

Using a Robot to Maximize Water Sampling Accuracy

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Abstract— In the modern world, environment is of a great concern to humanity. Many efforts to aid the spread of healthy aquatic lifeforms have been made, but with varied success. The intent of this project is to make water collection procedures uniform throughout watersheds in America by use of a revolutionary robotic and cyberinfrastructure linkage to accomplish great tasks in water collection. Currently, water samples are taken from one location, repeatedly. This results in inconsistencies of chemical measurements because different parts of a body of water contain different concentrations of certain chemicals. Thus, there is a need to obtain water samples from many different locations on the body of water. This report describes a fully functional teleoperated hoverboat that is capable of taking water samples from different parts of the body of water. It is equipped with a water collection unit to provide a prototype for future plans: to make the hoverboat fully autonomous. Many of these hoverboats could be launched in different parts of America (or even in the same body of water). Many hoverboats could be completely controlled by a single supercomputer. The supercomputer would process where each hoverboat should move using a GPS uplink as well as local range sensors. By use of a supercomputer with a large bandwidth, thousands of commands can be sent to thousands of hoverboats across America (or the globe for that matter) in order to take water samples at optimal locations of bodies of water.

Index Terms— Supercomputer, Water collection, Hoverboat, Positioning Systems, Blue Baby Syndrome



1 INTRODUCTION

Normal water collection groups only collect water on the side of a body of water; for example, a lake. After the groups get data on how much of a certain type of chemical is in the lake, they report it to a state database. Consequently, if certain chemicals' concentrations are out of line, state and/or local government agencies can come and investigate the lake as a potential threat to wildlife and/or humans. However, when water collection groups get data from the same location (the edge of a lake), it can lead to incorrect levels of chemicals detected. Thus, incorrect data is given to the database about the specified area (i.e. the data reported is not representative of the entire lake and is thus flawed). This action can cause 1) unnecessary investigation of a normal lake (i.e., wasting time and the money of local and state governments) or 2) no investigation of a polluted lake (which could kill or mutate wildlife and/or humans).

Some water collection groups use methods that do result in representative sampling of water at nonuniform locations. However, these methods are usually very time consuming and expensive. One example of this method is using a canoe to manually take water samples from all around the lake (which reports proper results). However, in many bodies of water, it is clearly unfeasible to use a canoe to take water samples.

Hoverboats used in conjunction with supercomputers (which control the hoverboats) could revolutionize the field of water collection. Hoverboats moving autonomously with super-computational accuracy of prime water test locations would completely change results in pond and lake survey tests. This would impact our world by quite a significant amount through more accurate measurements of aquatic

environments. Thus, there would be no wrong results reported to the database and the state/government agencies would be able to properly recognize a polluted lake and therefore be able to take the appropriate actions. This would contribute to more healthy aquatic ecosystems for both wildlife and humans.

2 STRUCTURE AND FUNCTION OF THE HOVERBOAT

The hoverboat is a relatively small (23 in. x 12 in. x 10 in.) robot made of Lexan, a clear and durable polycarbonate compound. The hoverboat performs two major tasks: movement and water collection.

2.1 Movement

The hoverboat uses a backward facing, pulse width modulated (PWM) motor at the stern. This powerful motor allows the hoverboat to move at 15 mph and to withstand up to a 10 mph wind. The direction of steering can be controlled by a servo motor connected to the primary rudder. The primary rudder is connected to the secondary rudder using a parallelogram four bar linkage. This allows for equal movement of both rudders at the same time. *See Fig. 1 for Blueprint of side view.*

2.2 Water Collection

The hoverboat uses a winch servo in order to coil up a cable. The cable is tied to the water collection vial, and the vial is weighted so it can easily drop into the water. The vial is lowered into the water using the winch apparatus, approximately 3 feet (easily modifiable based upon the length of the cable) into the water. After the vial fills with sample water, it is then raised and set on the deck of the hoverboat. After the hoverboat collects the water, it can then be steered towards the shore so that the water collecting group can use the sample water for their chemical tests. This method can be repeated so that the hoverboat goes to

many different parts of the body of water, thus ensuring that there will be collections from many different locations and not just one (thus solving the problem plaguing many water collecting groups today). See Fig. 2 for layout of Hoverboat and Fig. 3 for water collection.

