MOTUS CONTROL

January 25, 2016

Andrew Rawics
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 - Project Proposal for a Smart Room Control System

Dear Dr. Rawics,

The attached document, *Proposal for a Smart Room Control System*, outlines *MOTUSCONTROL*'s proposed project for Engineering Science 305W and 440W (Capstone Engineering Science Project). The aim of our project is to implement a room system that will control and secure electrical devices within the room based on hand-gesture recognition.

This document will provide an overview of the proposed product, design considerations, a projected budget, a tentative projected timeline and information regarding our company and its members. An explanation of the proposed product is also included in this document.

Our team at *MOTUSCONTROL* consists of five highly dedicated and hardworking fourth year engineering students: Moha Alharbi, Saad Alkhalifah, Ryadh Almuaili, Adrian Fettes, and Yuhui Jin. Should you have any questions or concerns regarding our project, please do not hesitate to contact me by phone at (604) 500-5416 or by email at salkhali@sfu.ca.

Sincerely,

Saad Alkhalifah
CEO, MOTUSCONTROL

Enclosure: *Proposal for a Smart Room Control System*

MOTUS CONTROL

Project Proposal for a Smart Room Control System

Project Team:
Moha Alharbi
Saad Alkhalifah
Ryadh Almuaili
Adrian Fettes
Yuhui Jin

Contact Person:
Moha Alharbi
malharbi@sfu.ca

Submitted to:
Dr. Andrew Rawicz
Mr. Steve Whitmore
School of Engineering Science
Simon Fraser University

Issued Date:
January 25, 2016

Revision:
1.1

Executive Summary

When an average person reads the two phrases “Turning on a light” and “Flicking a light switch”, they would say they mean the same thing. The same applies to actions such “Turning up the thermostat” and “Raising the temperature”. If you’re part of the 87% of the population without a disability [1], then it may never have occurred to you that these actions are separate. Not everyone is able to stand and reach a light switch, or to hear a ringing smoke alarm. Whereas most people complete these actions without thinking, for some they are difficult to the point of frustration.

So much new technology is aimed at bringing people to greater heights, providing us with new senses, new abilities. Google glass would provide us with a constant stream of information about our surroundings, and keep us constantly aware of the happenings of our digital lives. The Oculus Rift allows new entertainment opportunities such as Virtual Reality movies and games. Fitness tracking watches and other devices allow people to constantly monitor their bodies in a way, which was, until recently, impossible. It is easy to forget, as these new senses and controllers are created, that some people don’t have the same base capabilities that everyone else takes for granted.

The purpose of our project is to give disabled people the ability to complete simple, everyday actions with no more difficulty than anyone else. To solve this problem, we will connect various devices to a control center, and allow the user to control them with simple gestures. Some abilities which our control center will grant the user are to turn lights on and off, change the thermostat, check other parts of their house for movement, and be alerted if an alarm goes off. Our hope is that by removing the burden of completing these common tasks, we can significantly improve the quality of life for the differently abled.

To complete this project, we, the team of engineers at *MOTUSCONTROL*, will leverage our skills in different areas to connect the devices and implement a simple and easy to use form of motion control. We are confident that we can create a piece of technology with the potential to improve many people’s quality of life. The rest of this document will describe our strategy, choice of technologies, schedule, and budget for this project.

MOTUS CONTROL

Table of Contents

List of Figures:

List of Tables:

Glossary

Wi-Fi: Wireless Fidelity
SMS: Short Message Service
GSM: Global System for Mobile Communications
IMU: Inertial Measurement unit
ESSEF: Engineering Science Student Endowment Fund

1. Introduction

A home is not smart as a result of how it is built, how efficiently it uses space or because it is eco-friendly, using energy-efficient lighting and adjustable heating schedule [2]. A smart home may have these things, but what makes it unique is the interactive technologies that it contains.

With the evolution of technology and the continuous enhancement of people's standard of living, interactions between human and electrical devices have become quick and easy. However, elders and individuals with disabilities may find it tough to communicate with machines without external aid. Although there has been great development of different technologies with regards to smart home control systems, the differently abled still have many troubles in managing their space.

