Design of a Human Assisted Robotic Platform for Automated Sampling Water flea Populations in Nearshore Regions

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***Abstract*— The Great Lakes have nearly two hundred invasive species that severely impact the drinking water, shipping, and recreational industries for the surrounding areas. This has also led to a noticeable shift in the ecological balance of the land. Water fleas are one of these species. spiny water fleas can have a huge impact on aquatic life in lakes and ponds due to their rapid reproduction rates. The impact of this directly affects the young fish and species survivability. A critical step in controlling the spread is to monitor them frequently across large areas. Automation of any steps in the collection process will help with such a labor inducive task and a large area to cover. The project will focus on automating the collection process while preserving the samples from contamination.**

I. INTRODUCTION

The Spiny Water Flea is an invasive aquatic species that tend to pray on other microscopic organisms essential to the life of the native fish. As they are not found to be prey for any of the native species, they propagate fast leading to endangering the life. As mentioned above; this senior design project will focus on the design and modeling of an automated test sample retrieving module. This will later be concatenated with a design for a robotic platform for monitoring water flea populations. This research will focus mainly on the spiny water fleas (Bythotrephes longimanus) and the fishhook water fleas (Cercopagis pengoi) found in Lake Michigan. Currently the process to collect samples and study the data of the spiny water fleas come from marine biologists going into the field and casting out plankton nets, with a cod-end attached to a sampling bucket, into the lake. They let the net reach a desired depth before then pulling it back up and retrieving the sample.in order to speed this process an initial design was created by Rafal Krzysiak in which six cylindrical sample containers are rotated in a cycle during the collection process. This allows for up to six different samples to be taken at any one time compared to other products that only allow one sample per submersion. We will be expanding on this design focusing on the electronics that will be doing the automation. As well the waterproofing and water sealing of the device to ensure proper operation and no contamination of the samples.

II. PROBLEM DESCRIPTION

The automated device should be able to sample water fleas in nearshore waters, up to depths of 50 m. using electronics underwater means that proper attention must be placed on an electronics compartment for a microprocessor that is water proof but still allows information to be obtained by sensors in contact with the outside environment. Moving parts cause even more reason for this attention as they are prone to leaking by nature.

To help speed up the sampling process the device would be able to open a sample bucket when the desired depth has been reached and close the sample bucket when the sample is done being taken.

Once that sample has been collected is will be sealed off from outside contamination. The device can then be moved to a new location or a new depth and collect a new sample without the labor-intensive process of switching out sample buckets. Again, it is clear the importance for proper sealing when operating underwater.

III. OBJECTIVE

The desired result of the project would be to have made significant improvement to the design provided to us. The more autonomous we can make this process the closer we can get to this goal. The Water Flea Sampling Device will allow for up to six samples to be collected before needing to go back to land. The initial design lacked any electronic elements and will be a prime focus of the design additions. The additions will allow the detection of the devices depth and communicating that to a servo motor and the user. The initial device also did not contain much for the water sealing of the device and as such is another prime objective of this work.

IV. ELECTRONIC DESIGN

the electronic design consists of; a micro controller (Arduino nano every), a barometric pressure sensor (MS5803-14BA), servo motor (30KG, continuous), an OLED screen (0.96 inch oled i2c display), A lipo battery (7.4 V, 1000 mAh), and a 5 volt regulator. figure below shows a simple wiring schematic of all these devices. The pressure sensor needed to be prepped for I2C connection using a SOIC8 breakout board, a 10K resistor, and 100 nF capacitor. These components are shown in figure 2 below.