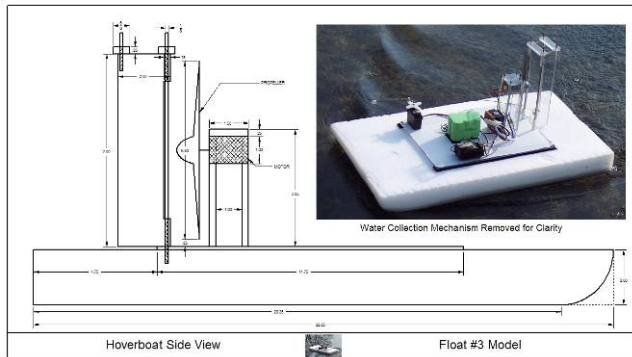


Fig. 1. Blueprint of side view of hoverboat with a picture of the boat.

3 AUTONOMY AND CYBERINFRASTRUCTURE

The hoverboat can be made autonomous by using local triangulation in order to find the real-time position of the boat. This technique uses sensors, which are put at the shore of the body of water. They continuously emit two types of electromagnetic waves (EMW)—radio and infrared waves. The two types of EMW move at different speeds; radio waves move slower compared to the faster infrared waves. At a given time, the sensor will emit both types of EMW simultaneously. However, the infrared wave will arrive at the receiver of the hoverboat first, followed a certain time later by the radio waves. The hoverboat then records the difference in time between the waves' arrival. Next, it sends this data to a laptop (belonging to the water collection group). This time difference can be used to calculate the distance from the sensor. For example, a smaller difference in time means a smaller distance from the sensor, which tells the hoverboat that it is close to the shore.

In addition, the hoverboat also sends coordinates of its latitude and longitude using a GPS system found on the boat to the laptop. The laptop sends all of the data to a supercomputer by means of encrypted signal. The supercomputer can also receive information about the area (such as high resolution satellite images and maps) from a third party source. Thus, it generates a virtual grid of coordinates relating to the lake position. It converts and averages the local triangulation and GPS coordinates to the virtual grid coordinates to find the exact position of the hoverboat.

The supercomputer then uses GPS to find the center of the lake. Next, it uses the polar coordinate system (with the lake's center as the origin) to create several randomly generated water collection points for the hoverboat to obtain water from. Subsequently, the supercomputer calculates the most time-efficient, obstacle-avoiding route for the hoverboat to take to get to the next water collection point.

Finally, the supercomputer sends the path the hoverboat is to take and the GPS map to the laptop at the site. There, a member of the water collection group reviews the path to

take with respect to possible unavaoided obstacles. If the path is satisfactory, the person can then specify how fast the hoverboat should move and sends that to the supercomputer. The supercomputer then commands the hoverboat to move at the specified speed and path. This whole process occurs hundreds of times per second in order to account for wind and other influential environmental factors.

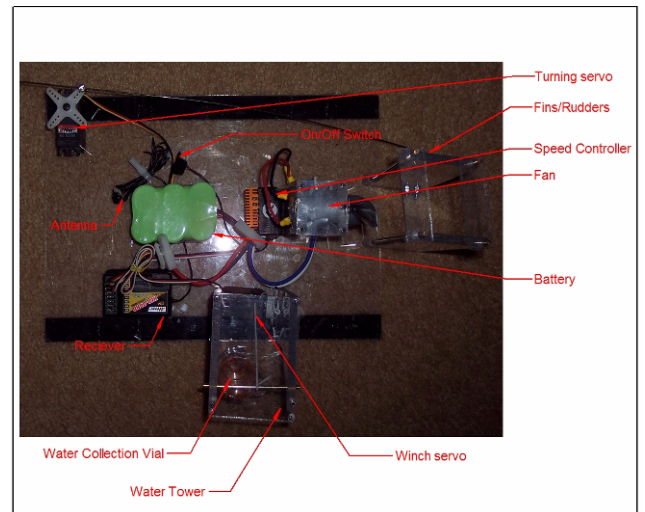


Fig. 2. Parts labeling on the barebones Lexan @ chassis.

