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Dr. Andrew Rawicz
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Re: ENSC 340 Process Report for SensorMate Parking System

Dear Dr. Rawicz,

The enclosed document, *Process Report for SensorMate Parking System*, outlines and defines our project for ENSC 340. The SensorMate Parking System is a parking lot status indication system that allows drivers to view the location of an open parking space on a large display device.

In the attached document, we will review the system overview of our project and the technical solution to our problem. Also, we will discuss the problems we encountered, from technical, financial, scheduling to group dynamics. As well, improvements and experiences we gained during the project will be presented.

Crystal Technologies is made up of four dedicated forth year engineering students – Jimmy Kan, Richard Fung, Steven Soong and Lawrence Tam. If you have any inquiries or concerns, please contact us at (604) 773-6658 or through email at sltam@sfu.ca.

Sincerely,

Lawrence Tam
CEO, Crystal Technologies

Enclosed: Process Report for SensorMate Parking System

Crystal Technologies

Process Report for

SensorMate Parking System

Submitted by
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Submitted to
Dr. Andrew Rawicz
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Date
January 14, 2002

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Introduction

From the conceptions of the SensorMate Parking System seventeen weeks ago, Crystal technologies has worked diligently towards its final completion. Since the beginning, we at Crystal technologies have imagined a system that will ease driver irritations during parking. With the SensorMate Parking System, drivers will immediately know whether spaces are available in a parking lot. Drivers will not only know if the parking lot still has a vacancy, but they will also be able to locate where the vacant spaces are.

Four innovative forth year engineering students who have experience in analog circuit design, digital analysis, micro-controller and software programming, staffs Crystal Technologies. The project had been multi-phased, consisting of research, development and construction of the SensorMate Parking System.

Through the different stages of this project, proposal, functional requirements, design specifications, implementation and testing, our team was able to fulfill the objectives that we established seventeen weeks ago. In this document, we will re-examine the process that we took to develop the SensorMate Parking System, as well as, the experience of each group member.

This document will first give an overview of the system along with the current state of the system. Deviations of the device and future improvements are also included to provide a reference for further enhancements to our product. Also, budgetary and time constraints are discussed followed by interpersonal and technical issues encountered by each member of our team.

Current State of the System

The objective of our project is to develop an indication system that provides drivers with vacancy status information of a parking lot. This project is not intended to restrict the driving behaviour of drivers; rather, it only serves as a device that assists drivers in locating a vacant parking space. With the aid of this system, a parking lot can operate in a much more efficient manner.

The SensorMate Parking system contains three major subsystems: sensory, control and display. Sensory components will be made up of reflective ultrasonic sensors that will relay space status to the controller. The controller will then interpret the data and output the result to a multi-display system consisting of a LED (Light Emitting Diode) cluster and a LCD (Liquid Crystal Display).

Sensory – The current ultrasonic sensor can detect cars at a range of 0.7 to 1.0 meters. Door sensor is currently implemented using push buttons.

Controller – The main controller unit currently handles an eight-stall parking lot. It is able to process inputs from all sensors and update all output devices accordingly. It is still capable of further expansions in the future.

Output – The output interfaces, LCD display and LED Billboard, are both functioning properly. The LCD display will show the appropriate messages when parking lot is full with the number of cars roaming and free stalls available. The LED Billboard functions as per designed.

System Overview

Figure 1 depicts the simplified overview of the SensorMate Parking System. Sensors are placed at each parking space, and the vacancy status is obtained and sent to the central processing unit. According to the input signals, the processing unit will output corresponding messages to a billboard, which is located at the entrance of the parking lot.

