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April 15th, 2013
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC Post Mortem for Blind Spot Detection System

Dear Dr. Rawicz,

Please find enclosed the post-mortem report for the: Blind Spot Detection System by Blind Spot Detection System Inc.

The design and implementation stage has been completed for the prototype of the BSDS.

In this post-mortem report, the document contains the current state of the BSDS system, deviations from the original design, and the future improvement of the BSDS. The final prototype and the stages development of BSDS will be included in this document. The team dynamics and individual reflections are included in the end.

Urban Wheel Inc. consists of four motivated and knowledgeable engineering students: Howard Sun, Emmanuel Yeung, David Cao and David Zhong. These four individuals bring their experiences and knowledge in hardware, software and telecommunications to the team.

For any inquiries or comments regarding our project, please contact our team through our contact person, Emmanuel Yeung via email at hhy6@sfu.ca.

Sincerely,

Howard Sun
Chief Executive Officer
Urban Wheel Inc.

A handwritten signature in black ink that reads "Howard".

Enclosed: Post-Mortem for Blind Spot Detection System



Post Mortem

Blind Spot Detection System

Urban Wheel Inc

Project Team:

Howard Sun
David Zhong
Emmanuel Yeung
David Cao

Contact Person:

Emmanuel Yeung
hhy6@sfu.ca

Submitted to:

Dr. Andrew Rawicz – ENSC440
Dr. Steve Whitemore – ENSC305
School of Engineering Science
Simon Fraser University

Issued:

April 13, 2013



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Introduction

Urban Wheel blind spot detection system is a highly accurate electronic add-on driving system for blind spot detection. The primary objective is to provide customers with safer driving experience in their current vehicles. The BSDS is capable of detecting obstacle hidden in either side of the vehicle's blind spot, and notify the driver accordingly to avoid accidents. Team members of BSDS have been working hard together to develop this project in the past four months. This document will provide the most current state and the deviation in design of BSDS prototype, and the issues encountered during the development process. Future developments for the system will also be discussed.

Current State of the System

The current system consists of two microcontrollers, both are communicating with the Ultrasonic sensors, Arduino LCD shield, turn signal, cameras, buzzer, vibration motor, LED lights, and LCD screen.

The First Arduino (Master) receives the distance data from the ultrasonic sensors, and send the lowest distance from both side of the car to the second Arduino (Slave). The master Arduino handles the buzzer and vibrational motor error reporting. It also gets the state of the turn signal to give appropriate response. The slave Arduino receives the distance data from the master, and display appropriate messages on the LCD shield. The slave Arduino also handles the LED lights, and the buttons for changing language and units for the LCD shield user interface.

The majority of the components are encased into a single enclosure. The main enclosure is to be mounted on top of the dashboard. The main enclosure contains two Arduino boards, LCD and LCD shield, and miscellaneous circuits. All the wires from the ultrasonic sensors and the turn signal module are linked to this main enclosure. The turn signal module is to be mounted on the steering column to get the turn signal state. The sensors are to be mounted on both sides of the car.

All the components are powered via the car's cigarette power plug. The cigarette power plug is split into two outputs, consisting one USB hub to power both Arduinos and sensors, and one single 12V rail for all other components.

