excess power generated by the panels in case of times when sun exposure may be limited or non existent.

4. Waypoint and log file storage system

   Since a goal of this project is to make it marketable for mass production, we need an easy to use system for waypoint programming and viewing log points. A small amount of on board flash memory will be a cost effective way for storing waypoint data and any measurements taken by the craft.

5. Wireless file transferring system for waypoint files and log files

   We want the craft to be watertight, which means that we must have no exposed connectors on the exterior of the craft. The easiest solution to this is to have a wireless file transferring system so that the user may upload and download files off the flash memory without having to breach the chassis.

6. External power switch

   As described above, the chassis needs to remain watertight, and that necessitates the use of an external power switch. This means we need to develop a way to turn on and off the craft without opening the chassis.

7. Global Positioning System (GPS)

   In order for the craft to be aware of its position and be able to calculate the heading for its next waypoint, it must have GPS capability.

8. Compass capability (cardinal direction detection)

   The craft knowing where it is on the globe solves only part of the problem when tracking waypoints. In order to make the waypoint tracking effective, we need to implement a compass capability so that the craft is aware of what direction it is facing.

9. Periodic position logging

   In order for the user to see the actual route travelled versus the planned route, there needs to be a system implemented that periodically logs the position of the craft. This is of lower priority since it does not affect the functionality of the craft and is a feature that is implemented purely in software.

10. Fault Tolerance

    If we want our drone to be able to go out on long term, potentially hazardous excursions, it must be able to reboot itself in the event of a total power loss, or recognize when a software bug occurs and reboot.

Customer

Our primary customer is the originator of this project, Dr. John Lund. This project is his brainchild and he wants to see it completed. Our secondary customer is the marine science, boating, and/or drone enthusiast community. An autonomous vessel such as this could have applications in oceanic research, monitoring, and even personal recreation for model boat enthusiasts.

Constraints

We have several general constraints that must be followed to insure the success of this project. In addition to these general constraints. Dr. Lund has given us specific constraints he requires for the project. The hardware portion of the project will be completed by the end of winter quarter of 2017. This includes all of the mechanical and electrical hardware such as chassis, PCB's, motors, and solar panels. The software of the drone will be developed and finished by the end of spring quarter 2017, at which time the final form of the project will be completed.

Our first general constraint is a small scale. For cost and manufacturing feasibility, our drone must be less than $\frac{1}{2}$ meter in each dimension. Another constraint we have to meet is power consumption; our solar panels must be able to continuously power the motors as well as all of the instrumentation and software on the drone, while charging the batteries enough to keep the motors going when there is no sunlight. This limitation requires us to ration our power consumption carefully.

The third constraint are the materials used to build the drone. The chassis material we use must be sufficiently buoyant to float in water, as well as seal out saltwater to protect the electronics inside. In addition to making the chassis watertight, coating the electronics with a saltwater resistant material will prevent damage from moisture that could get inside the chassis. All of these things must be within a reasonable budget. This drone should be able to be sold on the market for an MSRP of $50.

Dr. Lund requires us to design the boat to be fault tolerant. Handling a total loss of power and rebooting when power is available. Another fault tolerance would be detecting a software bug and forcing a reboot. Lund also requires us to be able to store a collection of 65,000 waypoints on the craft. This would allow a single 16-bit integer to count through the entire list of waypoints. The boat should also be able to detect if there is a closer waypoint than the next consecutive one, and choose the closer waypoint to avoid backtracking. Dr. Lund also would like us to maintain a log of the drone's path so that it may be compared to the path the drone was instructed to follow. The log must be saved in non-volatile memory so that the path may be recoverable after the drone has completed its journey.

The drone must also be able to overcome environmental conditions and hazards. The boat must be able to travel faster than the average surface current of the ocean, assumed to be about 0.2 m/s [1]. The boat must also be able to overcome average wind speeds of about 10 m/s [2]. The amount of drag from wind will largely be determined by the profile of the craft. Other environmental factors would be storm conditions, in which the craft may be flipped over, which will require detection and compensation of the paddle direction. The craft must also have some type of land travel, in order to deal with hazards such as floating kelp, sand bars, etc.