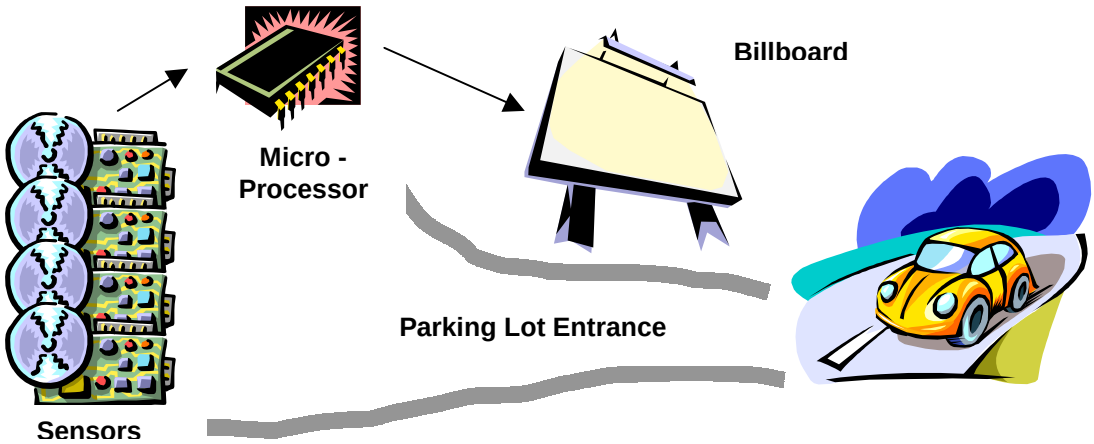

Figure 1 - System Overview

We have been pondering with the idea of using an electronic parking permit so that the sensor can detect whether a car is authorized to park at that space. If the car without a valid parking permit occupies the space, the system will notify the parking office through a network module, which directly links to a computer that has monitoring software installed. Due to the time constraint that we face, it is difficult to complete this part of the project. Nevertheless, a block diagram of this conceptual system is shown in **Error! Reference source not found.**.

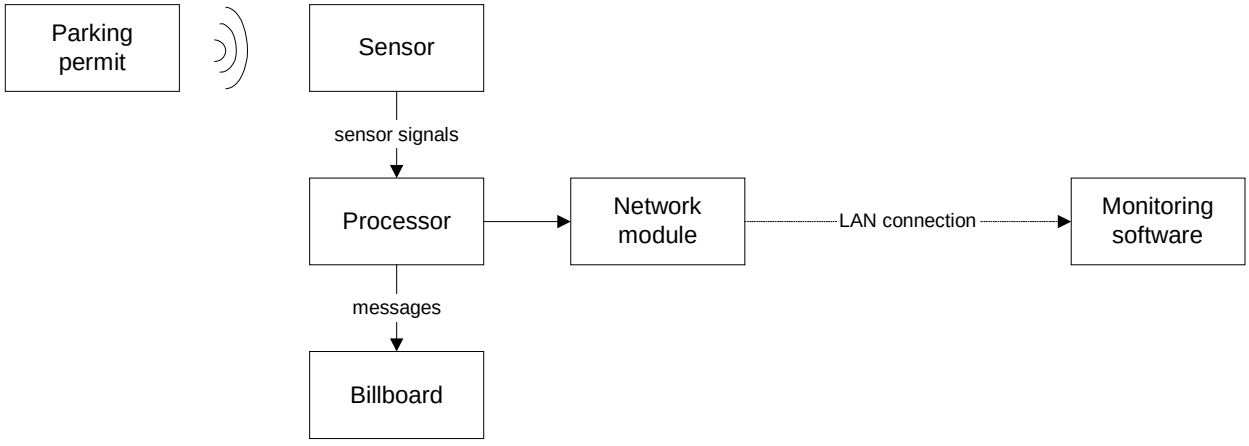

Figure 2 - System Block DiagramPossible Design Solutions

Deviation of the Device

Overall System

No major design changes were made to the system since the design specification was drafted in the early November. However, there were some implementation details that needed slight modification to our initial design. Details on the various changes are discussed in the following sections.

ICs Interface

At the integration stage of the project, we discovered that the microprocessor could not read the sensor output correctly. Even though the sensor was sending a HIGH signal (5V) to the processor, for some reasons the signal could not be detected. We solved the problem by adding an emitter follower as a signal buffer.

Components Selection

We found out that the ENSC laboratory provided the 8-channel multiplexer and de-multiplexer chips that our system required. The two components have the same functionality as the ones we originally looked at, though the hardware characteristics are slightly different. However, the differences could be easily adapted to by making minimal changes in the software and re-wiring certain parts of the circuits.

The door counter is too expensive to construct. Due to its simple nature but expensive cost, we decided to simulate the functionality of the door counters by using push-buttons. This simulation is justified because all a door counter does is to trigger a signal whenever a car rolls over it.

User Interface

As opposed to a single LED representing each parking spot, in our final prototype we had two LEDs – green light means empty and red light occupied. The reason for this change is that we want to give the drivers a stronger visual stimulation.

Presentation

Initially, we decided to present the demonstration in a real parking lot. After some careful thoughts and considerations, we agreed that demonstrating the product in a scaled down virtual parking lot indoor would give a better overview of our product. As a result of reducing the parking lot in size, the spacing between parking spots became smaller; therefore, we had to tune

down the detection range of each ultrasonic sensor so that interferences between sensors could be reduced.

