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Chief Executive Officer

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April 10, 2012

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

Re: ENSC 440 / 305 Process Report – PVision Electronics

Dear Dr. Rawicz,

Please find attached, the process report for the PVision Parking Convenience System designed by PVision Electronics Ltd. for the ENSC 440 / 305 project. It chalks out the entirety of the process our company went through in creating the product. The goal of our project was to design a parking system for large, outdoor parking lots which would enable drivers to know the exact location of the vacant spots instead of cruising mindlessly for parking. Our system uses IP cameras to constantly monitor the vacancy status of all the parking spots and then, via advanced image processing algorithms, displays the vacant and in-use parking spots on a large, user-friendly LCD display outside the parking lot for drivers to see. Furthermore, it also enables the parking lot administrators to monitor statistics and collect data using a separate UI designed for this purpose.

This document is a summary of the processes – technical, financial, and intellectual – that we underwent as a company in order to create the product we currently have. It highlights the ways in which we departed from our envisioned goal thirteen weeks ago, and explains some of the challenges we faced as a team. It also notes the future direction we would like to take with this system.

The PVision team consists of five engineers in our fourth year of academics – Milad Haji Hassan, Mohammad Akhlaghi, Noah Park, Oshi Mathur and YuJie Xu. We would be delighted to hear form you in case you have any questions or require any further information. Please feel free to email us at pvision-ensc440@sfu.ca or contact us via phone at (778) 997-1717.

Sincerely,
Mohammad Akhlaghi

Chief Executive Officer (CEO)
Pvision Electronics Limited

Enclosed: Functional Specification for Pvision Parking Convenience System

Post Mortem
Pvision Parking Convenience System

Pvision Electronics

Project Team:

Mohammad Akhlaghi - CEO
Oshi Mathur - COO
Milad Hajihassan - CTO
Noah Park - CFO
YuJie Xu - CMO

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Submitted to:

Andrew Rawicz (ENSC 440)
Steve Whitmore (ENSC 305)
School of Engineering Science
Simon Fraser University

Issued date:

April 10th, 2012
Revision 1.7

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Glossary

BMP	**Bitmap image file format**
C++	**A general-purpose programming language**
GPU	**Graphics Processing Unit**
IP	**Internet Protocol**
LAN	**Local Area Network**
LCD	**Liquid Crystal Display**
LED	**Light-Emitting Diode**
OpenCV	**Open source Computer Vision**
POE	**Power-over-Ethernet**
RGB	**Red, Green, and Blue**
USB	**Universal Serial Bus**

Introduction

PVision Electronics was formed by a team of five engineering student in their fourth year – Noah Park, Milad Haji Hassan, Oshi Mathur, YuJie Xu and Mohammad Akhlaghi – who were motivated to build a product that offers a practical and cost-effective solution to a real-world problem. This report analyzes the course they took to create a functioning prototype of the PVision Parking Convenience System.

Website

Most companies and businesses have webpages nowadays days. Many Small and large businesses use websites to provide customers with information about their products and to sell their products online. Some companies go so far as to provide online functionlality to the clients depending on the product. The Pvision parking system website –http://www.miladhajihassan.com/pvision/home/ - was designed to provide the users the availability of the parking spaces as well as providing relevant information about each parking space. The website also includes information about the development of the system and information about the founders of the corporation.

Figure 1: Prototype 1 online live layout

The website incorporates a dynamic layout for each parking lot depending on the layout of parking spaces. A sample live demo of the first prototype is included in website which lets the user find the available parking spaces using a computer or smart phone. It also provides the user other relevant information such as the recent time which is the recent availability time of each parking space. The website will include a client section in the future which will ask the user to login in order to access the protected area of the website which displays the available parking spaces. Another feature provided by the website is statistics which represents the availability of parking spaces for a given day.

Figure 2: Prototype 1 live statistics

The scripting languages which are used to develop the website include HTML, CSS, and PHP.

MySQL Database

The data generated by the image processing regarding each parking space is sent to the database of the website. The database includes a table for each parking lot and a row of each table represents the data for each parking space. The database holds information such as the status of spaces, free time, occupied time, and recent time for each parking space. The database gets updated once a change is detected by the image processing and the result is displayed on the website visually.

