Bowman Creek High Level Design

Team Bowman Creek

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1 Introduction

As a part of an initiative presented by Gary Gilot, the Bowman Creek restoration. The initiative seeks to improve the overall quality of the watershed particularly by lowering pollutants and creating a livable environment for aquatic life to thrive in. The goal is to reclaim the creek and to transform its heavily urbanized form into one that is not only beautiful but also environmentally safe and sound. With this is mind some of the improvements that must be made are centered in the underground and piped paths of the creek. The creek must not only be clean-flowing above ground but also throughout if the overall impact of a cleaner and healthy watershed is expected.

2 Problem Statement and Proposed Solution

We seek to solve the problems of the drastic change in flow rate due to obstructions caused by backflow in the underground sewer portions of the creek. The water flow rate as it is now is not well regulated and this leads to issues such a dry creek-bed when there is a lack of rain and also flooding during heavy rain periods. The flow must be monitored so that regulation systems including valves can appropriately allow a reasonable rate of water flow to not only prevent damage in the piping but also to have the creek have a steady flow throughout all its portions. With these sensors some other issues come to light, like powering such devices throughout the piping systems, whether they are to be independently powered or tied to the grid and whether the source of power is to be renewable or not as to maintain environmental goals. Along with that comes the problem of the sizing of the sensing equipment which must not obstruct the flow of water whatsoever. Also the equipment must have some protection from water so to not have chance of failure due to damage to the equipment.

In order to monitor the water depths we plan to design and build what will be a compact, affordable, and durable solution to the aforementioned problems. We plan to use solar panels as the primary power source to maintain the self-dependence of the sensors and batteries as a back-up power source which will help in cases of emergency as well as with maintenance. The unit will have a protective shell to prevent water damage. RF receivers and transmitters will allow communication between one sensory unit and a neighboring one. The two adjacent sensors will have their flow rates compared to decide if water needs to be routed differently while also saying if cleanup is necessary.

3 System Requirements

The final system will be powered by batteries. Ideally, the system should be able to run indefinitely because the solar cells we will use will power the rechargeable batteries in our system. Currently we are looking at Lithium-ion Phosphate batteries as the best choice for our system, but we still need to make sure this will be our final decision. We will have a wireless component to our system to allow for communication between the different wireless ports along the creek. What these will do is let the microcontroller know how the water pressure differs from point to point to show if there is a blockage in the creek. The current wireless transmitters we have allow for communication up to thirteen feet, so we will either need to look for different transmitters that might transmit further or have a fairly high number of transmitters along the creek.

The system we are designing will be only installed along the Bowman Creek in South Bend, so we will most likely be installing it ourselves or training a member of the Bowman Creek restoration team how to install it. If our final project becomes relevant in other environments, then we will need to train others how to install them which will involve placing the sensors along various points along the river and making sure the can communicate with each other.

One final requirement for our system is that it is weather-resistant. Because the purpose of the system is to sense differences in water pressure along a creek, and outside for that matter, some of our components will be immersed in water and snow throughout the year. This will mean that the system will need to withstand water and changes in temperature without negatively affecting any of the components.