4 EFFECTS OF HOVERBOATS ON LIFE ON EART

If the automation of the hoverboats using supercomputers could be carried out, many things would change in our world. Most importantly, public awareness for environmental concerns would rise. That is the first step to a clean earth. In addition, the hoverboat would expose polluted and biologically unstable streams more accurately and efficiently, thus leading to more swift action to protect polluted bodies of water.

Supercomputing and cyberinfrastructure will make the hoverboat easy to use; in fact, so easy that it will be the favored method of use in water sampling everywhere across the globe.

Freshwater bodies will be cleaner and more suitable for different types of life. Also, aquatic ecosystems would be affected as a whole; the snowy egrets and the trumpeter swans of Wisconsin that are killed because of high lead concentration in wetlands and ponds will be saved from certain death. This is because the hoverboat allows for an easy and efficient way to collect water samples to test for unhealthy amounts of lead. Similarly, endangered and threatened species across the world will be aided with a healthy environment.

A tragic effect of unclean water is Blue Baby Syndrome. Blue baby syndrome occurs when drinking water is contaminated with an abnormally high count of nitrates (NO_3^-). In Butler, PA in 1997, an outbreak of Blue Baby Syndrome emerged because Connoquenessing Creek, which was used to supply tap water to homes in the vicinity, was polluted. The nitrate count was abnormally high, and newborn babies were literally born blue (cyanosis) because of lack of oxygen (nitrates are known to limit the oxygen carrying

capacity of blood). The company releasing the nitrates (AK Steel) did not assume the responsibility of periodically checking the water. Neither did the public, nor the government; it simply took too much time and expertise. With the hoverboat-supercomputer link, time is cut down and more accuracy is gained because of the computational power of the supercomputer. This would reduce the likelihood for maladies such as Blue Baby Syndrome to exist.

5 CONCLUSIONS

The hoverboat-supercomputer linkage is extremely efficient; the hoverboat can be set at the edge of a body of water and the sensors are set up. Then, the hoverboat uses a supercomputer to find its position. Minutes later, a brace of water samples are at the technician's hands. Thanks to the speed of supercomputers, the hoverboat is given the most efficient route while avoiding all obstacles in the vicinity. The old water collection method (tossing a bucket into the center of the body of water) collects a single sample from the edge while retrieving the bucket back; this is simply unacceptable. All unmoving or slowly moving bodies of water have varied concentrations of chemicals from different parts of the water. It is important to be able to know the "spread" of the concentration of different dissolved substances in water (which can prospectively be used for drinking water). The teleoperated hoverboat itself is a novelty; it is useful, but a human cannot control it as well as a computer. Because of the supercomputer routing mechanism, the hoverboat can move in the most efficient manner possible, counteracting winds and water flow perfectly. Not only is this an epitome of usefulness, but also a single supercomputer can process information for hundreds (or even thousands) of hoverboats cleaning the world at the same time. Now, supercomputers can save the world too! We can save the world with technology or we can destroy the world with technology. There is only one choice.

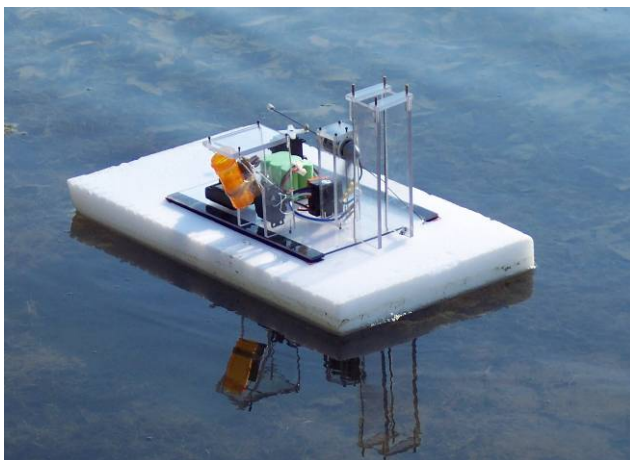


Fig. 3. The hoverboat pulling its water collection tube onto its deck

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