MySQL Code

MySQL server enables the vehicle occupancy data to be transferred to the webpage. MySQL access from eclipse was made via connectorJ, which is an eclipse-MySQL library that support real time upload of data to any designated MySQL server through network. The information that is sent over to the database consists of four components. Current occupancy represents the presence of vehicle in each of the parking spaces in Boolean value. Total occupancy time and total free time represent the amount of time which the specific parking space has been occupied or free. These two statistics will enable the parking managers to more efficiently manage their parking lot. Recent time represents the time from which the parking lot had its most recent occupancy status changes. These data are calculated and get transferred over to the MySQL server after each iteration of image processing. MySQL server is accessible from remotely located devices so that end users of the smart parking manager system will be able visit the site to check the parking lot occupancy anywhere and anytime.

Lighting

Lighting is essential in our system due to the fact that different lighting conditions may result in different outputs from the system. One essential idea is to have constant light when the system is running, so for example if someone walks past the small prototype the shadow of the person on the table (parking lot) might cause the system to give wrong results.

In order to fix this, we are using a standing lamp right over the prototype so that no shadows of the object around it would appear on the table. In addition the light intensity is high enough to eliminate all the other light sources around it so we get constant lighting all over the prototype.

Plate Numbers

Pvison smart parking guidance system dose not include the plate number detection algorithm. If we want our parking guidance system to be more competitive on the market, we need to add this detection algorithm to our system. The plate number received from the algorithm will be saved into the database, and if the parking lot has a ticket dispenser, the system can retrieve the data for the specified plate number.

Night Vision

The smart parking guidance system is mainly focusing on the day-time use. If system is also used in the night-time, we need to do some modifications on the color detection algorithm. During the night time, the RBG values of the pixels on the parking ground may be different compare to the day-time, so if we do not modified the code, the result will be wrong

Google Map Integration

One of the future plans involves using the Google maps API to overlay the parking convenience system on every parking lot, which is using our system. To elaborate further, the system will show the results online over the Google maps, just like the way Google shows traffic in major streets, our system will show the occupancy of spaces in parking lots. So as you zoom in to a parking lot, the spaces dynamically show whether they are occupied or empty by using different color settings.

Ticket Dispenser

One of the challenges we had to overcome in our system was the scenario that a driver is waiting for a car to pull out of a parking space and instantly parks there and at the same time another driver is looking at the screen and sees an empty space not knowing that someone has already planned to park there. To avoid this conflict we are planning to use a ticket dispenser system at the entrance of the parking lot. This dispenser will assign each driver a fixed parking space based on total status of the parking lot. An algorithm will calculate the best available parking space (closer to elevator or exits) and output a ticket with direction to how to get to that free space.

SMS System

We are also going to build a message system that if a driver has been parked his/her car in the parking lot overnight, so our smart message system will automatically send a message to the specified driver to tell him/her. For driver's information, the system can get from the plate number detection algorithm.

Algorithm Development

The current algorithm only detects the occupancy by analyzing the pixels from the image. However, this method has limitations in extreme weather conditions and at night time when there is not enough lighting available. It also has hard to recognizing the size difference in human or other small objects to the vehicle. In order to improve the accuracy, object detection algorithm is required. As object detection is much more reliable since it can self-adjust to the lighting changes in the environment.

Movement Detection

The current system is analyzing the every frame of images fed by the cameras. If the final product is to be sold in the market, it needs to be more energy efficient. Running the JAVA code for image processing require significant processing power which leads to more energy consumption. In order to reduce the energy consumption, we will modify the algorithm to begin the vehicle detection algorithm only when it detects movements in the parking lot. This will also be beneficial for end-users who want to store the video from the surveillance camera for days. Considering there is no car come in and out of parking lots half of the time, the half of images get stored in the server with no important information on it. Movement detection algorithm will reduce that wasted storage space.

Timeline

The Gantt chart on the next page shows the initial plan proposed. However, several factors caused us to run off-track on a few occasions. Likewise, having started the planning process for the business and the product, we were ahead of the game in certain aspects. This even enabled us to demo a week earlier than we had initially planned.