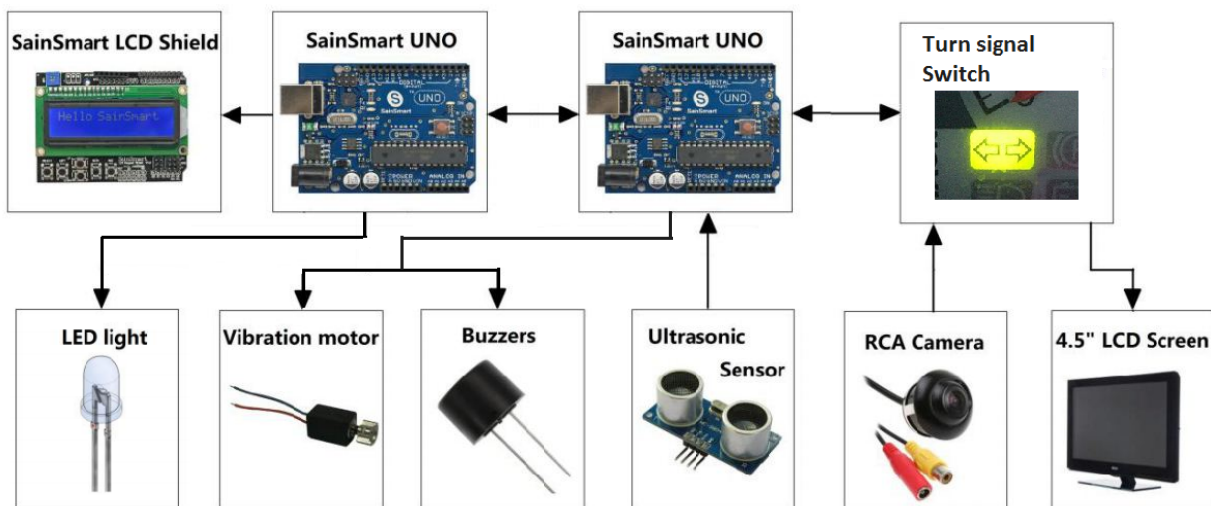


Figure 1 - System Block Diagram of the Blind Spot Detecting system

Deviation of the System

Overall system

Overall the system achieved our original proposed idea, and only missing the optional features due to time constraints. We originally planned to have a third camera installed to act as a rearview camera, and have extra ultrasonic sensors for both front and back. There are other minor deviations of the system, and details are discussed below.

Software

The system originally designed to have only a single Arduino board, but due to insufficient digital PIN, we have to add another Arduino, which barely met the PIN requirements (requiring 26 pins). Due to having the two boards communicating, the software is not fully optimized for performance. Using two boards introduced synchronization problem, where the Slave would miss the distance sent by the Master. The synchronization problem was fixed by introducing a server client methodology, having an acknowledgement (ACK) data line between the boards, where the Master would wait for the ACK from the Slave before sending another set of distance. However, having a send/receive block makes a huge impact on the speed of the system. Best solution is to replace two Arduino with a higher end model, which consists of 54 digital PINs, therefore eliminating the delays between the two boards.

Enclosure

The current enclosure is not optimized for size, the original plan is to have two enclosures, one for the LCDs, and one for the Arduinos. But the original plan was scrapped and a single large enclosure is made. Having a single enclosure decreases wire cluster, and made debugging much easier. However in order to fit both Arduinos and LCDs, a large enclosure has to be made, which would not be ideal for it to mount on the dashboard.

Ultrasonic sensors

Due to limited budget, we did not choose to use the waterproof ultrasonic sensors. The current chosen sensors has the best price-to-performance ratio, but it is not waterproof. Although "DIY" solutions has been applied to give it some waterproof ability, it is not the ideal solution.

Power management

Both of the Arduinos are powered by USB hub, and both Arduinos are powering the majority of peripherals such as ultrasonic sensors, LCD shields, buzzer, motor and LEDs. When all of the peripherals are active, some of the components will show signs of underpowered, for example the LCD shield backlight will be dimmed, or the buzzer sound volume will be lowered. Ideal solution will be powering the components by other means of power supply, instead of drawing power from the Arduinos. However it is not being implemented due to time constraints.



Future Work

Our system software is based on open-source platform. Due to its flexibility, it would be useful to integrate other devices in our system, such as GPS module (LS20031), which adds vehicle positioning function. Aesthetic of the casing can also be improved, by using better quality material, and better design with more color choices. Size of the system will be optimized making it as small as possible. The user interface of the system can be improved for better usability, for example, combining the LCD screen with the LCD shield will be less confusing to the user. The ultrasonic sensors can be replaced with superior sensors that have better range and detection angles. Waterproof ultrasonic sensors can also be applied to the system, providing that there are sufficient budget.

