Dr. Lucky One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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Re: ENSC 440 Post Mortem Report– ***Fish Spawning Data Collection System***

Dear Dr. One,

The attached document, Fish Spawning Data Collection System Post Mortem Report, outlines the process our team went through when designing and implementing our system for ENSC 440. Our project was to design and implement a system that could aide the Pacific Streamkeepers foundation in their efforts to manage and care for wildlife and wildlife habitats.

This document details the current state of the system, **deviations from our original plans,** a report on how our time was spent, and future plans for the device. Attached as well is an overview of the expenditures incurred over the course of the project and a description of some of the experiences that we encountered.

The Aqua Ichiban Innovations team is made up of four senior level undergraduate engineering students driven by a desire to innovate and graduate: J.P. Lee, Roger Stock, Willy Wu, and Jason Mahony. Should any questions or concerns arise, please contact J.P. Lee by e-mail at jpl@sfu.ca.

Sincerely,

J.P. Lee
Chief Ichiban Guy.
Enclosure: *ENSC 440 Post Mortem Report – Fish Spawning Data Collection System*

Ensc 440

Post Mortem Report

Aqua Ichiban Innovations

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Introduction

Over the course of the past semester, the conceptualization, realization, and implementation of the Fish Spawning Data Collection system has brought together the talents of Jason Mahony, J.P. Lee, Roger Stock and Willy Wu and produced an end project that accomplished our stated goals. In this report, we will examine the activities that led to the final project.

Current State of the Device

Overall System

As described in the project proposal, Fish Detection Module detects spawning salmon swimming upstream in the local creeks and records the fish count and timestamp into a database. The following figure illustrates the overall system flow of the process described above.

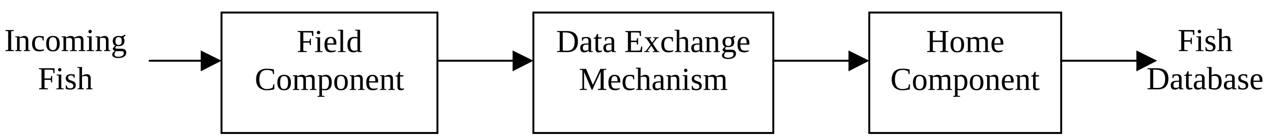

Figure 1: System Overview

As shown in figure 1, there are three main systems, Field Component (FC), Data Exchange Mechanism (DXM), and Home Component (HC), where each contains several subsystems. The overall system functionality can be explained by reviewing the functionality of each system.

Field Component

Field Component is consisted of two main subsystems, fish detection module and bank-side data storage system. The fish detection module is composed of two sets of laser emitters paired with infrared phototransistors and a Basic Stamp microcontroller. The sensors detect objects as they flow by and they send a signal to the Basic Stamp. The Basic Stamp contains a fish detection algorithm that will distinguish fish from random objects passing through the sensor beam. Once a fish is detected, the Basic Stamp will send a signal to the bank-side storage system where a timestamp will be taken and stored into memory. The FC also has an interface system that allows user to download the fish data into a Towitoko™ SmartCard reader.

Data Exchange Mechanism

Data Exchange Mechanism is the method of transporting data off the Field Component and onto the Home Component. Upon our evaluation of products that provide the robustness and low cost requirements that an FC would require, we chose to use SmartCard technology as a means of transport. SmartCards are small, reasonably waterproof, and easy to carry, thus making them excellent choices for the storage of FC data. Depending on the SmartCard brand and type, a typical model has the capacity to store 16K of memory space, which is equivalent to over 2000 fish records. There are hardware readers along with device driver to aid us in incorporating the technology into our project.

Home Component

The Home Component is the final stage of the system flow. This system contains a data analysis subsystem and a user interface subsystem. A Visual Basic program is developed to incorporate the two subsystems. The program contains a graphical user interface where a user can interact with the program to upload the fish data and to execute data processing functions. After the user has loaded data into the computer, fish data from the upstream and downstream Field Components can be merged and reorganized to produce a final database. This database is configured in Comma Separated Values (CSV) format and can be saved anywhere that the user selects on his or her home computer.

The testing for our system was performed in a controlled, laboratory environment, using a fish tank to simulate conditions in a stream.

Deviation of the Device

Overall System

In terms of functionality, we have achieved most of the goals we planned. Due to time constraints, we were unable to finish developing a power subsystem that will enable the Field Component to be powered by batteries. We were also unable to implement a multiple simultaneous fish detection system due to budgetary constraints. Additional deviations will be explained in the following sections.

Multiple Fish Detection

The current state of the sensor grid pattern limits our device to detect fish swimming in single file. The main reason for this limitation is the lack of conformity between various fish swimming patterns. However, with a larger budget and more time, AI is confident that it could come up with a reasonable solution to this problem. We originally designed a massive sensor grid system for detecting multiple fishes. Due to budget restraints, we were not able to implement a system with more than 4 laser-emitter pairs. Our sensor grid system would also need further improvement on the physical layout. Since each species of salmon has a different swimming pattern, expert knowledge is required.