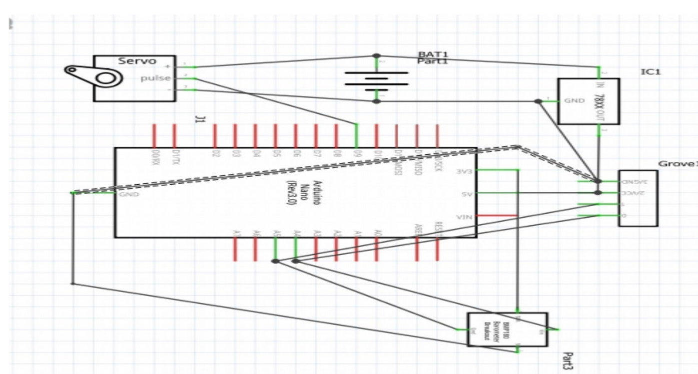

FIGURE 1 – wiring schematic

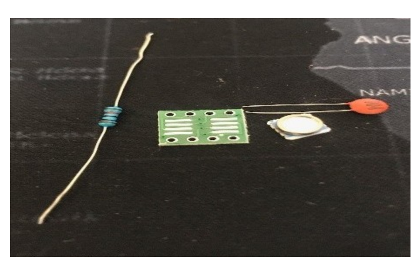

Figure 2 - sensor components

The battery will power the servo motor with its full voltage while the voltage regulator will decrease the output voltage to 5V for the Arduino. The 5V can also be used to supply power to the OLED screen. The pressure sensor will have to powered from a standard 3.3V Arduino pin. The sensor and the screen will be communicating with the Arduino via an I^2C connection. The servo will be controlled by the Arduino using pulse width modulation.

V. MATERIALS AND METHODS

The process goes as follows; using the pressure sensor detect the initial pressure in the air for a base. Then continue to read the pressure. These readings along with other important values will be displayed on the OLED screen. Using the pressure readings, we are able to calculate the depth by applying the equation below.

$$(P_{real} - P_{base})/98 = depth(m)$$

Equation 1

For initial testing we will be using a predetermined depth for our servo to operate. For example, 10 meters could be a possible depth and once that depth is calculated the servo motor will be signaled to operate and open a sample bucket. A count down will then initiate for how long until the servo again turns and closes the sample bucket.

VI. ELECTRONICS COMPARTMENT.

When designing the electronics compartment the restraints were for it to fit within the initial dimensions of the design given to build off of and to be waterproofed to be safe for electronics. The main material is PVC. Two PVC caps are connected with 3 bolts and compressed with a gasket in-between.

Figure 2 image of PVC cap

the sensor and OLED screen are connected through PVC threaded plugs. The plugs are mounted to the caps with PVC cement. Once secure a hole can be drilled to allow wiring to be passed through to allow connection. These holes will be covered on the inside of the cap using an epoxy stick. The inside of the plugs will be filled with nonconductive epoxy as to allow the proper function of the sensors circuit board, and to prevent water from entering the compartment.

VII. MECHANICAL DESIGN

The main mechanical components added to the pervious design are a Geneva drive for the servo motor to interact with and sealable caps for the sample buckets.

A. The Geneva drive

The Geneva drive will act as an error buffer for the servo motor. When rotating it is possible that the servo goes slightly further and slightly shorter than its intended distance. When ensuring no contamination this could cause issues.

B. Sample bucket caps

FIGURE 3 – Sample Bucket Cap

These lids will seal shut when not in position for sampling using a spring-loaded cap compressed against the metal chassis of the device.

C. Full Assembly

FIGURE 4 – Full Assembly

This is the full assembly in which will allow the cod ends to rotate. The sampling containers will rotate underneath the top plate aligning them with the piping that will be connected to the net. This will allow for the six containers to be filled individually without ever needing to bring it back up between samples.

VII. TESTS.

Tests have been conducted to ensure proper operation of the proper operation of the circuit and that the compartment is waterproof.

A. circuit tests.

The pressure sensor had to be installed to a breakout board and properly connected using a capacitor and a resistor to prepare it for I2C connection. Once connected the circuit could be tested using a "Scanner" code that detects weather an I2C device is connected and displays its address.

to test the connection of the servo with the pressure sensor, I needed to simulate high pressure on the sensor using a syringe. When the pressure needed to simulate a certain depth was reached the servo rotated.

B. Waterproofing

The sensor chamber was filled with epoxy and connected to the Arduino again to ensure the epoxy had not damaged the sensor. Then the sensor chamber was submerged underwater. After it was tested again with the Arduino and was operational

VIII. CONCLUSION

There is still a lot more to design for the full automation of multiple samples of spiney water fleas but a contribution has been made here. The electronic circuit needed will bring clarity on specific parts needed and the dimensions needed to fit for further progress.

The waterproofing of the electronics will bring peace of mind when considering building a larger structure around this.

AKNOWLEGMENTS

I would like to thank NIU for providing the budget for this project. Also to Sachit Butail and Rafal Krzysiak for providing an initial design for us to build off of.