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

## **(Team Section)**

| **Course Number and Title** | ECE 47700 *Digital Systems Senior Design Project* |
| --- | --- |
| **Semester / Year** | Fall 2023 |
| **Advisors** | Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Smart Seating System |

| Senior Design Students – Team Composition | | | |
| --- | --- | --- | --- |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Roshan Sundar | CMPE | Firmware | May 2024 |
| Lee Dongeun | EE | Hardware | December 2023 |
| Gabriel Wang | CMPE | Systems | December 2023 |
| Giang Nguyen | CMPE | Systems | December 2023 |

**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 smart seating system consists of 2 major components. A cushion containing various sensors/electronics is placed on seats, which then collects data on the seat’s occupancy. It uses Force Resistive Sensors and a Thermal Camera to detect human occupancy. This data is then forwarded to a web server via Wifi communication, which then makes a decision regarding the seats occupancy. The web server displays rows and columns of seats that are occupied ( red circle symbol )/not occupied ( seat symbol ).

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

## In light of the growing utilization of shared spaces and the challenges they pose in terms of occupancy management, the Smart Seating System effectively tackles the issue by tracking seating in common spaces, and reporting that information to visitors in a convenient way.

## This product has use cases in various fields/sectors, including educational institutions, restaurants, theaters, hospitals, etc. In essence, our product has value in any scenario where seat occupancy tracking is desirable

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.

## Our design process involved using drawings, modelings, and prototyping. We realized that the better we prototype our components the more we realize the best way to design our product. Initially, we thought about having a multiple system design that involved several mounts and connectivity wires. This would include a box mounted at the bottom of the seat that would house our PCB. The seat top will have a film that would encase the FSRs on the actual seat. The thermal camera would be mounted at the edge of the seat aiming at a person’s legs. After doing some prototyping, we decided that a single system design having all the hardware and connectivity happening in the cushion would be the most flush and simplistic design. Our final design revolves around a wooden case that would sit in the cushion itself. The FSRs would be lying against the wooden boards and the thermal camera would be extended to the top of the cushion.

1. Describe the design constraints, and resulting specifications, incorporated into your product (list a minimum of 3).

The proposed design has specific computational, electronic, thermal/power, mechanical, and economical constraints. On the computational side, the processor's primary role is data transfer and communication rather than complex calculation. The electronic constraints involve interfaces for the microcontroller, wireless module, static memory, sensors and battery, with considerations for various interface protocols. Power constraints mandate a robust power system with battery monitoring protocol, an auto sleep feature and specific power consumption rates. The mechanical constraints focus on achieving a light, shock resistant design that is able to withstand various environmental conditions. Moreover, the system must operate with specific temperature ranges that allow for flexible mountings and different seat types. Economic constraints set a target cost of around $100 for experimentation purposes, considering thermal and weight sensors, with a final prototype cost estimated at around $80, including necessary components and a margin of error.

1. Describe how each of the following factors influenced your design specifications and constraints.

## **Public Health, Safety, and Welfare:** Our primary concern regarding this topic is consumer privacy. As a human detection tool, it is imperative to develop a system that does not intrude upon an invasion of privacy. Although public spaces usually have lax guidelines regarding this, installing a separate product could provoke people to have a negative reaction. This eliminated the use of cameras in our design, and opened a route of using sensors for human detection. Our next concern would have to come from the mechanical packaging. Physically, we would need to make sure our system is completely safe for a normal user to handle. As the developers, making sure electrical and hardware connections are properly connected, insulated well enough, and out of the way for the user is very important. As long as the user follows our user manual when handling our product, there should not be any external safety or health concerns.

## **Global Factors:** While global considerations did not play a dominant role in shaping the product's design, it was intentionally crafted to avoid limiting its utility exclusively to the American or English-speaking contexts. Recognizing the universal challenge of managing public space usage, the design was purposefully developed without significant barriers to implementation in other countries. For example, the design of the cushion is such that it can accommodate a variety of weights/stress and be placed on a variety of chairs, with these factors potentially differing based on region or country. The primary potential obstacle lies in language, particularly concerning the front-end occupancy visualization of the system. However, this limitation can be effectively addressed through additional development efforts, introducing language settings to the front end and ensuring the adaptability of the Smart Seating System to diverse linguistic environments worldwide.