Budget and Time Constraints

Budget

Table 1 - the proposed budgeted cost and the actual cost of the project up to April 13th, 2013.

	Estimate Cost (\$)	Actual Cost (\$)
Electronic Parts		
SainSmart UNO + LCD package	60	75
OSEPP™ UNO R3 Plus	25	33
Ultrasonic Sensors x6	60	20
Night Vision Camera x3	90	45
Monitor	45	30
Raspberry Pi	55	N/A
Mechanical Parts		
Foam	1	15
Plastic board	2	10
Miscellaneous Parts		
Wire	Free	10
Charger	10	10
Grand total	293	248

The budget estimated for the structural category was more because we over estimated the cost of components. At the beginning, we considered using Raspberry Pi in the project; however, we took the suggestion from ESSEF. Also, we found the Raspberry simulation has slow response. Therefore, at the end, we used two UNO instead of Raspberry Pi, and we ordered most components on eBay to cut down the cost.

We were able to receive \$600 form the ESSEF (Engineering Student Society Endowment Fund) and \$50 worth electronic components from the Wighton fund.

Time Constraints

Below is our original planned schedule. Currently, our progress of development is behind planned schedule. According to the original plan, we should finish the debugging stage and everything should be integrated at the end of March. Although, the project is twelve days behind the proposed schedule, we still manage to finish the project before the actual deadline.