Our proposal is a Smart Room Control System that would allow elders and disabled individuals to maintain their independence and control of their own space by using expressive and meaningful hand gestures, which get converted to signals that are sent to a computing system. The system is programmed to operate lighting, temperature control, security, appliances, and many other functions to improve their quality of life. The arm's angular movement will be used for gesture recognition by an Inertia Measurement Unit sensor. A gyroscope will detect the arm's angular shift and its relative change will be detected by an accelerometer. The arms position and orientation will be used to determine gesture patterns that will serve as input gestures to execute a predefined action. Additionally, an independent feedback system will be added to our controller to enhance the security system. This system allows the user or the user's caretaker to monitor information such as temperatures, alarms, and air conditioning. The system overview is shown in Figure 1.

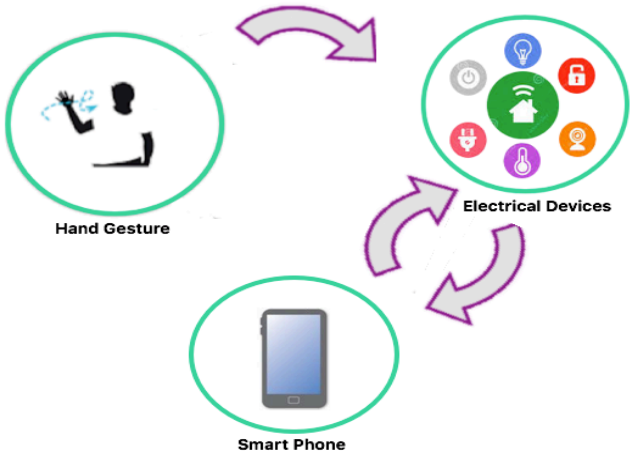

Figure 1: Smart Room Control System Overview [3]

Presented in this proposal is an outline of our product, including design considerations, sources of information, and project timeline. The proposal also includes budget and funding requirements, Gantt chart and milestones, as well as our company description.

2. System Overview

This section clarifies the scope, risk and benefit. The scope section demonstrates the proposed solution and alternative solution. It also includes graphs to illustrate our system architecture. The risk section discusses the potential errors that may be encountered during the design stage. The last section discusses the potential benefits from the product perspective. Below is the detailed section of scope, risk and benefit respectively.

2.1 Scope

MOTUSCONTROL aims to provide solutions to people with disabilities who face difficulties when it comes to controlling a device that is out of their reach. The solution that the *Smart Room Control System* provides is to provide control of the devices and peripherals surrounding you by simply using hand gestures.

There are alternative ways existing on the market, that allow the control of devices using phone applications or motion recognition using video cameras. However, the cost of using a smartphone would be higher than our proposed solution. Motion recognition-using camera requires excessive movement, which elders or handicaps may find it hard or even impossible, in some cases, to do. Figure 2 below shows the block diagram of our proposed solution.