## **Cultural Factors:** Ensuring the system's integration into a chair necessitates a balance of convenience, comfort, and minimal intrusion. Beyond addressing data privacy concerns, the physical design also aims to appear inconspicuous and comfortable, alleviating the inherent suspicion often associated with electronic monitoring products. Therefore, the design adopted the form of a comfortable cushion with embedded sensors and electronics, diverging from the initial choice of enclosures mounted on the chair itself. The initial design proposal, which prominently displayed the non-traditional nature of the chair, triggered a sense of unease among users. Consolidating all electronics within the cushion not only aligns with engineering efficiency but also enhances user comfort by presenting the design in a familiar package, mitigating concerns about being monitored.

## **Social Factors:** Central to the design is the importance of convenience, as it is the primary justification for the product's adoption. The emphasis on convenience is rooted in the desire for a system that operates with minimal user interaction, making it inherently 'hands-off.' The ultimate goal is to create a user experience where individuals need not engage with the physical product or system beyond checking the occupancy status. In pursuit of this objective, various design ideas were carefully considered and rejected. As one example, we decided against implementing a formal check-in system that would necessitate visitors to make reservations in advance. Other design ideas that violated this principle were also rejected in order to ensure that the final product was as convenient to users as we could make it.

## **Environmental Factors:** The product’s intended operating environment is indoors, dry, and temperature controlled. Therefore, general environmental hazards did not need to be addressed, allowing for a less physically robust - but cheaper - system. The only significant concern is that the design needs to be able to handle the weight of an adult human, in order to prevent the sensitive electronics in the design from being crushed. As such, the implementation of a wooden case inside the cushion addressed this need by being physically compact enough to fit in the cushion while being sturdy enough to handle the weight of a person sitting on the cushion.

## **Economic Factors:** The product has to be relatively low-cost per unit, since the design approach we settled on necessitates that one instance of the product has to be present in every seat. To that effect, expensive components had to be avoided as much as possible, and the design approach should be minimalist in nature. For the most part, this was adhered to in the final design. Most components are relatively low-cost resistors, capacitors, etc. The ESP32, for a microcontroller, is also relatively inexpensive while also having a decent array of capabilities. FSR sensors are also inexpensive. The only expensive part of the design is the thermal camera, and project cost could be reduced by replacing the thermal camera with server individual thermistors instead.

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

In the development of our smart seat occupancy system, several engineering standards have taken a crucial role in ensuring the product’s reliability, safety, and compatibility. Some of the standards that are taken in consideration and incorporated are given below.

* FCC regulation

Devices that either emit or receive radio frequencies typically necessitate approval from

the Federal Communications Commission (FCC). For initial development and prototyping, the FCC permits

individuals to use up to 5 intentional emitters without mandatory testing. A significant

advantage is that the ESP32, the primary intentional emitter within our product, is

already FCC certified. As a result, the certification process becomes considerably

simplified, requiring testing primarily to confirm that the overall properties and

specifications of the ESP32 remain unaltered. Successful completion of this verification

process ensures FCC certification for our product.

* Safety Standards for Electronic devices

various safety standards related to sensors and battery management have been considered during the process of designing our product. The standard taken was that the product’s battery did not create any leaks or damage the following components of the system. Additionally, regarding the ethical issues, when taking any data from the user, the product will inform the user for authorization of the data taken.

* Sensor standard

One of the main standards that has been incorporated into our system is that all the sensors cover accuracy, reliability and communication protocols.