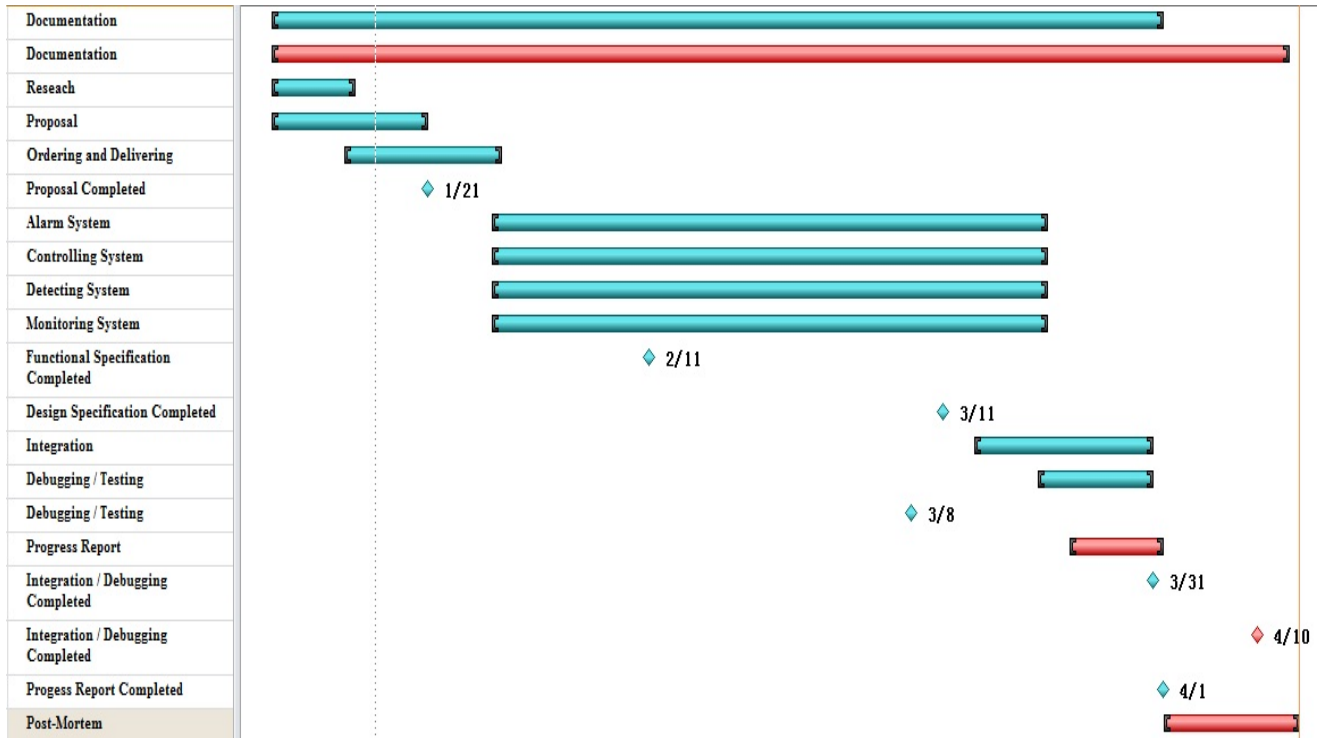


Figure 2 - Gantt chart

We did not strictly follow the proposed schedule. We found that working on each components of the system individually before a huge integration would be disastrous if there were design problem. Instead of following the proposed schedule, we integrated and tested each component frequently. If there is a design problem, we can easily locate the root cause and fix it. This methodology requires more time because it involves multiple integrations and testing.

Team Dynamics and Individual Reflections

The team of BSDS had a valuable experience in working together closely in the past few months. During these four months of cooperation, we discovered each individual's strength and weakness. Throughout the entire project, the tasks were assigned to individual base on their strength and interests to finish the tasks efficiently. When hardware, software, and design team encountered any issues, all four members would try to solve the problem together in order to move the development progress to next step. Because all members had strong sense of social responsibility and professional ethic, we worked smoothly and efficiently to deliver final BSDS prototype.

Howard Sun - CEO

Over the last three months, our team has put great effort working on the project of Urban Wheel Blind Spot Detection System (BSDS). Our system should work all kinds of vehicles, such as saloons, estates, lorries, and articulated lorries. In this project, we focused on passenger cars. We have had great team dynamics. Each member was willing to devote our own personal time to work on the project. There was building team pressure towards the end of the semester due to other course load and final exams. However, we managed the overcome the pressure by setting up and strictly follow the time schedule.

In a group of four, we split the task into hardware and software and integrate each part to generate the final product. The hardware team focused on casing and circuit design while the software team concentrated on coding the two Arduino boards. My role was a software programmer for the user interface and warning modules.

In this project has given the opportunity to learn about software development and apply Agile software methodology. I learned that researching and choosing the right parts is important before start working on the project. We considered using the Raspberry Pi at the beginning. We found that the Raspberry Pi is very slow booting, which is not suitable for the purpose of this project. And then we bought two Arduino UNO devices. If I were to do this project again, I would buy an Arduino Mega.

Emmanuel worked on the interaction between his board and sensors. I focused on the warning system and user interface. The most challenging part of coding with two boards was the communication and synchronization. Emmanuel and I worked overnight to troubleshoot and integrate the code.

Overall I enjoyed doing this project. Outside of the project time, we had movies from Takashi Miike together to celebrate our progress. We had numerous lunches and dinners together, and found that food on campus sucks ;)

David LiLi Cao – CFO

In the past 13 weeks, my team and I spent almost every day in my living room doing the BSDS project. The project slowly took over all aspects of our lives. The pressure and tension were built up slowly over the semester. We started as four classmates and ends up as four very good friends, although my apartment might not feel too pleased about that. We tried to make every bit of the project as fun as possible. I think we managed to achieve that with loud music and jokes.

The project is an enormous piece of cake stuffed with experiences. Every part of the project looks easy with the first glance, but the more we digged into it we found out the more we need to learn, manage and control. Dealing with an open source platform is a nice call, we can have all the freedom we need, but the freedom can be painful when we wanted to add a lot of features that we haven't thought about before. I haven't used Arduino board before. I got stunned how well it can be modified and controlled. The project is updated through a lot of emails everyday. The communication between our group members played a huge role in the development of the project. I am surprised that we got a nice compact design from raw materials and separate parts. The easiest thing turns to be the hardest at the end. Making cases and better wiring took us almost 2 weeks of time. And not all things that I have learnt are technical, learn to control emotions is also a good investment.