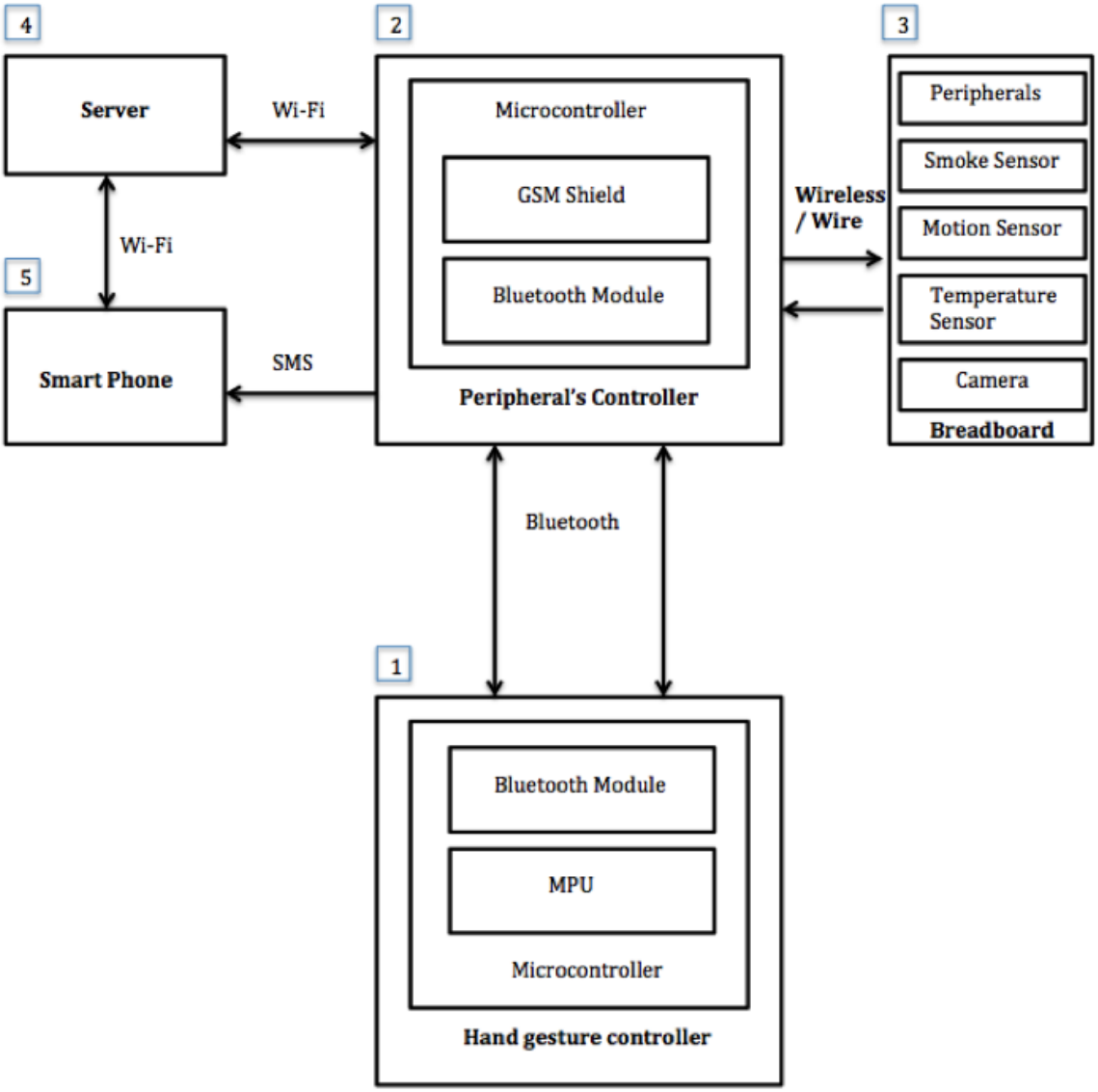

Figure 2: System Block Diagram

Label 1

Hand gesture controller is responsible for recording the coordinates of each movement using IMU sensor of type MPU6050. The microcontroller connected to our IMU sensor will process these coordinates and movement data, and mapping them to the correct peripheral. Then, the signal corresponding to the specific peripheral will be sent via Bluetooth to the peripheral's controller, which will then perform the intended action.

Label 2

The peripheral's controller is the main controlling unit that bridges the connections between all the components of the system. This unit will receive information via Bluetooth from the hand gesture controller, and then will control the peripheral that is specified in the information received.

Also, the peripheral's controller is connected to a GSM shield. The GSM shield will allow the system to send a warning SMS in the case that the Internet is not working. This SMS would be sent to the caretaker of the system user, to inform them of any potential problems as soon as possible.

Label 3

Our central microcontroller will be connected to the peripheral's controller with both wired and wireless connections in order to control the peripherals. There are two classes of peripherals we want to connect to, control peripherals and feedback peripherals. The feedback peripherals will simply send information about their state back to the controller. Some examples of these peripherals are a smoke sensor, motion sensor, temperature sensor and camera. We also have some peripherals we want to control, such as lights and air conditioning.