1. Describe the final status of your product.

The final status of our product has two major components: our seat cushion and the web server. From the outside, the seat cushion may just look like a normal cushion, however, the hardware for our occupancy detection is integrated inside. Below our cushion, there is a flap for easy access to all the materials inside. Our PCB is mounted on a wooden board, which is then covered with another wooden board and extra film/fluff for protection. Our FSRs are integrated flat on top of the covering wooden board, which will provide for a hard and smooth service for the FSRs to receive pressure. The thermal camera will protrude from the side of the PCB and will be integrated against the top layer of the cushion. Finally, our cushion will be connected to our web server (PC) that will handle the occupancy requests and calculations. The web server will have a frontend (website) that will cleanly display the seat occupancy status of a certain room. Any user should be able to access this website given the link to it.

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 project team is composed of three computer engineers and one electrical engineer focused in firmware, systems and networking. To establish our goals, plan ahead and meet the objectives of this project, we made a communication channel using Microsoft Teams. Using this communication channel we were able to share documents, and plan ahead. We also met in our Man lab every wednesday to discuss our progress each week and what we can do the coming week.

Roshan played a multirole in the project, focusing on prototyping by integrating key components, leading PCB layout optimization, and primarily firmware development, addressing challenges such as sensor interfacing, interrupts, timers, tasks, and collaborating on wifi communication with Giang.

As the team's system engineer, Gabriel played a pivotal role in developing and integrating the system, including testing and selecting components, prototyping sensors, contributing to PCB testing, and overseeing the integration of firmware and sensors into the mechanical packaging

Lee focused on the hardware aspects of the project, PCB design, soldering, and debugging, including selecting and designing the buck boost, studying EasyEDA for PCB layouts, practicing and executing soldering on multiple PCBs, and contributing to the packaging design

Giang led multiple aspects of the project, excelling in component research & optimization and PCB hardware design, including layout, soldering, and debugging. He played a crucial role in translating conceptual designs into detailed schematics and overseeing their implementation on the PCB. In the software realm, Giang developed firmware for seamless sensor interfacing and took charge of network programming. He also designed a web server, enabling remote display of seat occupancy data.

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 audiences for whom these materials were intended.

There were two kinds of documents, one was a shared document of our main proposal and the goals that this project will meet, and an individual document that everyone of our team had to complete each week.

* Shared document ( Initial Project Proposal, Final Project Proposal, functional specification, component analysis, bills of materials, Professional Component Assignments )

This document consists of all the broad ideas and goals that had to be accomplished during this whole semester. The composition of this document consists of a project description where we had to describe what kind of product we are making and why this product is important. The second part consists of team members/team roles and their particular responsibilities. The next main part is the estimated budget and the project specific design requirements ( which composes hardware and software components). Other team documents such as functional specification, component analysis and bills of material take detailed description of the idea proposed in the first document and each of our teammates had to explain in detail. Professional Component Assignment includes details such as the legal and regulatory analysis, ethical and environmental analysis, User Manual, and reliability and safety analysis. These were documents that were submitted individually but had to be discussed in group as these aspects were very important for research and development.

* Individual document ( Progress report, Software overview, electrical overview, mechanical overview, software formalization )

In these individual documents, every teammate talked about their own progress and how they contributed to this project. The following composition of the progress reports include evidence such as pictures/video, time taken to finish a project, and description of the week's progress. The other individual documents describe different categorical overviews which includes software, electrical, mechanical, ethical and others.

1. 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 final oral design review will be attended by other teams and by the course staff. To prepare for the final review, the team will look over both internal and external feedback from the last review, and aim to address deficiencies, namely in better context for the problem space and better descriptions for design choices. The presentation materials will also be prepared and practiced in advance.

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

## **(Individual Reflections Section)**

| **Course Number and Title** | ECE 47700 *Digital Systems Senior Design Project* |
| --- | --- |
| **Semester / Year** | Fall 2023 |
| **Advisors** | Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Smart Seating System |

| Senior Design Student Completing This Section | | | |
| --- | --- | --- | --- |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Roshan Sundar | CMPE | Firmware | May 2024 |

**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.

## Throughout the project, my involvement spanned a multitude of roles, with a primary focus on prototyping, PCB design, and Firmware development. In the prototyping phase, I integrated critical components such as FSRs, Thermal Camera, and Coulomb counter, ensuring communication with the microcontroller. In the realm of PCB design, I took the lead in revising the layout post-design review, optimizing space utilization and enhancing the overall visual appeal. The majority of my efforts, however, were concentrated on firmware development. I took charge of crafting the majority of the firmware, excluding wifi communication, which was a collaborative effort with Giang. This involved implementing fundamental sensor interfacing concepts established during the prototyping phase, incorporating interrupts, timers, tasks, and addressing challenges like race conditions and exceptions.