One of the best things about the project is our team worked very well together. Everyone is hardworking and trustworthy. Everybody is available and helpful if others need a hand. We met almost every day brainstorming and communicating. This ensured our team dynamics.

Overall, this project is like a ride on rollercoaster, bumpy and exciting. Lucky we have a nice team to ride along.

Emmanuel Yeung - CTO

At the start of the semester, I had no idea what to expect. Our group had a slow start and things seem to be going smoothly. During the mid-phase of the project, our other courses' has increased coursework and projects, which decreased our productivity, and tension is building within all of us. I am satisfied with our final project and the overall experiences.

This project has given me a lot of experience on both technical and nontechnical skills. Our project heavily utilizes Arduino microcontrollers and its' peripherals. I had never used an Arduino before, and this project gave me this great opportunity to finally learn about Arduino, utilizing all of the functionality of the Arduino. I finally realize Arduinos are very easy and powerful platform, and will continue to utilize them on my future projects if possible. Since Arduino coding style is based on C, I had an opportunity to improve my C programming skill, which not a lot of engineering courses will give me this opportunity, and applying a lot of programming style I learned from RIM co-op. I also learned about utilizing ultrasonic distance measuring, which no other course ever taught me.

Regarding nontechnical skills, my time management skills and communication skills has improved. Managing meeting times and balancing other course work is very important. I realize that the communication between team members plays a huge role towards the "success" of our project; we communicate every day through emails, strengthening the relationship between our team members, maintaining great team dynamics.

I am very happy with our final product, and the overall experience. I would have never imagined the project to be finished, or even functional. But with great team members and planning, everything is possible.



David Zhong – COO

My role in the Urban Wheel Inc BSDS project was to help the CEO form the BSDS project team, outline the essential functions of project and responsibilities of each team member. As well as foreseeing the potential challenge of the BSDS project. At the same time, I worked as project manager inside the team, making sure the project is always on schedule.

As the COO, my job was to ensure the company operations were efficient and effective, the proper management of resources, and make sure the development of product met the requirement and deadline.

At the beginning the development stage, I mainly focused on research the hardware and software requirements. As well as assisting CFO estimate the cost of the project. Also, help the team buying the parts which we cannot order online. For example, at the very beginning, the UNO board was not working properly with the ultrasonic sensors. Eventually, I found out the updated UNO library to encounter this issue to make the project progress.

At the development stage, for documentation, I was more focusing on research and hardware SolidWorks design. Before we actually design the system in the real life, design the simulation on SolidWorks helped us find out what design problems and advantage in advance. The simulation helped us reduce the waste time on actual issues. Also, keeping documents and hardware components organized was my main job to help the team work more efficiently and effectively. For the actual project development, my job was well rounded. I was involved from software, project design development, and wiring. When the team encountered some problems in technical and cooperation problem, I tried my best to smooth things out in order to get the team working on right direction of the project.

The largest challenge is to ensure all team members had enough time, energy, and motivation to work effectively and efficiently since everyone in the team has different other classes schedule. I have to keep track of everyone's schedule and deadline of the project in order to organize the meetings, and project time. Although during several stage of the project development, the project was delayed due to hardware component deliver delay and some technical issues.

Despite the above issues causing some minor delay, our BSDS teams was working hard together and eventually deliver the final product on time.



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Conclusion

The BSDS prototype has been successfully completed. The goals that Urban Wheel Inc. set have been accomplished. Valuable experience in technical and non-technical was obtained in the project phases, design, implementation, and testing.

Appendix – Meeting Minutes

Urban Wheel Inc.