The points were we deviated form the expected timeline have been highlighted in figure 3 below. The solid green boxes mark the tasks we completed earlier than expected while the yellow boxes have been suffixed next to tasks where we were behind schedule. Both of the above have been discussed below in the order in which they appear on the Gantt chart from top to bottom.

Marketing Research

A few of the members had been in discussion about the idea before the semester started. As such, the market research started earlier than expected and was complete before the end of January.

Research and Planning

Despite being a couple of members short, we were able to complete the research and planning earlier than predicted since the market research was completed early.

Design Specification

We faced a big delay in the shipment of the graphics-processing unit, SmartGPU. The unit arrived over two weeks later than promised by the manufacturer.

Testing

The camera we initially ordered was at a time when we thought that a single camera would be sufficient to aid the image processing that we needed. The field of view however, was restricted and we determined that we would need two cameras at least in order to correctly ascertain the available and in-use parking spots correctly for our first prototype (and also the second one). Thus, we had to order two new cameras while trying very hard to stay within the budget we set. This pushed us back a lot but we were able to catch-up just in time.

Implementation

Our first prototype was seeing the use of the embedded system which would process images at frequent intervals using C++. The SmartGPU and Arduino were programmed using C++ as well to pick up information from the embedded system in the form of zero's and one's for any given parking spot being vacant or taken, respectively. The GPU (attached to the Arduino) was then supposed to display this information graphically at the same intervals of time with no apparent lag. While the two components worked really well individually, we found that it was essentially impossible to write a piece of code which would receive the output form the embedded system and then input that to the display system (GPU with Arduino) in real-time. We consulted several online sources and fellow engineering students and re-did our coding entirely in Java in hopes of getting the system to work. Unfortunately, we did not have much luck despite this mammoth effort on our part.

Final Testing

Having taken a head start in the development of the final prototype, we found it to be working without errors, unlike our first prototype. This enabled us to test and film the implementation of our final prototype early.