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

## The prototyping phase built upon the knowledge I learned in ECE270 and ECE362. Prototyping was done on a breadboard, and ECE270 involved extensive breadboarding and prototyping in digital electronics. ECE362 also involved a significant amount of prototyping, but with a special focus on interfacing between microcontrollers and peripherals, which was the key objective in the prototyping phase. The difference was that the interfacing and breadboarding were unguided, unlike the labs in those classes. I had to figure out how parts interfaced with others by consulting technical documents and through experimentation. Through this, I learned better prototyping and debugging strategies that will help me in the future. As far as firmware goes, most of it was new to me. The closest classes that covered similar content was ECE362. However, many things were different, as the micro used in this project is the ESP32 which worked on the FreeRTOS system. As such, I learned about tasks and how to manage them, which is different from the STM32 used in ECE362.

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 learned knowledge through a combination of consulting others and through trial and error. The ‘others’ includes actual people, such as the TAs, professor, lab assistant, other students, etc. It also includes online resources, such as forums, technical documentation, and AI assistants. Of course I had to learn much through trial-and-error due to the particular nature of this project, meaning a lack of resources. To effectively acquire skills and knowledge, I made use of certain strategies. The main one was where to find assistance based on the topic area. I tend to find that the esp-idf examples along with chatgpt were the best resources for programming, the in-person staff resources were good for hardware issues, and technical documentation was the best for prototyping. In addition, I learned to think more systematically to solve issues, as the integration of hardware and software makes getting things to function a much more challenging task when learning through trial-and-error.

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

## In designing the Smart Seating System, the prioritization of user privacy and legal compliance is paramount. Ensuring that the data collection process is transparent is imperative for retaining user trust and complying with professional ethics. In addition, ensuring that the data collected by the system is anonymous is also crucial. I was responsible for keeping these factors in mind during the firmware development. In addition, adherence to communication and engineering standards was also an important aspect in the firmware development process. Following the recommended hardware and firmware design guidelines from Espressif and the Wifi Alliance was critical to ensure compliance with general sound engineering design, minimizing interference with other electronic systems, and compliance with FCC regulations.

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?

## From an economic standpoint, the system has the potential to improve operational efficiency in businesses and public spaces by optimizing seating arrangements. This optimization can result in heightened customer satisfaction and potentially increased revenue by fostering a more efficient utilization of space, benefiting both visitors and providers.

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## On the societal level, the product prioritizes convenience and accessibility. Real-time information about available seating is readily accessible to visitors in public spaces, enabling them to make well-informed decisions, ultimately saving time and money. Moreover, during peak periods, the system can play a crucial role in alleviating congestion and reducing the risk of overcrowding, thereby contributing to a more comfortable and user-friendly environment for all. Businesses can leverage the system to monitor space usage, allowing them to fine-tune their environments and strategies to enhance customer experiences.

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## The product also holds the capability to influence the environment by optimizing space usage more efficiently. By enabling prospective visitors to assess a space's occupancy beforehand, it eliminates the necessity for individuals to travel to the location solely for such evaluations. This not only saves visitors time but also diminishes the environmental consequences associated with unnecessary travel.

## In terms of global impact, the design would enable the optimization of public spaces worldwide. The time saving effect on the population leads to a host of ancillary benefits, such as leaving more time for students to study, or enabling families to plan outings more effectively. These benefits cascade, more students studying leads to more innovation and productivity, for example.

## To assess the impacts of this project comprehensively, a thorough trial period could be implemented, monitoring the product's performance and effects in a real-world setting. This would facilitate the collection of valuable stakeholder feedback, enabling necessary design revisions to better align with their specific needs.