Label 4

Our main controlling unit is also connected to a server via Wi-Fi that will bridge the connection between our *Smart room control system* and the smart phone application.

Label 5

We will make a smartphone application that will allow the person who is taking care of the disabled person to conveniently view the room real-time if there is an unexpected movement, smoke or increase in temperature.

Figure 3 shows the proposed usage of our product using a simple flowchart.

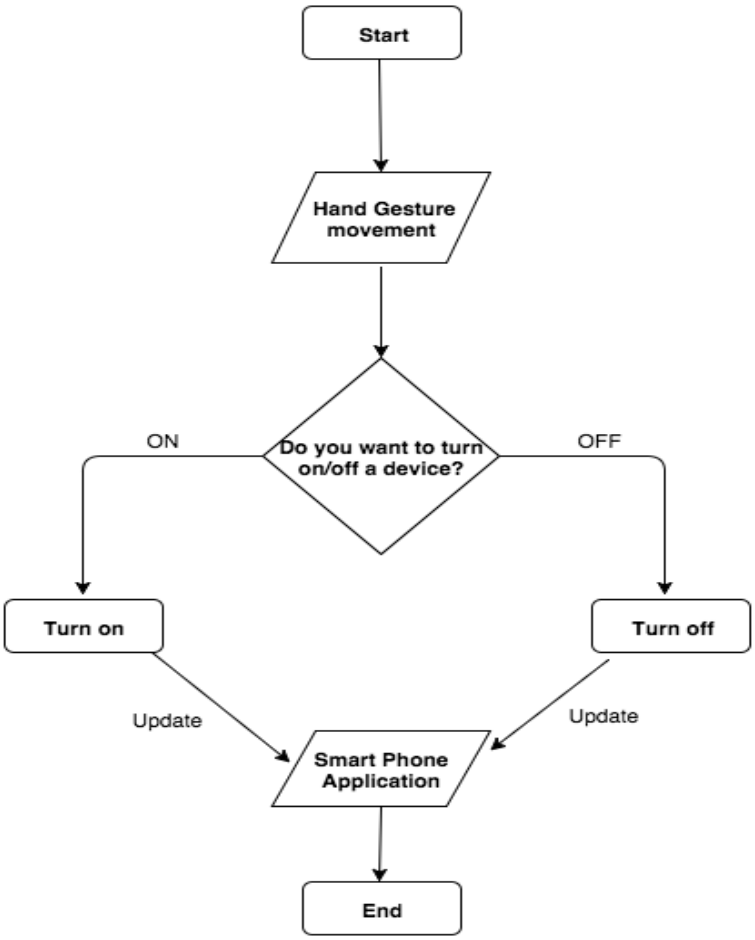

Figure 3: Flowchart of the System

2.2 Benefits

Our project is aimed at helping people to enjoy their everyday life, especially those with disabilities, and the people who work with those with disabilities. For example, it will increase the work efficiency of nursing workers by simplifying their workflow. They don't need to go to each room to adjust the temperature or check the patient. Instead, they can use our product to adjust room temperature and watch them through the live feed cameras. Furthermore, it can warn the user when there is a fire or break-in in your house by sending you a message, so you don't have to be worried by these things. Our product could also be enjoyed by the general population, as anyone can enjoy turning their lights on and off by simply waving their hands. Moreover, by continuing to develop

our product; it will be no longer a fantasy to have an affordable house control system, as we add more and more compatible devices to our central system.

2.3 Risks

As a marketable consumer product, health and safety factor is the first priority in the design parameter for *MOTUSCONTROL*. The final product will be a fully enclosed system with the shielding material that is non-reactive to consumer's skin and will not impose any health/safety issues when used over long period of time. Other potential hazards will also be investigated during the research and development process and will be integrated into our system and documentation as our research continues.