4 System Block Diagram

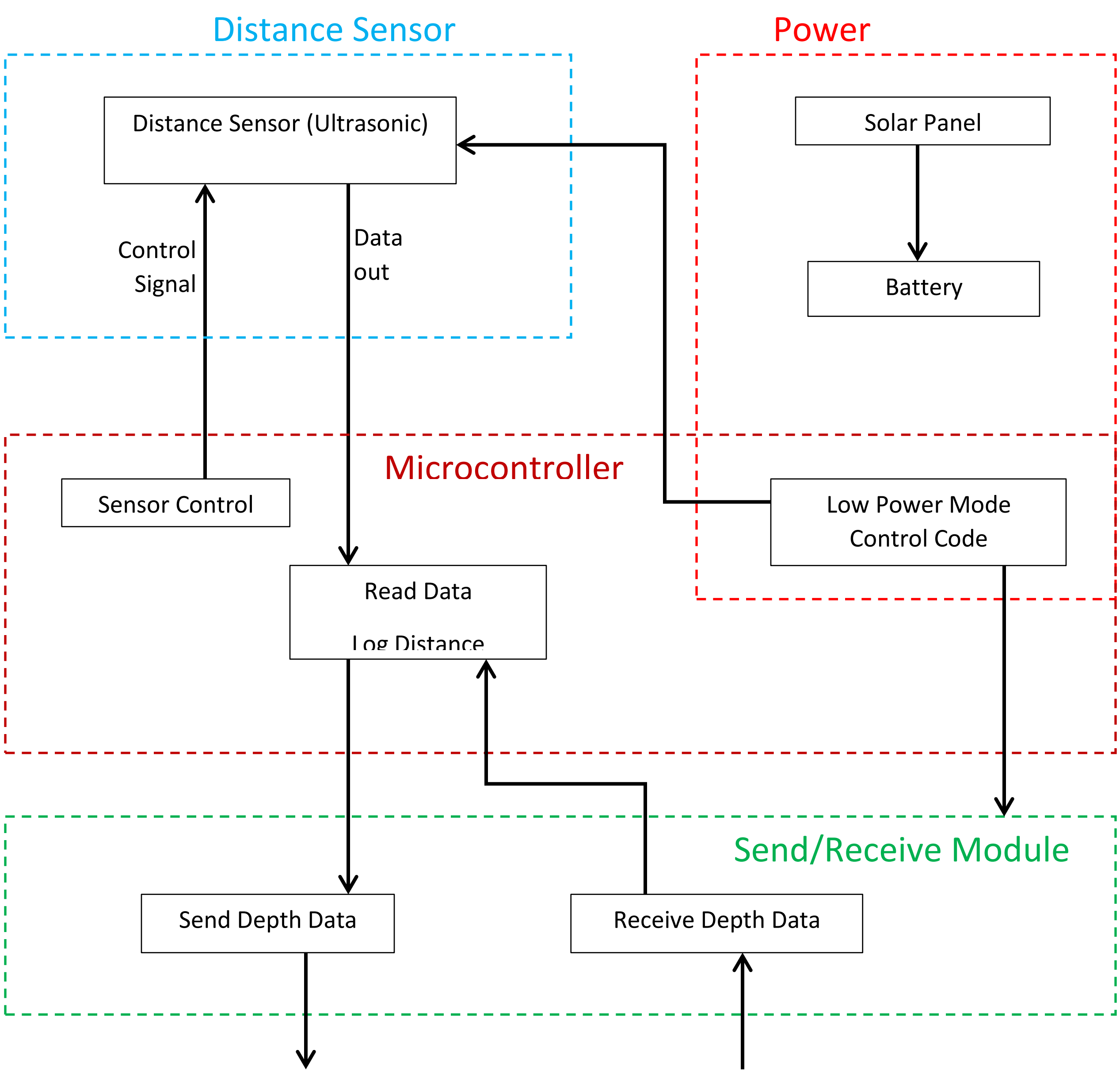
The system has only a few major requirements that must be fulfilled in order to complete its task of monitoring the water flow in the underground sections of Bowman Creek. It must first be able to measure the current depth of the water in the pipes with a reasonable degree of accuracy. The data that it collects must then be sent to the other devices in the network, and eventually to a user, in a way that will allow the flow of water in the system to be understood and acted upon by a user. The devices must also be low maintenance, with the ability to run for long periods of time without requiring batteries to be changed or similar user intervention. The system will be divided into four parts: the water depth sensor, the power generation and control block, the central processing unit, and the send/receive module. Each subsystem has a few defined functions, and will work in conjunction with the other subsystems to fulfill the requirements of the entire system.

The distance sensor subsystem has the task of measuring the depth of the water in the pipe, filling the main role of the overall system. This data must then be transmitted by the sensor to the microcontroller subsystem.

The send/receive module performs the task of sending the measured data to other systems in the network, as well as receiving the data regarding the depth of the water in other parts of the creek. One or all of the devices will also need to send data to be received by a user, rather than another device in the creek network.

The microcontroller will coordinate the transfer of data through the system, as well as control the other subsystems. As the main processor of the device, it will log data, control timing of processes, communications, and other commands as necessary.

The power subsystem fulfills the function of providing power for the other subsystems to run on. In addition to providing power, this subsystem will include software intended to minimize the power used by the system. This will minimize the need for large batteries and power generating equipment, though both of these units will still be included.