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

## **(Individual Reflections Section)**

| **Course Number and Title** | ECE 47700 *Digital Systems Senior Design Project* |
| --- | --- |
| **Semester / Year** | Fall 2023 |
| **Advisors** | Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Smart Seating System |

| Senior Design Student Completing This Section | | | |
| --- | --- | --- | --- |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Lee Dongeun | EE | Hardware | December 2023 |

**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.

In this project, my main focus was on the hardware of the project ( PCB design, soldering, and debugging the assembled PCB, mechanical packaging design ). In the prototype phase, I worked on designing and choosing the buck boost ( power of our PCB ) and went through the tutorial of EasyEDA as this was my first time doing EasyEDA. In the PCB design phase, I was one of the two experts designing our prototype PCB layout and our final design. I took a lot of time trying to find the available parts in stock and designing the layout in EasyEDA. In the pre-assembly phase, I practiced soldering using the practice PCB ( before doing the main assembly, I was able to manage 4 PCB practice PCBs ). After getting the parts, my main job was to solder the buck boost and some parts of the ESP32. Giang and I were able to solder 4 PCBs at the end of this project. During the assembly phase I also had some time to work on the packaging design. Although my first design was using a compression spring, I was able to find that it was not very suitable and thus had to use a sandwich method.

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

Most of my earlier courses worked mostly on ASIC design, computer architecture and DSPs, so I did not have a lot of hands-on experience. However, ECE 362 and ECE 20008 were some of my earlier course works that helped me alot. In ECE 20008, I learnt how to solder and get familiar with the electric components and their names. In ECE 362, I learnt how to program a STM micro and how I can control it using C programming. These classes helped me in this project.

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

Some of the new knowledge that I acquired during this class and applied them are listed below:

* I learnt advanced skills of soldering that were really helpful in my soldering. For Instance, while desoldering an IC or a large component, I learnt from Joe that using a chip quik helps. Moreover, I learnt that rather than using a pointy soldering tip, I can use a flat blade tip that can spread the heat on a larger surface.
* Secondly, I learnt from Joe about how to clean the whole PCB. Later in the process of testing, there is no corrosion because of the flux. I was able to use a brush and go through the IC chips.
* I was able to acquire a deep knowledge on PCB design and layout by studying and going through the videos of EasyEDA and KiCAD. This helped me go through the PCB design and layout.

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

● Privacy Concerns: The collection and storage of user seating data may give rise to privacy apprehensions, as users may feel uneasy about their location or activity information being monitored. Principle 13 of the Association for Computing Machinery (ACM) underscores the significance of respecting individual privacy and safeguarding personal information. As an engineering student, our design implements a live checking system, meaning it doesn't store information but rather collects it at regular intervals to verify the user's seating status. Furthermore, adhering to ACM Principle 13, we've incorporated a specific sensor (FSR, pressure) that ensures user privacy is not compromised.

● Informed Consent: Obtaining informed consent from users for data collection and usage is pivotal in our system. Users should be fully informed about the data being collected, its potential uses, and should have the option to choose. This aligns with Canon 4 and 5 of the IEEE Code of Ethics, emphasizing the respect for others' privacy and ensuring informed consent.To guarantee user awareness regarding data collection, our app presents a consent form upon download. This form communicates all instructions and details about the data being used, allowing users the choice to opt in or out.

● Data Security: Safeguarding the data collected by the smart seating system is paramount to prevent manipulation of seating arrangements and user confusion. The ISC2 Code of Ethics underscores the responsibility of information security professionals to protect and secure information.To secure the data within our cloud-based system, our team has implemented a highly secure software environment that is resistant to hacking attempts.

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?

On a societal level, the system stands to enhance efficiency by saving individuals time and reducing the need for aimless wandering in search of available seats. This societal benefit, in turn, could lead to positive environmental outcomes. Time and space savings create opportunities for individuals to contribute to environmental well-being, fostering a healthier and more sustainable society ( such as planting more trees ). Although, this point might be an over-stretch of the product's outcome, if we see this product in a long time and many people use it, the time and efficiency reached can lead to an individual's capital to increase. In the global context, we will try to expand our product to consumers that will help them in their daily lives.

