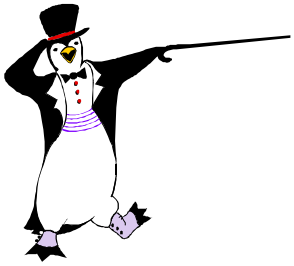

LightTouch Limited

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April 20, 1999

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC 370 Project LightTouch Process Report

Dear Dr. Rawicz,

The attached document, LightTouch Process Report, outlines the process our group experienced during the design and implementation of our device for ENSC 370. The purpose of the device is to implement a PC pointing device using CCD's.

This document covers the problems encountered during the design and implementation of the device, the differences between the actual prototype and the one in the design specification, and the personal and technical experiences of each team member.

LightTouch Limited consists of four motivated, creative, and talented third-year engineering students: Bruce Chen, Gary Chu, Alex Jiang and Jonathan Young. Please feel free to contact Jonathan Young at jmy@sfu.ca if you have questions.

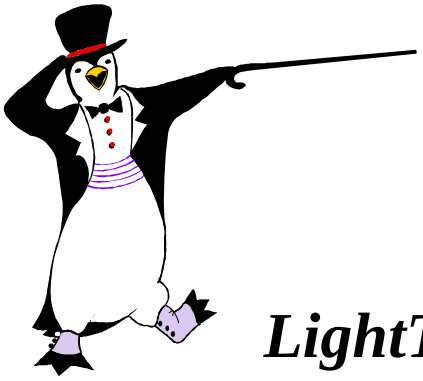
Sincerely,

Jonathan Young,
LightTouch Limited

Enclosure: ENSC 370 LightTouch Process Report

LightTouch System

Process Report



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1. Beginning of the Project

At the early stages of our project, our group decided that our goal was to deliver a good design such that it would simplify later work stages, allowing us to spend our time more efficiently. Therefore, a large amount of time was dedicated to theoretical discussion and design blueprints. We had group meetings very frequently to exchange ideas, integrate individual designs and models, and evaluate the results. This emphasis on a meticulous design was to make our project more robust and free of any major late modifications. However, we spent too much time on the paper design and overlooked the importance of the actual experimentation that should verify and validate the design. We were over-optimistic about the performance of certain components such as lenses and sensors and expected them to produce the ideal results. Although we had a good design, the lack of experimentation caused a number of difficulties as the project progress forward.

2. Problems Encountered and Changes Made

During the project implementation, we encountered three major problems related to lenses and CCD sensors: defining and finding the right lenses, programming CCD sensor driver software, and poor physical CCD sensor characteristics.

After a lot of research and consultation, we were not able to source lenses that are most suitable for our project. Ideally our CCD sensors require lenses that have very small focal length, about 5 mm, and provide a minimum viewing angle of 90 degrees. The type of lenses that qualify these requirements are the converging lenses used in video cameras. Unfortunately we were not able to source one and use it in our project. Other possible substitutes were either too expensive or too complicated to implement. Instead, we used the same type of converging lenses, but with a much longer focal length and smaller minimum viewing angle than desired. Because of the undesired lens quality, we were not able to demonstrate our project on the monitor as expected. The longer focal length and smaller viewing angle changed the original touch screen demonstration to a touch pad demonstration.

The second problem occurred when we underestimated the level of difficulty of the CCD sensor driver software. In the original design, the CCD sensor driver software was designed to receive analog output from CCD sensors, perform analog-to-digital conversion, and transfer sampled digital data to the host PC. It seemed like a simple task; however, it became much more complicated when the software design was implemented on the microcontroller. The software on the microcontroller in fact required a lot of interfacing among CCD sensor, microcontroller, and PC, such as synchronization of the entire system, exact time for specific events and actions, and handshaking protocols between different units. In addition, the driver required several memory management functions such as data buffering and queuing.

The third problem encountered was the characteristics of CCD sensors. In order to satisfy the linear motion detection requirement, a parallel background light source must be used. Without background lighting, the ambient lighting condition was so dark that CCD sensors could not detect light intensity changes. Without parallel background lighting, CCD sensors could not accurately locate the presence of the object because the point light source, a light bulb for example, produced a lot of undesired light scattering and interference that significantly deteriorated the quality of images. Moreover, CCD sensors were extremely sensitive so that their outputs were not as constant as desired.