Benefits

The benefit of this drone will be a proof of concept for small crafts capable of large excursions. A working build of this drone will prove that a small unmanned aquatic vehicle is able to navigate across open water. This drone would also benefit technologies in remote oceanic research by serving as a platform for possible monitoring equipment. One possible application of oceanic monitoring could be using the drone to generate a map of water temperature in a given area. This could be programmed by setting a waypoint path in a body of water and with a thermometer peripheral take data at each waypoint. In our research we have come across several unmanned submersible drones, generally for military use and reconnaissance [3][4]. Our drone could have similar applications at much lower cost for surface level surveying/reconnaissance once the initial proof of concept is successful.

Preliminary Development Plan

Our preliminary development plan involves inquiring in other departments about outsourcing the construction and development of the chassis of our watercraft. We believe if we can outsource our watercraft, it can be built by someone with more experience in manufacturing and design, which is well out of our expertise. If we are unable to find someone to develop our chassis, we will have to spend the remaining time prior to December 2nd, 2016 to develop our own chassis. Finishing our chassis before December 2nd gives us sufficient time during our winter quarter to focus purely on the electronics hardware, which we believe will lead to a better end product.

The first step in this project is getting the hardware design ready for fabrication. This includes designing or outsourcing the chassis as discussed above. Also the circuit boards for the watercraft need to be designed and printed, which requires components to be selected and circuits to be designed and tested.

Once the hardware is completed, our first step in the software design portion is to get the motor controllers to work, because our top priority is being able to move our watercraft. Once we have locomotion, we will implement a filesystem so we can load a list of waypoints onto the drone before it embarks on any voyages. The filesystem will require a wireless communication module through which data can be transferred to and from a PC. We will be using wireless in order to keep the entire craft sealed while still being able to communicate with it. This will allow us to work on GPS and navigation sensory so the craft can control its direction and follow the programmed waypoints. Last on the priority list would be a low power mode, which would be necessary for multiple day excursions, but less so for trips of less than a few hours, about the time it would take to navigate a small lake or island at an average speed of 0.2 m/s.

Mitchell will head the filesystem, and Joe will head the motor controller. Both of these parts of the project have ties to the GPS and navigation functions, so those two functions will be a shared effort. The low power mode will be worked on by whoever finishes their respective tasks first.

To demonstrate our project, assuming it successfully operates, we will provide a video during presentations. This video will show the drone in action, performing basic functions such as turning, compensating for overshot waypoints, and bootstrapping. We will play the video on a PC and have the drone on a table next to the PC. If possible, we will have the drone opened up so that people may see our PCB design and the structure of the craft.

Preliminary block diagrams and illustrations are shown below. The block diagrams have been organized into power distribution (Fig. 1), hardware signals (Fig. 2), and software (Fig. 3). Figure 4 shows a potential design for the drone, having four separately driven paddles, top and bottom solar panels, and two water tight pontoons for buoyancy and protecting the electronics inside.