4.1 Subsystem and Interface Requirements:

Subsystem and Interface Requirements	
Distance Sensor	
General	Measure water level in pipe
Accuracy	Must measure water level to within 6 inches of actual height Should take multiple readings and filter outliers
Software	Send instruction to measure, receive depth data
Send/Receive Module	
General	Send depth and location data to other devices in network; receive similar input from other devices
Power	Peak power draw must be limited, should enter low power mode when not transmitting/receiving
Distance	Must be able to transmit over sizable distances underground in order to minimize number of devices
Software	Synchronize timing with other device to transfer data
Microcontroller	
General	Send instructions to other subsystems
Data	Receive data from sensor, log, and export to send/receive module
Control	Control send commands to send/receive, take data, and enter and exit low power mode
Power	
General	Provide power for other subsystems
Voltage	Provide correct voltages for each subsystem (3.3V, 5V, ...)
Battery	Store enough power for multiple days without significant charging Maximize cycle life for long term use
Solar Panel	Charge battery quickly (less than 2 hours)
Software	Activate the system to send/receive data and measure water depth Deactivate nonessential systems and enter low power mode where possible to minimize consumption

4.2 Future Enhancement Requirements

The initiative to restore Bowman Creek is ongoing, so there should be some room to improve the system beyond the current proposed design capabilities. Listed here are a few improvements that are currently outside the scope of the project, but which may be useful improvements to be made in the future.

It may be useful to create a user interface to interface with the devices. This interface might be passive in nature, receiving data that the devices output and then graphically displaying the current water levels in the system and how the levels have changed over time. A model of the flow conditions of the creek might also be assembled to predict trends of water levels in the future, or the effect of changes to the system, once enough data has been collected. To this effect, the data should be output in such a way as to be imported easily into a computer.

Another possible improvement could be to use the devices to directly interface with the system of valves and gates that will control the flow of Bowman Creek. This would eliminate the need for human intervention, as the devices could measure the current levels and decide whether to open or close the valves in order to maintain a steady flow of water through the creek. In order to do this, it may be wise to leave room on the device for additional connections to be made, which could be utilized later for communication with the flow control devices.

If the flow in the creek becomes more stable, the solar panels could be replaced with a hydroelectric power generation system, which would eliminate the dependence of the system on sunlight, which can at times be unreliable. This would require design of the power supply circuit such that it could work with a more constant (but possibly weaker) source of power.

5 High Level Design Decisions

The overall system is separated into the sensing and communicating between sensors. The sensing subsystem will be controlled through the microcontroller to sense the distance to the water if there is an obstacle the distance will reveal the change due to the obstruction. This will then notify that there is there is an obstruction on the LCD.

Though this done through the communication subsystem by comparing the different water level from the other sensor. As it is compared, if the distance has a large discrepancy compared to the level of the previous sensor it will then it will display on the LCD display. The communication system will most likely be RF to allow the communication between sensors for a decent range.

The other crucial system for the project is the powering system. The system will be powered through replaceable rechargeable batteries which will in turn be charged by the solar panel if that is the path we take. The enclosure will allow access to replace the batteries when necessary. The power will be monitored and if the batteries are too low it will indicate need to replace or that charging will need to take place.

6 Open Questions

As of this moment we are not sure in which way we plan to exactly communicate between different water level sensors throughout the Bowman Creek. We must further examine any existing system at Bowman Creek to modify the needs Since this is going to be a part of the water flow monitoring system we need to have make sure it can have quality communication from a distance especially since each water sensing module will be separate from the others. Another question we must think about is the material we will use to house the water sensor because we wish to have it be rugged to withstand the elements. Other questions we still have are about the kind of battery we wish to power the entire system with because it will determine the size on enclosure as well as cost to power our device.

7 Major Component Costs

The major costs for our system will probably be due to the microcontroller and the communication subsystem because we will probably test out a few different approaches to communicate between the different water level sensors to be able to measure the changes. Also the costs need to be accounting for two water level detecting modules in order to test out how the water sensors work together. If we are using the solar panel charging idea we must take in to account the cost not only for a decent charger but also a battery for the system. The ultrasonic sensor cost about $5 each so that should just run about $10 for both unless we go for a different approach. The microcontroller we plan on using will roughly go for about $50 each, therefore about $100 for both. The case will depend on the material but do not think it should go for over $60 total. The batteries should run around $10 and the solar cell will run about $40.

8 Conclusion

Overall, we are well on our way to getting the final design down. Some decisions still need to be made as to the exact components that will be used in our final design, whether the preliminary parts we have ordered to test will be enough to make our system robust. We need to communicate with the people in the Bowman Creek Restoration team to understand more about requirements such as how much of the creek they would like to monitor and other important factors. Other than that, our team seems to be pretty confident we will be able to get the system working well to help the creek and its surrounding environment.