Because of this non-optimal configuration, the resulting image was not very stable. The background subtraction feature for image processing therefore became impractical, and it was not implemented.

4. Things That Should Have Been Done

If given the chance to redo this project, we would like to improve on three different process of the project. First, we would do much more research into optics. This includes learning more theoretical matters, as well as more experimentation of possible setups for the project. We sought the help of a number of people from the physics faculty, but received little help from them as we approached them near the end of the semester, when they were leaving for the inter-semester break. We didn't seek their help earlier because we needed the hardware first to test the optics setup. In retrospect, we should have asked for help much earlier, even without the completion of the hardware.

Another task that should have been performed earlier is the characterization of the CCD sensors under the typical operating environment of the system. But this step is almost impossible without building the rest of the hardware, which shows what the CCD's "see." To get a sense of the CCD output, we should have asked the CCD manufacturer for samples of field outputs of the sensors.

5. Group Dynamics

The aim of the group was to complete the project in the most efficient manner possible. Tasks were assigned to the person most qualified for them, and each task was assigned to a single person to minimize communication and integration overhead. This delegation resulted in two personal dissatisfactions. First, learning opportunities are limited as every member does what they are best at, and do not get much exposure to other areas. We accepted this drawback in face of the time constraints. Another problem is that the project halts to a stop whenever a task, one that other tasks depends on, is not finished in time. The problem got worse when the responsible member was unable to work on it

All decision making processes were performed in democratic fashion. Everyone voted and majority ruled. With a team of four, stalemates occurred quite frequently. A stalemate led to more discussion and sometimes turned into heated discussion. A lot of time was wasted this way during the initial period. The stalemates were resolved when Alex Jiang forcefully stopped the arguments. Our solution to this problem was to give one person an extra vote. Its effectiveness remains untested as it was implemented near the end of the project after which most of the main decisions had all been made. In retrospect, we agreed that a more formal and hierarchical structure should have been adopted.

6. Personal and Technical Experiences

Jonathan Young

It seems strange to write such a document on Inter-Personal and Technical experiences because I am fairly sure that my future experiences will not resemble this one enough to make this document useful. The keys to working well in a design group seem to be adaptability, attention to minute details of a design and hard work. While the latter is universal, little can be done about the first two until a project exists.

Technically, I learned how difficult it is to write software driver software on the PC. I learned rudimentary techniques for programming on the HC11 as well as gained practice using various test equipment. Also I have gained experience in hunting for electronics parts out in the real world, which I have never done before. I gained insight on the software architecture of mouse drivers for DOS and Windows, although in our final project I decided that all the effort was not worth it. I learned how to access the parallel port from a PC side as well as the serial port, under DOS and Windows, and now I appreciate how easy a single tasking operating system makes timing dependant programming compared to Windows. I also understand more fully the difficulties with real time PC programming and the need for very thoroughly considered communications protocols. One of the best ways to learn to be careful when programming communications software is to make a subtle mistake which causes a project to blow up in your face and punish you for hours or even days.

The most important factors when working with other team members seems to be patience, asking the right questions and preparing for meetings with the proper research. In theory sticking to a planned schedule is extremely important but often practically impossible when learning to work with new, unknown technology. The ‘unknown’ factor when testing and debugging new equipment, in our case optical sensors, microcontrollers, and communication protocols is simply too great to expect a group to successfully follow the procedures listed in a Gantt chart. In retrospect, if we had forged ahead to meet our deadlines instead of taking the time to ask for help from professors and teaching assistants we would have only wasted time. Designing properly with full understanding is more beneficial in the long term than rushing through to meet deadlines.

At this point, near the final completion stage of our project where results really count, I am extremely pleased with all my group members. By creating a project from an idea to having a current working prototype in the lab we have demonstrated our ability as future engineers and we have done it together. Several times I had given up this project for dead only to discover my colleagues had solved the problem. Our success with the optical portion of this project shows ability not only in electronics but in ability for fine tune physical casings, light sources, lenses and pointers to achieve desired results. Though our prototype is not perfect, we have accomplished much and I am very pleased and satisfied with the results LightTouch Limited produced this semester.