Possible Future Enhancements

Sensors

When the sensors are to be implemented in a real world environment, magnetic sensors will be sensor type of choice based on their high reliability and resilient to weathering. This will even decrease the cost of the individual sensors since bulk purchases of this type of sensor are in the range of a few cents each. Since these sensors are usually buried underground, the cost of replacement of these sensors increases.

Billboard Output

Audio aids

In an implementation of the system in a larger scale, audio aids may be used in order to help drivers arrive at their empty spots of choice. Auditory signal such as spoken words can be broadcasted over a specific frequency that drivers can receive on their radios upon entering the parking lots.

Error Detection algorithm

Additional system checking to ensure that the system's state is a valid one and that the system is running smoothly under all times. This system will ensure the output of the system to be accurate and boost the users; confidence in the reliability of the system.

Input and Output Redundancy

In more critical application of this system such as aircraft parking bays, redundancy should be used in order to ensure 100% failsafe operation of the system.

Sectional billboard

The clusters of lights on the billboard can be overwhelming in a sizable parking lot. Thus, breaking up the billboard into several sections may help simplify the task of finding an available spot among all the occupied spots.

Validation

A passive validation device can be placed inside the car for validation purposes. A magnetic gateway can be placed at the entrance of the parking lot in order to sense validated and invalidated cars coming in and out of the lot. Appropriate actions maybe propagated when an invalid pass passes through the entrance.

Warning lights on billboard

Perhaps the light bulbs used in the billboard can be modified so that it shows an extra color such as yellow in order to warn operators and customers that a particular sensor is malfunctioning or stopped working.

Budget and Time Constraints

Budget

As we conclude from the budget table below, we have made a generous allotment of funds for our project. We find that our funding was met well under our expectations.

Materials Required	**Estimated Cost/Real ($)**
Sensors (Ultrasonic)	300/20
Microprocessors and Evaluation Board	300/200
Liquid Crystal Display	100/15
Discrete Components	100/20
Power Supply	100/10
Cables and Wires	50/20
Miscellaneous	50/40
Total	**1000/325**

Time constraints

While the design and the specification stages were completed well ahead of schedule, the actual concept prototype was delayed for a few weeks after our expected completion date of mid December of 2001. This was because of our compacted schedules and exams period. However, we managed to complete and present our project in early January after many consecutive days of hard work.

Major Events	**Date**
Concept conceived	In September 2001
Project Proposal	Accepted in late September
Functional Requirements	Confirmed in early October
Design Specification	Frozen in late October
Design Prototype	Constructed in early January 2002

Interpersonal and Technical Experience

Jimmy Kan

The most important aspect that I have learnt from this 340 project is working effectively in an engineering group. I enjoyed very much being able to accomplish a sizable task with a group of people who shared the same goal. We valued and respected the differences in opinion, which are almost unavoidable in a team environment. Furthermore, I feel especially proud that none of us were afraid to voice any arising question or concern. I believe that much of the success for this team is based on this candid relationship among us.

This project was split into several functional blocks and each of us was assigned to a different block. I was mainly responsible for designing and programming the system algorithm. I was also involved in the overall system design. Technically, I learned a great deal about choosing the right microprocessor for the task on hand. Many processors from different manufacturers were suitable for the project, but I chose the Atmel AVR microprocessor family because of its low cost and ease of development. A starter kit was available so that we could start writing code immediately. AVR is also supported by a set of excellent documentation, which makes the development process a lot easier. During the course of developing and debugging codes, I learned how to deal with problems related to the real-time behaviour of the circuit components, such as propagation delay of a few microseconds, switch bouncing, and high frequency noise interference.

Unfortunately, the 340 project was scheduled in a semester with three other upper division engineering courses. As a result, time management was difficult. We tried not to be overly ambitious with the scope of the project, although we were very tempted to include more functionality and feature given that this project was highly expandable. Nevertheless, this project has given me valuable experience in producing an electronics product from ideas to a working prototype.

Lawrence Tam

From the beginning of this project seventeen weeks ago, I expected this project would not only be a demanding one, but also an enjoyable experience. Seventeen weeks later, much of those same ideals in the first week still hold true. I have never gone through a whole project process from proposing a solution, to design and finally to completion of the system. Our team was focused, motivated and enthusiastic during the whole development process of the SensorMate Parking System.

Much of the success for this project has to be contributed to the excellent team dynamics we have during this project. While I had worked with Jimmy, Richard and Steven on past projects and laboratories before, we had not worked together on a project quite as extensive and intense as this one. From the very beginning, each team member had an equal voice in the development of the idea for the project. Once the goal was set, each member was focused on the tasks at hand. Regular meetings and updates kept the team informed of our progress and contributed to the successful completion of our project.