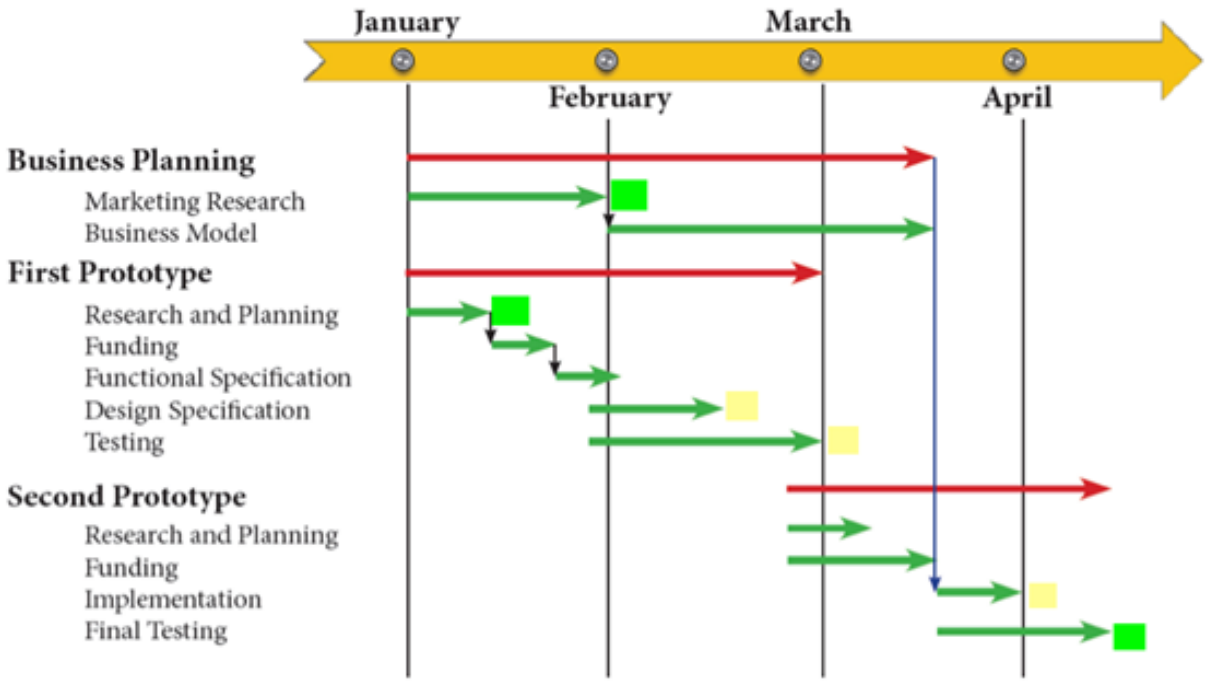

Figure 3: Gantt Chart of Timeline

Table below shows our cash flow statement. The two columns compare the estimated costs and the actual cost.

Components	Estimated Cost	Actual Cost
720p webcam * 1	$60	$38
Arduino Board w/ GPU, LCD	$160	$120
Model Table	$50	$67
Sandpaper * 2	$15	$16
1st Prototype total	$285	$241
720p HD IP Camera with night vision * 2	$500	$430 + 24(TAX)
POE switch	$70	$82
60m LAN cable	$30	$20
RJ45 jack * 17 (30cents each)	$10	$5
720p HD IP Camera after refunded/restocking fee	-	$22
2nd Prototype total	$610	$583
Total	$895	$824

Table 1: Budget and cost table

Testimonials

Mohammad Akhlaghi

Chief Executive Officer (CEO)

I started thinking about my 440 project a year ago, since I knew this was going to be a challenging course and it really was. I could easily say 440 was one true engineering course since we had to do everything ourselves from scratch. All the pre planning finally paid off and the project turned out to be more amazing than I was imagining it in my mind.

At first I was planning to work on the software side of the project however after having multiple meetings I figured Noah has more experience in that field than I do so I decided to move to hardware side of the project. I started by creating the small scale prototype which was very challenging since I had to think of many different variables while designing it. The prototype had to be stable, reliable and at the same time flexible in a way that we would be able to test every different scenario on it. The 3D design of it took a while and I eventually came up with the best design that came across my mind, my journal is a good representation of my thought process. The wood work turned out to be very challenging due to the fact that I had no previous experience working with wood. After all, the end result was very satisfying.

I moved on to work with the Arduino and add a hardware element to our device which was faced with a lot of problems. Problems that, with the power of teamwork, we eventually did overcome. Here I learned how teamwork is essential in completing a task. My past experience in developing websites motivated me to suggest the idea of having a website. I wasn't expecting it to be this amazing but what can I say the group did an amazing job putting it together. Milad and I started the web development and Noah and Steve helped us integrated the board with our database.

I very much enjoyed every second of this journey. Even though we had some tough times along the way but the positivity of the group kept us going. We started with a vision to make this idea a reality and we eventually did make it happen. I am very proud of the end result of the project. Everyone did their best to make this happen and I was blessed to be part of this amazing team.

The future potential of our project is huge and I am not planning to let go of this opportunity. I will keep looking for potential investors to patent this invention and eventually make this into a business. I'm sure our team has the potential to start one of the most successful corporations in Canada.

Noah Park

Chief Financial Officer (CFO)

Before taking ENSC440, friends who had previously taken ENSC440 described the course as"last step to becoming a professional engineer." After four months of planning and developing the final product, I have to agree that this course really does provide a "must have experience" for future professional engineers. My experience with ENSC440 is different from the experience I had with other courses. The course not only challenges students with the technical aspect of engineering, but also forces the students to develop good time management skills and team dynamics skills.

As a 5th year engineering student, I thought I had a solid understanding in programming languages and that I had confidence to overcome the challenges previously faced in my computing science courses. However, as I was first given a task of developing software for vehicle detection system, I realized that my knowledge in programming language was quite limited and I was afraid of being unable to complete the task. First thing I had to do was research different methods of image processing and trying to come up with an efficient algorithm that provided enough accuracy even in extreme weather condition.

