## **Purdue ECE Senior Design Semester Report**

## **(Team Section)**

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| **Course Number and Title** | ECE 477 *Digital Systems Senior Design Project* |
| **Semester / Year** | Fall 2019 |
| **Advisors** | Prof. Thottethodi, Todd Wild |
| **Team Number** | 10 |
| **Project Title** | Gesture Controlled Remote for Smart Home |

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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Timothy Huang | Computer Engineering | Software Development | Dec 2019 |
| Xi Wu | Electrical Engineering | PCB Design | May 2020 |
| Tsung Lin Hsia | Computer Engineering | Software | May 2020 |
| Wan Hsuan Lo | Electrical Engineering | Software | May 2020 |

**Project Description:** Provide a brief (2-3 page) technical description of the design project, as outlined below:

1. Provide a general description of the product to be delivered by this design project.

The Gesture-Control Smart Home Remote is designed for users to use gestures to control smart devices such as smart speakers, smart light bulbs, etc. This is an alternative to using voice control to control smart home devices. The product is targeted at users that prefer using gestures over talking to a smart-home device or users who have difficulties speaking. There are two stages in gesture reading. First, the users have to let the product know which smart device the user wants to control. Secondly, once the desired smart home device has been identified and connected, the user makes another gesture to control the device. Meanwhile, the LCD on the front side will display the smart-home device the product is currently connected to, as well as the instruction given by the user. Since the product is portable and requires battery, the LCD will also display battery status at all time and warn the user is the battery is running low.

1. What is the purpose of this product? For whom is it intended?

Gesture controlled smart home is a device that has functions similar to Google Mini or

Amazon Alexa. It is designed to be used in environmental conditions where hand

gestures are more convenient for users to control their home devices than voice

commands. The device is intended to be in a portable setting where users can carry it

with them at all times and recharge it if necessary. As for the nature of users, anyone

with the ability to make hand gestures can use the device.

1. Describe how the engineering design process used to create your product was utilized in this project. Include how you were able to develop and conduct appropriate experiments, analyze and interpret data, and use engineering judgment to draw conclusions related to the development of your product.

We decided on the project idea because we saw a lack of supply in smart home device controllers that operate based on anything other than voice commands.

Throughout the prototyping process, we have applied many engineering design skills. In the beginning, the components were decided based on the interfaces required in this project and the compatibility for one another. Most of our research in the early stage focused on what kind of interfaces are the most suitable for our project and based on the decisions made from our research we moved onto components selection. Knowing all the interfaces we will be using; we look through every interested component’s datasheet to make sure that the component can provide the interfaces we need and is the most financially ideal.

For software development, there are 3 main parts. The first part is gesture sensor and LCD. Second is the battery monitor, and the third is the WiFi module. We started off with the gesture sensor and LCD and then worked the WiFi module and the battery monitor at the same time. For each part, we test our program separately and make sure it functions as expected. Once the testing was finished, we merged all of them together.

1. Describe the design constraints, and resulting specifications, incorporated into your product (list a minimum of 3).
2. Portability: A portable product requires batteries, which makes our project a little more challenging because the product is not plugged into power outlet all the time. This requires extra effort on both PCB design and software development. Because of the usage of battery, we ordered a component that can monitor battery life and update to the microcontroller. Once the device goes into low battery mode, the LCD would remind user to charge the device
3. IFTTT: Not all the smart-home devices can be connected through IFTTT’s applets. Therefore, our product is limited to the available smart-home devices on IFTTT. In future development, we might be able to include more comm
4. Gesture Sensor: The sensor requires that, in order for the sensor to read gestures accurately, users have to be close enough to the sensor. As a result, the product will only work properly if the user is within its readable distance. That is also one of the reasons why we chose to make the device portable, so that the user could carry the device with them while using it.
5. Low Power Mode: Displays a warning message when the battery enters low power mode
6. Describe how each of the following factors influenced your design specifications and constraints.

## **Health, Safety, and Welfare:** Some people have disability of speaking and gesture control can solve the problem so that they can experience controlling smart home devices.

## **Global:** People from all over the world have different languages but with some simple hand gestures, everyone can control smart home devices.

## **Cultural:** People from all over the world have different cultures. The hand gestures are simple and intuitive that people can understand them easily.

## **Social:** People can control smart home devices without actually touching any devices. This could be especially convenient when the user’s hands are dirty from other activities.

## **Environmental:** The design process took into consideration to reduce environmental impact. The chosen components are low environmental impact that can also last longer. The power supply is rechargeable battery that can last for a very long time.

## **Economic:** The design process took into consideration to reduce the cost of the modules so that it will be affordable for people to purchase.