This project gave me numerous new technical experiences, as well as encountering a few old ones. While we learn about different circuit implementations for current buffers in our electronic classes, I had never used such circuits in projects. Careful design and testing was essential to the project as reliability was one of the goals of the project. Moving from the theory to the practical had been a great experience for me. To be able to apply what I learnt in theories to a project I can see, I have greatly enhanced engineering skills. Some old experiences, such as programming the LCD display, I have done in my first year of engineering were a welcoming part of this project. While I have programmed LCD displays before, I had never set one up from scratch and being able to rely on old knowledge in a new setting was a great experience.

At the start of this project, our team has been a close-knit group both in and out of school. I am happy to report that after these seventeen weeks, we are still dedicated to each other. While we had to stay late at SFU for many nights during the completion of this project, I have to say that I could not have spent it with finer company. This project taught me much about engineering, but also it taught me friendship and humanity. It was a pleasure to work with my team and I hope we can all have the same experience again in the future.

I would especially like to take the opportunity to thank my team: Richard, Jimmy and Steven, who spent many days and nights dedicated to the project. Thank You!

Richard Fung

Implementing the sensors and getting them to give the desired results was challenging, but worthwhile in terms of gaining experience. This task involved some analog circuit design, debugging, and soldering.

The type of sensor chosen was of a generic type so we were able to find a circuit that used the same sensing technique and take the parts that we needed from it. Concepts learned during the 13 weeks in other courses proved useful in developing the sensors. Particularly, multistage circuit components learned in Microelectronics II were used extensively to condition the original signal produced by the sensor circuit from an analog signal to a digital signal suitable for input into the microprocessor. It was interesting to change the signal at each stage and get closer to the desired result each time. Soldering was also difficult at first, but after some initial attempts that did not work, things improved and the sensors were made. General debugging was required for the circuits and also when they did not work when soldered onto a prototype board. Some general skills practiced were patience and perseverance.

I found the group meetings to be concise and productive. Brainstorming was found to be a good way to generate ideas and get all of them on paper. Afterwards deciding on which direction to go was discussed and decided deliberately.

One of the things we did well was communicate. Each of the members was given an individual task, but we all knew that our tasks depended on the tasks of the other group members such as receiving input from and giving output to the components made by others. In order to avoid future problems we all knew what was required of our parts to make them compatible with the other parts to make the system. We gained this important knowledge by talking frequently with the other members of the group.

In conclusion, I found the undertaking to be a good learning process and a good opportunity to put theoretical concepts into practice.

Steven Soong

One of the most valuable skills that I have gained from this 340 project is cooperating in a team. This can be related to my various past coop terms where I was also placed in a group of experienced and enthusiastic engineers. I have enhanced my communications and managements skills throughout several months of interactions with my team members. Furthermore, this project allowed me to experience being both a time manager and planner. Since this course was loosely defined at the beginning of the semester, our team basically had to plan, design, and coordinate the construction of the concept prototype. Even though there were several instances where we consulted our TAs for advice, many times we had to figure out and sort out conflicts by ourselves. I believe that these experiences will enhance my interpersonal skills and with my skills of working with other engineers.

Since the project was divided into several functional blocks among the team members, keeping track of the progress of each block is important. One of my responsibilities was to see that all the parts and deadlines were being met and that the prototype was completed in our estimated time frame.

My other responsibility included the construction of the scale model parking lot which we used as a platform to demonstrate the functionality of our system. Some difficulties were encountered when I was trying to obtain the dimensions for the scale model when the functionality of the sensors was not totally set in stone. The construction and layout of the scale model was essential in the simulation of our prototype.

In addition, I helped with the design and construction of the sensor input buffer. The problem was the output and the sensor which was 0v and 5v were not picked up by the microprocessor. We designed a buffer circuit which was a common collector, also called an emitter follower, which used the EVB power supply as the reference to the input pins.

Furthermore, I have also learned that designing the circuit is only part of the project. Transferring the bread-boarded prototypes onto permanent circuit boards was also important. I have encountered unforeseen problems when some circuits do not function as they originally did on the bread board. Troubleshooting these problems enhanced my problem solving skills and boosted my confidence in troubleshooting. Mounting and wiring up all the different components on the demonstration platform was both a tedious and challenging task. As the volumes of wires are overwhelming, good organization skills was required to install and document the wiring of the demonstration platform.

In conclusion, I believe the skills I have gained in working on this project will benefit and enhance my engineering career in the future.