In the beginning phase of the development, the algorithms were developed in C++ language using Visual Studio. However, we learned that VS has relatively slow file I/O speed and lacked serial port communications library for Arduino board. Making a decision to convert everything into JAVA and giving up the entire C++ code which I have worked very hard for the last month and half was quite challenging. Luckily, I was able to find a JAVA library called "Processing" which supports every image processing functionality that the algorithm needed. Using JAVA also dramatically decreased the image processing time for each frame.

How to make flawless connections to my SQL database was another challenge. Synchronizing to the server and to the website was something I had no experience with in the past. But with help from Milad, I was able to complete the task successfully. I have to thank Steve for implementing the algorithm for edge detection. As we were having trouble finding the right library, Steve suggested that we just develop our own. It took us a significant amount of time, but I think it was worth the effort as it's working flawlessly with other components of the algorithm.

I am glad we successfully finished our project on time. I am not sure if we will further develop the system so that we can sell the product in market in the future, but I can say that I had a great time working with other team members. Moreover, it was great to have a sense of achievement from developing something new and interesting on my own.

Milad Hajihassan

Chief Technology Officer (CTO)

Throughout the progression of this project, I have gained very valuable technical skills and teamwork abilities. This project helped to develop my teamwork abilities effectively and efficiently. It also improved my problem solving skills.
The main areas I worked on included - image processing using edge detecting method with C++, writing a C++ code for the Arduino board, integrating the SmartGPU with the Arduino board, and developing the project website.

At the beginning of course when we started the project I didn't have a clear picture of all the components and parts, which I was going to contribute. I had some previous experience in embedded programming and I decided to program the SmartGPU with Oshi as he had some previous experience in this field. It took us some time to receive the SmartGPU unit and I started to get the SmartGPU running using Arduino board. We initially used the Arduino application to run the code for smartGup but then we decided to use C++ as the Arduino application was very limited. There were some problems with the integration of SmartGPU code to the image processing code. The libraries of SmartGUP provided by Vizic technologies were written in Java. The other problem was dealing with the serial ports being occupied by the SmartGPU when we were trying to send the data to the Arduino board. I tried many different methods to overcome these problems. We finally decided to convert the entire code to Java in order to integrate the codes more efficiently.

We felt it would be a good idea to add another feature to our system and show the real time result of the system on a website. I started developing the website of project and I added some features such as live status of parking lots and the statistics. I used the "Jquery library" which is a powerful Java libarary to show the live status; it was a great learning opportunity for me.

I have learned a lot during the course of this project and pleased with the execution of it.

Oshi Mathur

Chief Operating Officer (COO)

The past three months have been a roller-coaster ride. I was lucky to have worked as part of this talented team of engineering students. I found the experience both rewarding and challenging. It was great to start the project in the company of my team mates; our skill sets complemented each other quite well. Initially, it was very exciting to plan the whole process – the ideas flowed smoothly and we knew we were up for an inspiring experience.

I was excited to take on the editor's role when it came to all the documentation for our group's work. On the more technical side of things, I had the great experience of using my programming skills while working with Milad on the GPU and constructing a UI which would be able to receive zero's and one's from the embedded system and be able to display them on a shiny LCD screen in a user friendly schematic. I enjoyed playing around with the Arduino prototyping board and the SmartGPU – I was reminded about the importance of being self-taught in this respect. Most of the code was written with the help of online examples that we had to tailor to our needs using the available libraries. I realized that while the ideation of a process is easy, the implementation of even the simplest components can be agonizingly complex.

I also enjoyed the group-dynamics and the team-building process. We often ran into minor conflicts, which we were able to resolve quickly. The importance of clear communication became even more important in situations like this and we had to remind ourselves that the focus should be on bringing out the best possible product for our customers given the constraints that we were facing.

Lastly, it was very rewarding to see that as a team we were able to support each other by being flexible with our roles. Even when any of us did not have the specific skills for a particular component of the project, we were still able to help the members who did have those skills, by acting as proof-readers and testers.

Overall, this was a great opportunity and I gained both technical and entrepreneurial skills while being part of a wonderful and talented team.