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

## **(Individual Reflections Section)**

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| **Advisors** | Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Smart Seating System |

| Senior Design Student Completing This Section | | | |
| --- | --- | --- | --- |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Gabriel Wang | CMPE | Systems | December 2023 |

**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.

## As the team’s system engineer, I bounced around a lot helping with different tasks as needed. One of my major roles involves developing how are system will be built and integrated. This includes finding how our hardware will interact with the software and finding the best place to put components. One of my first contributions involved testing out all the components that would be contestants in our final product design and picking out the select few that would work the best. Not only did I have to consider which components provided the best results, but I also needed to figure out which ones can work best in our developed system. Since our system involves at least 2 sensors, I prototyped several different types. An example of a good sensor that didn’t prove to work well in our designed system included some ultrasonic sensors and the human presence sensor. These sensors’ had faults in at least one category of their detection range, frequency, output, size, or power consumption that would not have been a good component to choose for our single system design. Towards the later part of this class, I focused on helping out with our PCB testing, setting up our development environment and mechanical design. This included making sure the firmware interacted well enough with our PCB and collecting/building our mechanical packaging. With some help from my team, I assembled two prototypes of our mechanical packaging, one of which we will officially use for our project demonstration. A challenge that I faced is making sure the integration between the PCB/our sensors is nicely placed into the pad without any outstanding interference.

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

## My earlier course work that is relevant to my contributions involves ECE 36200 and ECE 20007. ECE 36200 taught me tools like using a microcontroller and understanding all its peripherals. It really made interfacing with our ESP32 very seamless, and I got very used to looking at documentation for any problems or questions. For 20007, it helped me understand all the hardware circuitry used to design our schematics and to test out connections within our board/PCB. In addition, there are some other software programming classes, such as ECE 26400 Advanced C programming and ECE 36800 Data Structures and Algorithms, that taught concepts to properly prototype our components using software scripts. These topics included proper program flow, code structure, object oriented techniques, and syntax. There were several instances where a good proficiency in both hardware and software debugging allowed me to efficiently know where certain problems may exist from and fix them. On the hardware side, this especially came in handy when assembling our PCB to check where shorts can happen from. On the software side, I was able to quickly diagnose which line the code gave out unusual behavior and come up with an alternative solution.

## 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 regards to software/firmware prototyping, I learned that it’s a lot better to test one small part at a time. It’s often helpful to include as many print lines in a code block just to see where the code may fail at (where it doesn’t reach). An extension strategy that was extremely useful in ECE 36200 was the heavy use of documentation. I realized that there are often solutions to our problems posted online, it was just our duty to find it. Often time, reading the documentation of a certain component is good enough to find the answer to the problem. For example, I found out that the HLK-LD2410B-P Radar Sensor that we had acquired required a special wiring of the serial port in order to work the way it was intended too.

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

## Since our product is about human detection, addressing a concern for the invasion of privacy is very important. Thus, deciding on using IR and force sensors completely eliminated that concern which would have been an issue if we had gone with using an actual camera. My responsibility as a systems engineer is to also make sure the integration is rather flawless and does not negatively affect the user in any way. Most of this comes in regards to our hardware packaging including making sure all electrical connections are secure and out of the way.

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?

## Economic - Our product should not have much of an economic impact as it is mainly used as a tool for public spaces. These public spaces can greatly benefit by adding our system which will most likely increase customer satisfaction. However, due to the low scale level of our product, there should not be any economic impact.

## Environmental - Our product is engineered with rather sustainable materials that could easily be replaced/switched around. The power system is commanded by a 3.7 LiPo battery that is rechargeable. As calculated from the reliability document, all our hardware were calculated to have a very good reliability score, meaning the “shelf-life” of our product is nothing to worry about. One slight concern would be that there could have been better heat consideration in our final packaging.

## Societal - Again, our product is a public space tool, and it is used to provide convenience for the general public. It can potentially impact crowds and lines at certain places but we will have to do further analysis on that end.

## Global - We hope to keep expanding our product to more consumers, allowing for widespread access to our system and product.