Power System

Currently, the Field Component System is powered by a laboratory power supply. This differs from the functional specifications in that the functional specifications stated that the power subsystem would be independently operational for up to 2 months. However, due to budgetary constraints we were not able to afford a large enough battery to power the PC that is out in the field. In addition, using an independent power source to supply the PC would have introduced instability into our system. We did take the power subsystem into consideration when selecting the lasers for the sensors. By choosing lasers with power consumption rates of under a mW, we were able to ensure that if an independent power subsystem were to be designed, the lasers would drain the battery as slowly as possible.

FC Data Storage Subsystem

The FC data storage subsystem deviates slightly from what was initially planned in the functional specification. The data was intended to be stored in a "single chip computer" but the development of a firmware driver that can communicate with the SmartCard Reader via the proper protocol was hard to overcome and time consuming. We have sacrificed the compact size advantage and incorporated a strip-down PC to handle the file transfer between the BASIC STAMP and SmartCard Reader. Nevertheless, this modification has successfully accomplished our intended goal.

Future Plans

During an interview with Dr. John Bird, our group realized that the technology we were developing had other possible applications as well. Dr. Bird told us that a device residing on the field taking periodic measurements of temperature and turbidity of the water had value as a research tool. In order for our system to be in use to Dr. Bird, we would have to design a way for the data acquired by the sensors to be written on a SmartCards without the use of a PC. By doing so, we would greatly reduce the power consumption rate.

In terms of developing the fish sensor, we would be interested in being able to modify the software so that sensor settings could be added or removed more easily. Presently, the sensor settings are designed to support only 2 pairs of sensors, however, it is quite modular in its design. As a result, by adding a few lines of code, the fish sensing system can be made to support multiple inputs, and count objects passing both with current and against current.

Finally, to make our project truly applicable in the field, a power subsystem must be added. Because the design of a waterproof, sustainable, lightweight, environmentally friendly and quiet power subsystem is difficult to achieve, it becomes increasingly important to have power consumption as low as possible. A way of drastically reducing power consumption would be to eliminate the PC in our system. The PC can be eliminated when we can find a replacement way to interface with the SmartCard reader and communicate with the Basic Stamp microcontroller, as well as provide time stamping functionality into our system.

Budgetary and Time Constraints

Budget

The following table is our budget.

Required Material	Estimated Cost	Actual Cost
2 Smart Card Reader/Writers	$150	On Loan from PICS SmartCards
4 Sensors: Phototransistors, Laser Diodes, Resin, Epoxy, Wiring, Heat Shrink, Waterproof casing, LEDs	$300	$130
Custom Designed Mounting Brackets	$700	Sponsored by Mr. S. Stock
Basic Stamp Microcontroller	$190	$190

Time

The design of the project allowed us to have a framework in which we could assign each section of the project to a prime, and the prime would be able to go about their task independently, with help from other members of the group.

Fish Sensing

After the design document was in place, we were able to research the options that were commercially available to us. At the beginning of March, we still were uncertain about the viability and the possibility that we could purchase commercially built lasers. Therefore, we began researching to see if we could produce our own lasers in house. By mid March, we had identified prototypes that we knew would work in water, and by late March, we had completed a working prototype that was able to sense and receive information through water. During April and throughout examination periods, much work was spent on the fabrication of the remaining laser and receiver pairs. In the process, we also designed the mounting bracket of our presentation environment, which we then sent off to a custom machinist to fabricate. By the end of April, were able to integrate it with the Basic Stamp Microcontroller without any problems.

The Fish Processing Unit

In early March, the needs were identified that we needed a discrete processor to perform logic functions with respect to time. An analysis was made of project available on the market and we decided that with its quick implementation and ease of use, the Basic Stamp Microcontroller would be the best product for us to use. Before the Design Specification was due, the major modules were designed and tested, allowing us to confirm that the use of a Basic Stamp in our project was indeed a sound decision. In March, it was decided that the Basic Stamp could serve a dual purpose of not only processing the signals obtained from the sensors, but receive input from the user as well. Work was also performed to determine whether the Basic Stamp required buffering and voltage comparators or Schmidt Triggers in order to work. It was discovered through experimentation that no additional buffering was required for our particular implementation.

The Field Component

The software of the Field component was designed in early March. We had identified the major parts of the software, which was to handle input signals from the Basic Stamp, to create time stamps, and to write and read from the SmartCards Interface. By mid March, a prototype Field Component was completed, and throughout late March and early April, bug testing was performed, and problems such as unsigned integers and un-handled exceptions were identified and corrected.

The Home Component

Because of the modularity of the system, portions of the Field Component, particularly the portions that process timestamps and interfaces to the Smart Card, were reusable. After the prototype of the Field Component was completed, we found that the Home component took a fraction of the time to implement. By mid April, the Home Component had been completed, exactly upon schedule.

System Integration

Our design allowed us to identify potential problems early. By having a modular design with clearly defined inputs and outputs, it became easy to identify whether or not each section was behaving properly. Each section had to be thoroughly tested for compliance with the design specification. Therefore, system integration was rapid and required much less time because we already knew that each part worked as it should have, and therefore system integration became only a problem of finding a stable operating system and ironing out small details such as hardware layout.