YuJie Xu

Chief Marketing Officer (CMO)

It is my great pleasure to work with these four guys, Noah, Mohammad, Oshi and Milad. This project could not have been done without any of them. We divided the work into software and hardware parts. Everyone tried their best on this project and finished their own tasks before the deadline. The hardware team (Mohammad, Oshi and Milad) and the software team (Noah and myself) were working in conjunction and held regular group meetings every Friday to keep track of our progress.

From a technical perspective, I have learned how to write the edge detection code in C++ in order to figure out whether a given parking spot is occupied or free. Basically, the edge detection function detects the edge of the vehicle and finds location of the cars. Then, the location of cars at each instant of time is compared to the location of parking spaces using the layout of the parking lot. Moreover, I also learned how to build the basic mySQL database. Before doing this project, the term “mySQL” was totally new to me. Thanks to Noah, I learned how to add or delete the variable values in the mysql database and then send them to a server.
From a non-technical perspective, I realized that for the group project, the communication between every member can be very important for the project development. Meanwhile, I also learned that writing the lab journal is another key point for project development. By writing the lab journal, we can keep tracking our project progress and every detail in our project. Thus, it is easier for us to decide the further plan of action for our project. I also wrote down new tasks we should finish in the future when we are doing the current task. In this way, if next time we forgot what new tasks we should do, I could just easily find them in my lab journal.

The timeline was another important aspect of the group project. We had our timelines, however, due to various reasons; some of our group members do not obey that timelines very strictly, which resulted in delays. I think that in order to finish a group project in time, meeting the timeline is critical. In the future, I will pay more attention to the timeline.

After completion of this capstone project, I am very confident as a future engineer. This could not have happened without all the help, motivation and supported from my other four group members. Thanks to Noah, again - we could not have finished our project on time without the efforts you made.

Company Profile

Mohammad Akhlaghi
Chief Executive Officer (CEO)

Mohammad Akhlaghi is a fourth year electronics engineering student at Simon Fraser University and he is also working towards his minor in Business. A team-focused, task-oriented, and results-driven engineering student with a strong business background. He has gained a lot of technical knowledge through two coop work terms in the industry and research. Experienced in project management, technical support, and working in multi-disciplinary teams. Puts a strong emphasis on effective communication, organizational sustainability, and meeting client and market needs.

Noah Park
Chief Financial Officer (CFO)

Noah Park is a fifth year computer engineering student at Simon Fraser University. He has gained significant practical experience through co-op work terms at Siemens and DongWon where he worked as a software engineer for designing and developing software for analyzing test data. These coop experiences exposed him to the business side and organizations of a large corporation as well. As a student, he has gained wide-range of knowledge in programming languages such as C/C++ and Java. He is also familiar with using VHDL to design custom circuits. With his extensive experience in programming, his contribution to the team will be focused in the area of software engineering.

Milad Hajihassan
Chief Technology Officer (CTO)

Milad is a fourth year systems engineering student at Simon Fraser University. His areas of interest include software development and graphic designing. He has taken courses in microelectronics, robotics, and real-time and embedded systems during past few years of his studies. He has experience working with microcontrollers as well as implementing games using C and Linux which he gained from the previous engineering projects.

Oshi Mathur
Chief Operating Officer (COO)

Oshi is in his fourth year of my engineering degree with a concentration in Biomedical Engineering. Thanks to the engineering courses offered at SFU, he finds himself adept at the basics of circuit design, programming, and problem solving. A two-semester Co-op work term at Active Network Ltd. gave him great background in working as part of a big team while focusing on the technical back-end of software solutions that run the city halls, recreation centers and universities of all major North American Cities. Liaising with clients and different departments both within and outside a company are things that his position taught him best. Through plethora of extra-curricular employment in SFU's university Life, he has had the chance of working with a diverse population of people wile gaining leadership skills.

YuJie Xu
Chief Marketing Officer (CMO)

YuJie Xu is a fourth year electronics engineering student at Simon Fraser University. Through one year co-op work term at the Montior King Ltd, he obtained plenty of practical experiences on hardware assembling. He has finished the programming languages, like C or C++ and real-time and embedded systems in his third year studies. With his co-op work experience and course studies, he will be responsible for both hardware and software design in our company.