AGENDA

January 9, 2013

10:30-12:30

On Campus

Purpose of Meeting: group intro, scheduling, exchange contact number

Items for Discussion:

- Group members self introduction
- Meeting planning and scheduling
- Exchange contact numbers

Urban Wheel Inc.

MINUTES

January 9, 2013

10:30-12:30

On Campus

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: group intro, scheduling, exchange contact number

Minutes:

A. Group members self introduction

Group members introduce themselves. Get to know their background and area of expertise

B. Meeting scheduling

Come up with a meeting schedule that fits everybody

C. Exchange contact numbers

Exchange phone number, email addresses

D. Next Meeting Date

The next meeting was arranged for January 10, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

January 10, 2013

10:30-12:30

On Campus

Purpose of Meeting: Discuss possible topics

Items for Discussion:

- Discuss possible topics
- Talk to Andrew and finalize the topic

Urban Wheel Inc.

MINUTES

January 10, 2013

10:30-12:30

On Campus

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Discuss possible topics

Minutes:

A. Discuss possible topics

Discussion: pros and cons of each possible topic. Group members gave professional advices

B. Talk to Andrew and finalize the topic

Discussion: Talk to Andrew to get professional feedbacks on each possible topic

C. Made final decision on the topic

Discussion: Made decision based on the feedbacks and group members' area of expertise and interest

D. Next Meeting Date

The next meeting was arranged for January 12, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

January 12, 2013

11:30-noon

On Campus

Purpose of Meeting: Company name and logo

Items for Discussion:

- Company name
- Design company logo

Urban Wheel Inc.

MINUTES

January 12, 2013

11:30-noon

On Campus

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Company name and logo

Minutes:

A. Company name

Discuss a suitable name for the company

B. Company logo design

Design company logo and draw it on Photoshop

C. Next Meeting Date

The next meeting was arranged for January 13, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

January 13, 2013

13:30-15:30

On Campus

Purpose of Meeting: Research the topic. Work on ESSEF funding application.

Items for Discussion:

- Research the topic
- ESSEF funding application
- Parts ordering

Urban Wheel Inc.

MINUTES

January 13, 2013

13:30-15:30

On Campus

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Research the topic. Work on ESSEF funding application. Parts ordering

Minutes:

A. Research the topic.

Research the topic, find out what we need to buy for the project. Estimate costs

B. ESSEF funding application

Work on the ESSEF funding application and the presentation slide. Sent application via email.

C. Parts ordering

Discuss parts need to be ordered and order parts.

D. Next Meeting Date

The next meeting was arranged for January 23, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

January 23, 2013

10:30-16:30

On Campus

Purpose of Meeting: Perform unit test on individual component

Items for Discussion:

- Unit test component
- Unit test functionality

Urban Wheel Inc.

MINUTES

January 23, 2013

10:30-16:30

On Campus

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Perform unit test on individual component

Minutes:

A. Unit test each components

Action: Downloaded drivers for the microcontroller boards. Tested the functionality of cameras, monitor, microcontrollers, ultrasonic sensors. Designed the circuits and mounting mechanism

B. Next Meeting Date

The next meeting was arranged for January 30, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

January 30, 2013

11:00-11:30

On Campus

Purpose of Meeting: Make changes to original design. Split tasks

Items for Discussion:

- Make changes to original design
- Split tasks

Urban Wheel Inc.

MINUTES

January 30, 2013

11:00-11:30

On Campus

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Make changes to original design. Split tasks

Minutes:

A. Make changes to original design

Action: Made necessary changes to optimize the original design.

B. Split tasks

Action: Split the tasks into hardware and software components and assign the task equally to each member. Group members will work on their own time at their own convenience.

C. Next Meeting Date

The next meeting was arranged for February 15, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

February 15, 2013

9:30-15:00

David C's house

Purpose of Meeting: Modular test, hardware/software troubleshooting and debugging
Items for Discussion:

- Modular test
- Troubleshooting and Debugging

Urban Wheel Inc.