Predefined hand gestures are used to communicate with devices; however, some random gestures may be recognized as desired gestures if they are being performed on a certain axis. Additionally, the feedback and hand gesture recognition systems would consume a relatively large amount of power (100 mA/h). Moreover, the outer shell of the device is expecting to be not aesthetically pleasing for the user. Therefore, to improve the devices' performance, a more precise IMU sensor needs to be purchased and installed on our system to increase the flexibility of the user. The hardware modules should enter sleep mode or power save modes when they are not being used. This small change could significantly reduce the power consumption of the system. The code needs to be optimized in order to reduce the memory requirements of the system, and the hardware components should be placed on a single PCB in order to minimize the size of the device.

3. Market Competition

As technology becomes more advanced, Motus Control is eager to provide a new elegant solution to existing issue. So far there are few companies which have a similar approach to our design. However, our solution is new and unique to the market and it has a potential to compete with the existing products.

Most of the companies attempt to build and design a smart home controller to facilitate client's day-to-day experience with the surrounding devices. One of the current designs is a wearable band that detects the muscle tension, and then performs a certain action. Others use a built in sensor or camera monitor, in both cases requiring the client to physically be close to the appliances to control them.

Our targeted clients are elderly and disabled people that are able to move their hands. Those people may find it difficult to perform a basic task without external help such as a

nurse or specific device. Our product provides clients with the aid they need to ensure their safety and convenience.

4. Budgets and Funding

4.1 Budget Breakdown

Table 1 shows the major components needed and the tentative budget for *Smart Room Control System*. Price of the equipment is based on Lee's Electronics Shop. Several other components might be needed later on in order to enhance usability of the product, such as an IR remote for IR remote control and other accessories. In addition, due to the potential unexpected component failure, there is a 20% overestimation of the total cost. This overestimation is shown in the table below.

Table 1: Project Budget Breakdown

Equipment	Estimated cost
Arduino Uno Board	CAD $33
Arduino Yun Board	CAD $90
Sensor, PIR Motion	CAD $13
Triple Axis Accelerator & Gyro Breakout – MPU6050 * 2	CAD $40 * 2
Arduino GSM Shield	CAD $105
Logitech C270 Webcam	CAD $50
Flame Sensor	CAD $1.2
Contingency (20%)	CAD $74.44
Total Cost	CAD $446.64

4.2 Funding

We have completed the ESSEF (Engineering Science Student Endowment Fund) form and the proposal presentation. Therefore, ESSEF will be our primary funding source, and the rest of the funding will come from group members and Wighton Engineering Development Fund. Since our estimated cost is less than $500, we believe these three sources of funding will cover the costs.

4.3 Schedule

Table 2 shows the expected time to be spent on different design & build related tasks of our project.

Table 2: Gantt Chart of Project Progress

	Task	2016												
		1/3	1/10	1/17	1/24	1/31	2/7	2/14	2/21	2/28	3/6	3/13	3/20	3/27	4/3	4/10
1	Proposal															
2	Ordering & Receiving Parts															
3	Research															
4	Functional Specification															
5	Gesture Control Design & Build															
6	Feedback System Design & Build															
7	Design Specification															
8	Integration/Prototype Testing/Debugging															
9	User Friendly Feature Design															
10	Progress Report/ Test Plan															
11	Documentation															

Figure 4 highlights the progress milestones of the project.

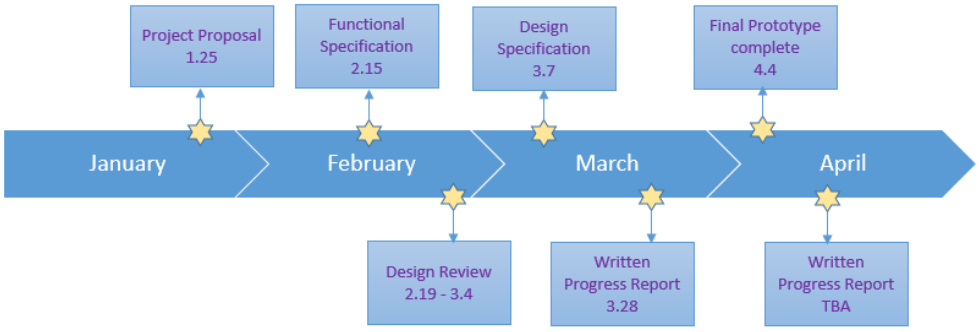

Figure 4: Milestone Chart

5. Company Profile

Saad Alkhalifah – Chief Executive Officer (CEO)
Saad Alkhalifah is a fourth year engineering student. His major area of specialty is computer engineering with a minor in computer science. He has a strong background in circuit analysis and coding. Moreover, he can effectively use Microsoft Office, Hspice, LTSpice, Visual studio, and Xcode. He is also familiar with software languages such as C, C++, Vhdl, and matlab. He has developed a software program in one of his courses. He is fast learner, good communicator and hard worker.