1. Describe the appropriate engineering standards incorporated into the creation of your product.

In the process of developing our product, we have taken into account some of the engineering standards that could be applicable to our project. One of them is the IEEE standard for software life cycle processes - ISO/IEC/IEEE 15288. This International Standard establishes a common framework for software life cycle processes, with well-defined terminology, that can be referenced by the software industry. It contains processes, activities, and tasks that are to be applied during the acquisition of a software system, product or service and during the supply, development, operation, maintenance and disposal of software products. Since we flash the software program onto our microprocessor, we need to consider the source, operation, as well as the maintenance software we are using to drive the device. For example, we made sure that all the STM32 code we have referenced to is open source code and free for everyone to use. Furthermore, to keep the device up to date, we would need to maintain our software routinely in future development.

Another standard that we have included in our design is the 1625-2008 - IEEE Standard for Rechargeable Batteries for Mobile Devices. Since we are using a rechargeable battery as our power supply, it is important to refer to the standards that might influence our product into consideration.

1. Describe the final status of your product.

Our design meets the desired functions. The sensor is able to sense different gesture sensor and send to microcontroller. Microcontroller successfully decodes and interprets the input gesture and send the command to the slave devices through the WiFi module. The WiFi module is able to connect to WiFi and connect to ifttt. The battery gauge system is able to track the battery usage and protect the battery. Finally, the LCD displayed the command triggered.

1. Describe the makeup of your project team and how you were organized to establish goals, plan tasks, and meet the objectives of this project.

## Our team consists of four members. We divide up the tasks depending on each person’s strength and interest, and when it comes to tasks that are more complicated, we would team up within the group to work on one thing together. Each week we organize meetings to discuss our weekly goals, and make sure that everyone is up to date on each part of the project. If we fall behind on one part, we would shift our focus to that specific task temporarily.

1. Did your project require the production of any written documentation other than this document (i.e., manuals, educational materials, etc.)? If so, describe the types, composition, and nature of the audience for whom these materials were intended.

## We had a user manual for our design. The user manual describes how the devices is connected to WiFi network and the steps for first-time set up as well as a brief description of what each gesture means when controlling different devices. Since the manual is in written English, the audience is expected to have the ability to read as well as interpret English. At the same time, the manual describes how to use the device in a rather simple manner, so the user would not be expected to have deep knowledge about technology.

## Describe the types, composition, and nature of the audiences in attendance for the final oral design review. Discuss how you prepared for this audience.

## The audience at the final design review would include the professors and instructors of the course, other senior design teams, as well as teaching assistants. To introduce our project to the other senior design teams, we will need to prepare for an introduction and application note of the product. l The instructors and teaching assistants would already be somewhat familiar with the topic of our project, therefore we would need to include more in-depth details of the development of the device. Most of the audience will have the ability to comprehend the technical details of the project, so we will include information on some specific techniques that we have used throughout the development.

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## **(Individual Section)**

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| **Advisors** | Prof. Thottethodi, Todd Wild |
| **Team Number** | 10 |
| **Project Title** | Gesture Controlled Smart Home Device |

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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Wan Hsuan Lo | EE | Software | May 2020 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

I worked mainly on the gesture sensor configuration and battery gauge of our system. For both parts, I worked on its communication with microcontroller, and for the sensor, I also worked on the gesture decoding for the microcontroller on both development board and our pcb boards. I also helped debug the uart connection between wifi module and the microcontroller as well as hardware connection and testing each signal.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

Both gesture sensor and battery gauge IC communicate with microcontroller using I2C protocol. In ECE 362, we had labs on communication protocol to microcontroller STM32F0. In this project, though we changed to STM32F4, the logic of the protocols we use the same. There are just some registers differences and clock issue that we need to solve.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

I read through the datasheet of gesture sensor and battery IC to learn some basic set up and which register needed to be set for the sensor and battery IC to function properly. I also looked up some online resources to get some general ideas on how others use gesture sensor and battery IC.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

We chose the battery with IC protection and configure it with different mode to prevent danger in over-charging and over-draining as well as to save power when the device is not used. For sensor configuration, my ethical and professional responsibilities are to increase its response speed and avoid sensing error.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

There are numerous smart home devices in the market, and the goal of our design is to keep the price low and friendly to all users. When choosing our component parts, we make sure that the chosen one has high power efficiency and safe to environment. For global, our design is friendly to all users in all age and who speaks in different languages. As for societal, our design allows user to interact with smart home device in ways other than voice, and it is also portable.