MINUTES

February 15, 2013

9:30-15:00

David C's house

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Modular test, hardware/software troubleshooting and debugging

Minutes:

A. Modular test

Action: Tested the codes on the microcontrollers. Tested the sensors and display on the detection module and the warning module. Tested the circuits and rigidity of the case.

B. Troubleshooting and Debugging

Action: Debugged the code, Troubleshoot the synchronization and communication between the two microcontroller boards.

C. Next Meeting Date

The next meeting was arranged for March 4, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

March 4, 2013

11:30-20:30

David C's house

Purpose of Meeting: Progress update, Partial System integration test
Items for Discussion:

- Updating the work progress
- Partially integrate the system for testing

Urban Wheel Inc.

MINUTES

March 4, 2013

11:30-20:30

David C's house

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Progress update, Partial System integration test

Minutes:

A. Progress Update

Action: Discussed the current development progress, ensure the interoperability of our code and design

B. Partial System Integration Test

Action: Partially integrated the system, tested the communication between the Arduino and successfully transmit and receive data between them

C. Next Meeting Date

The next meeting was arranged for March 15, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

March 15, 2013

11:30-18:30

David C's house

Purpose of Meeting: Partial integration, develop the video switching mechanism

Items for Discussion:

- Partially integrate the system once again with updated code
- Discuss and develop the video switching circuit

Urban Wheel Inc.

MINUTES

March 15, 2013

11:30-18:30

David C's house

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Partial integration, developing the video switching mechanism

Minutes:

A. Partial integration

Action: Integrate the up to date code together, ensured base functionality is still functioning

B. Developing the video switching mechanism

Action: Designed and prototyped the video switching mechanism.

C. Next Meeting Date

The next meeting was arranged for March 22, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

March 22, 2013

10:30-11:30

David C's house

Purpose of Meeting: Discuss issues with buzzer, enclosure design

Items for Discussion:

- Find an effective method to control the buzzer

Urban Wheel Inc.

MINUTES

March 22, 2013

10:30-11:30

David C's house

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Discuss issues with buzzer and motor

Minutes:

A. Find an effective method to control the buzzer

Action: A LM555 timer will be built for the buzzer to give a 1kHz frequency signal. The circuit should be designed and tested right away once the LM555 chip is obtained from Fred Heep.

B. Discuss enclosure design

Action: Design has been made, and material choice will be corrugated plastic board.

C. Next Meeting Date

The next meeting was arranged for April 10, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

April 10, 2013

10:30-20:30

David C's house

Purpose of Meeting: Final system integration, system testing

Items for Discussion:

- Integrate everything
- Test the finish product

Urban Wheel Inc.

MINUTES

April 10, 2013

10:30-20:30

David C's house

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Final system integration, system testing

Minutes:

A. Final system integration, system testing

Action: Integrated everything, including buzzer, vibration motor, turn signal video switch circuit etc.
The finish system is put inside an enclosure.

B. System testing

Action: Tested the functionality of the prototype. Ensured the wire connectivity is secured

C. Next Meeting Date

The next meeting was arranged for April 12, the meeting time will be sent via email

Urban Wheel Inc.

AGENDA

April 12, 2013

9:30-23:30

David C's house

Purpose of Meeting: Field testing, Prepare for presentation and demo
Items for Discussion:

- Field Testing on real vehicle
- Preparation for presentation slides and demo videos

Urban Wheel Inc.

MINUTES

April 12, 2013

9:30-23:30

David C's house

Present: Howard Sun, Emmanuel Yeung, David Cao, David Zhong

Absent: N/A

Purpose of Meeting: Field testing, Prepare for presentation and demo

Minutes:

A. Field Testing

Action: Installed the prototype device on a Toyota Corolla for field testing. Tested the functionality and rigidity.

B. Prepare for presentation and demo

Action: Making the powerpoint slides, and filming a video of the working system.