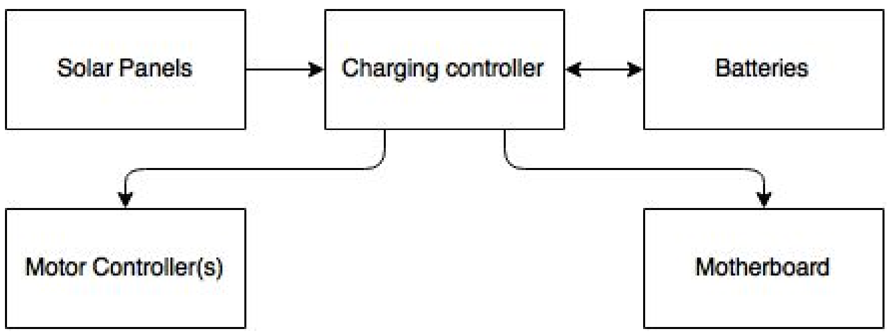


Figure 1: *Block diagram of power distribution*

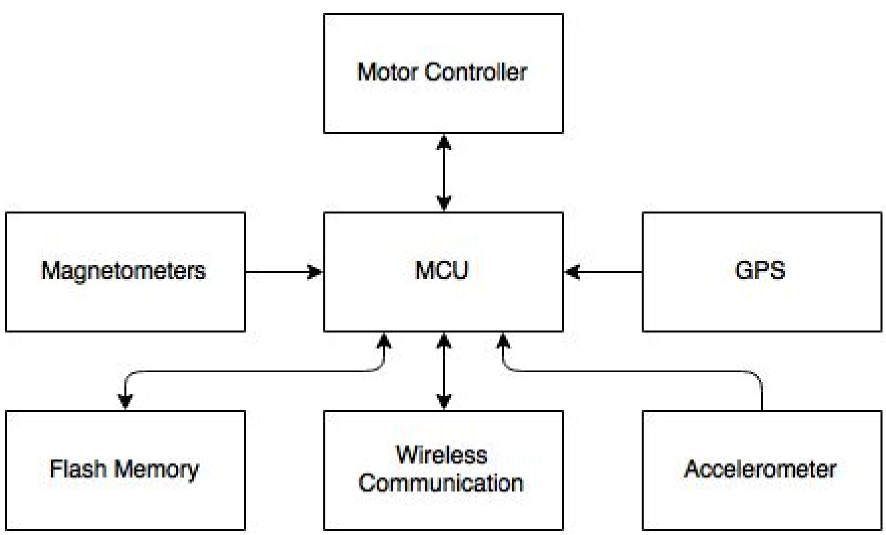
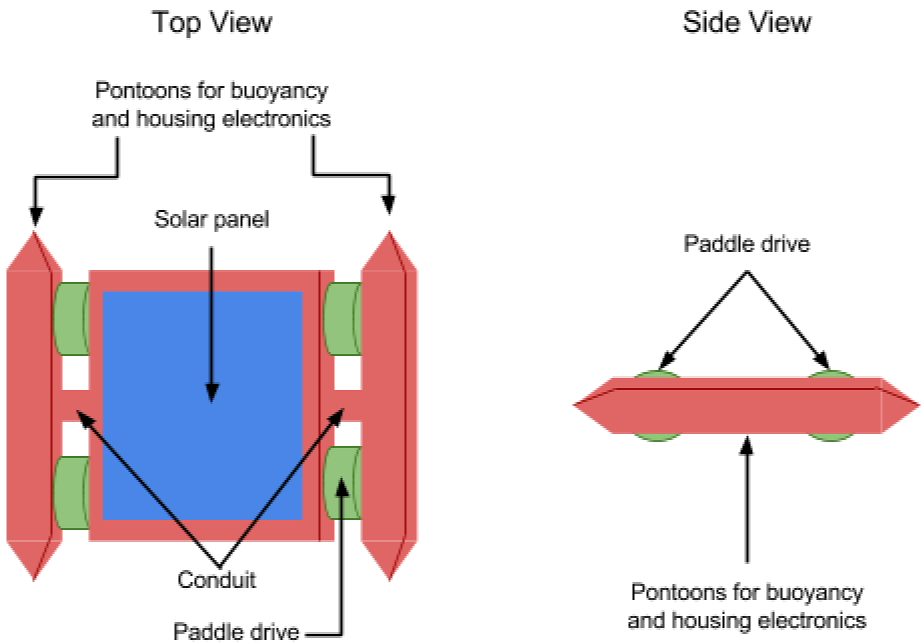


Figure 2: *Block diagram of hardware communication signals*



<u>Figure 4:</u> *Diagram of potential chassis of drone (not to scale)*

Bibliography

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