Gary Chu

The last four months have lead me into a number of technical areas, including PC interfaces, microcontrollers, real time systems, CCD operation, image recognition, and the hardest of all, optics. These are the things I wanted to get into with this project. However, at times, I regretted having a project that involved so many fields, most of which our group had little or no experience with in the beginning.

Writing all these documents is a good way to learn the engineering design process: the specification, design, and implementation. I strongly believe in designing the system before implementing it. However, this project is giving me reason to think otherwise. Our actual design is almost entirely different from the one in the design specification. One little unexpected change in the response of a component lead to quite a big change in the design. So it is worth the time to put these unstable / preliminary design on paper in such detail in the first place?

The most important thing I learned from this project is teamwork. More specifically, how to work in a team (actually how to work with someone other than myself). I have learned that different people have different motivations and needs, and trying to force other people into my point of view simplify does not work. And that my belief could be devastating wrong! Compromise and trust are the key to teamwork.

Like other group members, I am very satisfied and happy that we, as LightTouch Limited, are able to turn an idea into a working (albeit not perfect) prototype.

Alex Jiang

Working on this Ensc370 project has been quite challenging at times. The technical challenges were expected as the required skills in fields such as optics were lacking. The lack of skills however was also an opportunity to expand beyond our intended fields of study. But towards the end of the semester the shortage of time forced us to each specialize on a portion of the project. Furthermore we partitioned the project tasks in accord with each individuals' skills, to maximize efficiency. My task focused on the hardware portion of the project. I was responsible for the design and building of the circuit boards as well as the casing and the positioning of the lens. In addition I helped out with debugging the software program as needed.

An unexpected difficulty we faced was the problem with group dynamics. Opposing views often meant long periods of, in my opinion, unproductive arguments. There was a definite need for better communication between group members. I believe that listening more often to the other person's point of view would have helped to eliminate the time wasted in heated arguments. In an attempt to resolve this problem I took on the role of mediator. However unable to remain impartial, the role of mediator often transformed into the role of arbitrator. This arbitration resulted in greater efficiency, but with the

negative side effect of limited creative thought. Despite this I have learned that paying attention to each group member will in the end have a greater positive result. Compromise is essential.

Bruce Chen

This ENSC370 project provided me a valuable chance to understand other peoples and my own interpersonal and technical strengths and weakness, and to learn how to cooperate with others to reach our common goal successfully.

Technically each task of our project was assigned the member who is most capable in that area. I was mainly responsible for the optical lens selection, the characterization of the CCD sensor output, and the mapping of the sensor output to the monitor output. The lens selection was the most difficult task in our project. We underestimated its technical difficulty and started the research and experimentation too late. Even after we had consulted several professors and optics experts, we were still not able to obtain the best suitable lens and design the optimal configuration. This mistake caused the biggest bottleneck and incurred a series of problems in our project. Thus this teaches us an unforgettable lesson: it is extremely important to recognize the level of difficulty of each task accurately and prioritize the tasks accordingly in the early stage of the project; never underestimate the difficulty of every single task in a project.

In addition to my major tasks, my role in our group was to assist other members with their tasks and therefore I was able to participate in most aspects of our project. I have gained a lot of exposure to different areas such as building prototype boards, programming microcontrollers, and image processing. On the other hand, although I gained broad knowledge and experience, I did not learn all the details I wanted in many tasks of the project. In short, our task assignment method does not provide desirable personal satisfaction in terms of the amount of technical experience gained; however it does provide excellent team satisfaction because our engineering process was efficient and successful.

The organization of our group vividly reveals our strengths and weaknesses in the group dynamics. We had frequently group meetings and consistently carried on our discussion regarding the project. But much of our time was devoted to theoretical discussion and paper design of the project because a smart design was our first priority. Subsequently we did too much talking and too little working. In addition, often our group members were not easily persuaded and unwilling to compromise in the decision making process. Our group structure was too democratic such that our discussion was usually suspended on the same topic for a long period of time. Although I was always willing to compromise and accept other opinions, I was often not firm enough and did not step up to help the decision making process when I should have.

In conclusion, two improvements are crucial for enhancing the success of our group in the future. Technical tasks should be more balanced to maximize both valuable learning chances and project efficiency. Finally, stronger leadership and more compromises are needed to resolve and smooth the painful decision making process.