Ryadh Almuaili – Chief Financial Officer (CFO)
Ryadh is a fourth year Computer Engineering student at Simon Fraser University. Last year, Ryadh had his first cooperative work experience at ABB (ASEA Brown Boveri). He worked as an Automation Engineer with a team that is responsible for integrating Intelligent Electronic Devices (IEDs) with an automation system that allows to remotely control substations. His job required testing, troubleshooting and inspections to evaluate the performance of the system. He is proficient in many programming languages such as C, C++, VHDL and Swift.

Adrian Fettes – Vice President of Operations (VP Operations)
Adrian is a fourth year Systems Engineering student with a Computer Science minor, with previous co-op experience as a software developer with SAP. He has some experience in many areas. He has microcontroller programming experience, mostly in C. he has designed, built, and tested many different sorts of circuits in the lab. He has also done lots of programming in many languages, including topics such as image processing and web development. Finally, he has experience in digital circuit design, using mostly VHDL to implement various algorithms.

Yuhui Jin – Chief Technology Officer (CTO)
Yuhui is a fourth year Computer Engineering student with previous Co-op experience at BlackBerry as a product development specialist. He has proficient hardware debugging skill as well as familiarity in using different set of electronic and radio frequency test equipment. He also is familiar with JAVA, python and C++, can performs lower level programming using these languages. He has strong mechanical aptitude and familiar with manual, mechanical tools and basic understanding of electromechanical systems.

Moha Alharbi – Chief Operating Engineer (COE)
Moha Alharbi is a fourth year in Electronics Engineering at Simon Fraser University.
In addition to his background of hardware circuitry and software programming, he has experience in mechanical design, motors, and various sensors and actuators. He has completed a co-op work term at Johns Hopkins Aramco Healthcare (JHAH) as a clinical

engineer. During his time at JHAH, he gained valuable experience in biomedical technologies and learned how to excel in a team environment.

6. Conclusion

In this new age of inexpensive automation, it should no longer be necessary for anyone to struggle with simple tasks when they could be automated. Tasks such as turning on lights should never be frustrating or difficult to complete. Modus Control is dedicated to make this idea a reality, by integrating together existing technologies in a simple to use and understand system.

Our system will not only improve the quality of life for the disabled, but also their safety. No longer will they need to stretch to reach a thermostat or light switch, or worry about hearing their fire alarm. The ability to send information wirelessly to a caretaker ensures that in the case that something goes wrong, our system ensures a quick response. Our system surpasses previous home automation attempts in that it is designed for the disabled, and takes into account their abilities.

We have presented in this document our project schedule, funding sources, and technologies that we will be using. To complete this project will mean integrating many different layers of technology, including simple circuits, microcontrollers, and wireless communications, and we at Modus Control are certain that with our wide range of talents, we will accomplish our objective.

Reference

[1] Statistics Canada. *Canadian Survey on Disability 2012: Tables, Table 1.1 Prevalence of disability for adults by sex and age group, Canada, 2012*, Catalogue no. 89-654-X, Ottawa, 2013.

[2] R. Harper, *Inside the smart home*. London: Springer, 2003, pp. 14 - 19.

[3] S. Home, "Vector Illustration of a Smart Home", *Dreamstime*, 2016. [Online]. Available: http://www.dreamstime.com/stock-illustration-vector-illustration-smart-home-white-isolated-background-modern-cottage-remote-control-system-stock-image49450614. [Accessed: 19- Jan- 2016].