Inter-Personal and Technical Experiences

J.P. Lee

Over the course of this project, I learned how important it was to state my ideas clearly in order to reduce ambiguity. At the beginning of the term, I had a clear but unrefined idea of what I was trying to accomplish. I had even thought about the parts that I wanted to use, and was thinking about how they were going to fit together. However, being told that I had to think about the project in terms of functional components and how they communicated with one another set my progress back somewhat, but it did give me the opportunity to analyze all the parts of the system and allowed me to realize that some parts of the system were either unnecessary or could be performed through cheaper means.

I regret that much time was spent unwisely in the middle of the semester as my group and I had to overcome the feeling of hopelessness as we felt the scope of the project was beyond us. But we overcame that problem when we agreed to change our expectations, and we challenged each other to come up with solutions, once we had a working design.

The biggest thing that I would want to take from Ensc 440 is that once the direction is set, nothing but "fire in the belly" determination can take you to your final destination. Be determined, and don't give up easily!

Roger Stock

Undertaking this project was a valuable experience for me in many areas. In this project, I felt I had a chance to play a broad role for our team, being involved with many areas of the project. I am pleased with what our team accomplished this semester.

I enjoyed playing an active role in project management, which helped our project take shape before any of our ideas could be implemented. I found the greatest challenge for our project was working on the high-level design and definition of the project. As opposed to other projects that may have a clearly defined goal or result to aim for, this project required a lot of effort to define and work out what we were trying to accomplish.

From a technical standpoint, I gained software experience dealing specifically with the Field Component of the project including data management, serial communications, and encoding algorithms. Helping out in other areas of the project exposed me to research for the project applications (the Streamkeepers program), research of sensor technologies including through-beams and lasers, and reacquainted me to microcontrollers.

I don't feel there is much I would do differently in undertaking this project in retrospect; I've come to realize time management lessons may the hardest to learn, and perhaps long nights in the lab are truly inevitable.

Jason Mahony

Through the process of designing and building our project I learned to appreciate the importance of creative thought. Allowing everyone to express their opinions fully before offering criticisms is crucial to the brainstorming process. One problem that I have experienced in the past is a tendency to favor individual work rather than group work. In the early stages of the project, however, I learned the value of working as a group. Learning to understand this value became extremely important whenever I was stuck on a problem. Rather than beating my head against a wall, I spoke with other group members who were able to add a great deal of insight. The value of teamwork was particularly evident as we worked together to create the functionality of our device.

In addition to learning various interpersonal skills, I also gained a great deal of technical experience. For instance, when confronted with a difficult task, always search for a more simplified solution. While designing and modifying the sensors and transmitters, I frequently came across physical and mental roadblocks. However, by learning from past mistakes and communicating with other group members, colleagues, professors and friends I was able to finish the task. Furthermore, I have become much more familiar with electric circuits, component and various pieces of technical equipment in the lab as well as the Basic Stamp. Finally, I have now become much more familiar with how to use a variety of resigns, drills, soldering irons and epoxies. Prior to this project, I had little experience with these building materials. However, I now feel much more confidant getting my hands dirty.

Willy Wu

From the technical perspective, I have gained both software and hardware experience from this project. In terms of software, I learned how to program in Visual Basic, and this is a valuable experience and much needed programming skill to add to my software-lacking knowledge. From the FC Application made by Roger, I also have learned how to program communication with the serial/com port. Working with SmartCard technology is an interesting and unique experience. I have studied how smart card operates and the various different type of protocol it uses. I found the SmartCard is quite useful and can be applied to many different applications such as personal identification and physical information for medical purposes. In programming aspect, the Towitoko driver is extremely helpful on bridging my VB code to the SmartCards reader. If possible, I would like to dig into more detail of how the driver works in the firmware level. Aside from dealing with the usual electronic circuitry, I have taken apart a computer for the first time. Stripping down a computer down to its bare minimum operational stage and configuring the component to serve our FC Data Storage System is rather interesting to learn. In addition, if time permits, I would like to see how Jason accomplished his great work on waterproof sensors.

Through out the entire course, I have endured through the exhausting project planning and designing. It was tiresome, but it is very valuable experience to me. With a good project planning and design, I was able to implement the assigned work with ease. Before this, I always step into implementation first and plan second. I usually end up wasting time and modify my design due to the difficulty encountered during implementation. It was different in this project; with the help of teammates, we were able to clearly state what we wish to accomplish and the path to take. By clearly defining the functional and design specification, I have solved countless problems and unclear issues that I would not have solved if those specifications weren't complete.

Even though I have several experience of working in a group, this group experience was an important one to me. The reason is that I don't really know my group members before the project, so communicating with them is an important lesson for me. I have learned to discuss calmly and to accept their ideas. Throughout the project, we did not have major argument that would delay the thinking process. The team chemistry also grew stronger as the semester passed and deadlines approached. This is something I have never experience before, greatly due to the fact that most of my group work were done with friends. Working with strangers also implies that one must accept others' weakness and embrace others' greatness. At last, this project is not just an ordinary project, but a great learning experience and lesson for what is needed to join the real engineering work force.