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| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Tsung Lin Hsia | Computer Engineering | Software | May 2020 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## I completed ILI9341 LCD configurations. The LCD is able to display internal processing statuses such as microcontroller initializations and WIFI connectivity, and user information such as sensed gestures and outputted instructions for respective home devices. I also worked on the battery gauge, which should be able to display battery life. I was able to achieve accurate and reliable transmission between STM32 and ESP8266 using UART and subsequently communication between ESP8266 and IFTTT using WIFI. I also worked on the final packaging of the product, including 3D printing the base and front cover.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## I was able to apply knowledge from ECE362 and ECE463 that covered microcontroller and computer networks. For LCD, I’m using the SPI protocol, which I had experience with it during mini-project in ECE 362. For transmission between STM32 and ESP8266, I’m using UART protocol, which I also learned in ECE362. For transmission between ESP8266 and WIFI, I applied my knowledge about WIFI from ECE463.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## I looked through the data sheet about the specifications of the register and flow diagram of the modules to understand the functionality. Also, I looked at some online resources to understand the design processes and the potential reason for the failures. For example, Stackoverflow is a good platform to find others who had encountered the same situation and their solutions about it. When I encounter difficulties, I will reach out to my teammates, and if we can’t solve the problem, we will reach out to professors, instructors, and TAs.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## During the design process, I think about the safety issues thoroughly and I tried to prevent the danger happened from my design. In battery IC, we set different modes to prevent the battery overdrain and overcharge. For my professional responsibilities, I need to make sure that transmission between STM32 and ESP8266 and subsequently communication between ESP8266 and IFTTT are accurate and reliable.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

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Economically, our product takes advantage of the low cost of microcontrollers, which also carries the added benefits of lower energy consumption and ease of implementation on a day to day basis. The gesture control is a key feature of our product because we believe time is an invisible cost to our users; the ability to waive the hassle of a remote at the wave of a hand has been an inspiration throughout the design process. The ease of use further translates to safety in certain environments. Phone use at the wheel has been a huge societal hazard in recent years; we foresee a drop in accidents when users can designate gestures to avoid looking at their screens. Gestures eliminate the language barrier between cultures, which can be utilized globally. The exterior build of our product is 3D printed using PLA spools, which is not only renewable but also naturally degradable.

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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Xi Wu | EE | PCB Design | May 2020 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

I have contributed towards the project mainly in the area of PCB design and package design. I have designed the main microcontroller board, the power supply board, as well as the packaging of the device. Once we finalized the design and received the boards, I have worked on the assembly of the electronic components and testing of each connection. I have also helped debugging LCD and gesture sensor software.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

I was able to apply knowledge from previous courses that cover both hardware and software sides of electrical and computer engineering. As for software, I find ECE362 very helpful, since we learned how to program and interface with microprocessors in that course; and for hardware, I was able to utilize the skills I learned from ECE207 such as using oscilloscope and multimeter to debug circuits.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

In order to contribute to the project, I have newly acquired skills on how to design complicated circuits, how to use electrical CAD software, and many techniques on designing board layouts. I have used many online resources and learned to read datasheet in meaningful ways to deepen my understanding of different components and circuits. The professors and TAs also provided a lot of help along the way.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

As the PCB designer of the project, I am responsible for developing PCBs that are original and creating designs that are unique to our own product. My ethical and professional responsibilities include using environmentally friendly materials and consider the possible uses for the device and tailor my design to eliminate potential issues.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## Since our design uses gestures as user inputs instead of languages and most gestures are universal, it would easily work in a global setting. As for its societal impact, users could free up their hands to do other things and control the device at the same time, which could potentially influence how people work or use devices in the society. Economically, a single device could be produced in under 50 dollars, which is relatively affordable compared to similar devices. Last but not the least, the device is mostly made of PLA material and acrylic glass. It has a relatively low impact on the environment, since the materials are regenerable. A possible improvement in the future could be to reduce the use of plastic in the device.

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| **Semester / Year** | <Insert Appropriate Semester/Year Here> |
| **Advisors** | Prof. Thottethodi, Todd Wild |
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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Timothy Huang | Computer Engineering | Software Development | Dec 2019 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## I mainly focused on the programming parts, specifically gesture sensor, WiFi module, and battery monitor. In addition, I also created four applets on IFTTT. The first one is to turn on the Philip Hue. Second one is to turn off light bulbs. Third one is to change color. The fourth one is generate a color loop.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## Most of the knowledge used to build this project came from ECE362. In ECE362, we learned how to implement I2C, SPI, DMA, UART, etc. For my part, I have used UART and I2C for the WiFi module and gesture sensor. A little part of this project requires knowledge in Internet Protocol, which I have learned from ECE404. When making a request from ESP8266 to IFTTT applets, we made HTML web GET requests to trigger the event.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## Most new knowledge is acquired from StackoverFlow, STM32 forum, freelancers’ personal websites, and GitHub. I have also read some online documents to learn more about the components I am working with. For problems with interfaces, I usually looked up tutorial or textbook to understand how interfaces work. For syntactic problems, I usually used StackoverFlow to find answers.

## 

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## My responsibilities include but not limited to successfully complete tasks and ensure the robustness of our program, making sure there are no bugs in our program and it is functioning as expected.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## Economically, since most smart-home devices on the market are voice-control based, our gesture based smart home device could be a new trend on the market. Environmentally, most of our components are environmentally friendly. The pollution to earth is minimal. Societally and globally, the product can change the way people interact with their smart home devices such as smart speakers, smart lightbulb, etc.