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

## **(Individual Reflections Section)**

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| **Semester / Year** | Fall 2023 |
| **Advisors** | Phil Walter |
| **Team Number** | 8 |
| **Project Title** | Smart Seating System |

| Senior Design Student Completing This Section | | | |
| --- | --- | --- | --- |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Giang Nguyen | CMPE | Systems | December 2023 |

**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.

In this project, my contributions were multifaceted, encompassing both hardware and software realms. I took a lead role in the power supply design, conducting a detailed analysis of sensor requirements, selecting suitable voltage regulators, and ensuring optimal power distribution. Beyond this, I played a pivotal role in schematic development and PCB integration, translating conceptual designs into detailed schematics and overseeing their implementation on the PCB.

In the software domain, I not only developed firmware for effective sensor interfacing, ensuring seamless communication between the microcontroller and sensors but also actively contributed to the front-end software development. This included the creation of an intuitive interface for end-users, making the complex system accessible and user-friendly. I dedicated substantial effort to crafting a responsive web server and website that not only complemented the hardware capabilities but also provided a seamless experience for users interacting with the system.

Soldering, testing, and debugging were integral aspects of my involvement, ensuring the precision assembly and seamless functionality of the entire system. Lastly, recognizing the need for an efficient design tool, I initiated the integration of EasyEDA into our workflow, significantly enhancing our schematic capture and PCB layout. My commitment to both the hardware and software facets of the project aimed to deliver a cohesive and high-performance solution.

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

My contributions drew extensively from the knowledge and skills acquired in earlier coursework, particularly from ECE 362 (Microcontroller Interfacing), ECE 40862 (Embedded Systems and IoT), ECE 20001, and ECE 20002 (Electrical Fundamentals 1 and 2). The understanding of microcontroller interfacing from ECE 362 formed the basis for firmware development, enabling effective communication with sensors. ECE 40862 equipped me with the skills to design embedded systems, which proved invaluable in the integration of electronic components. The principles learned in electrical fundamentals courses guided my approach to power supply design, ensuring compliance with voltage and current requirements. These courses collectively provided a strong foundation that empowered me to navigate the complexities of both hardware and software aspects in this design project.

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 navigating the complexities of this project, my learning strategy involved comprehensive research and hands-on application. Delving into sensor requirements, voltage regulator specifications, and power distribution intricacies demanded an in-depth understanding. Practical simulations and worst-case scenario analyses validated the viability of chosen designs, translating theoretical knowledge into real-world application.

For firmware and software development, I drew extensively from the foundation laid in ECE 362 (Microcontroller Interfacing) and ECE 40862 (Embedded Systems and IoT). Continuous exploration of online resources ensured the incorporation of the latest practices in microcontroller interfacing, firmware development, and software design. Embracing EasyEDA as our design tool of choice required a multifaceted approach. I engaged with online tutorials to understand its functionalities, simultaneously applying this knowledge to hands-on experimentation. This dynamic learning strategy ensured a robust understanding of both theoretical concepts and practical implementation, empowering me to contribute significantly to various facets of the project.

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

Throughout the engineering design experience, ethical considerations were paramount. The accurate analysis of sensor requirements and the meticulous selection of components reflected a commitment to designing a system that meets specifications reliably. Ensuring the optimal use of resources, such as power supply efficiency, aligned with professional responsibilities for sustainable design. Transparency and open communication within the team were integral to ethical practices, fostering an environment where challenges were collectively addressed. Adherence to design standards and best practices, especially in soldering and PCB layout, demonstrated a commitment to the highest professional and ethical standards.

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?

The Seat Occupancy System, once implemented, can significantly impact various contexts. Economically, its application in vehicles or office spaces could enhance safety and efficiency. Environmentally, optimizing power supply design aligns with sustainability goals, ensuring efficient energy use. Societally, the system's potential to contribute to safety and comfort in various settings underscores its societal value.

Focusing on safety and comfort, the system excels in providing real-time seat occupancy data. In vehicles, this feature enhances safety by alerting drivers to the presence or absence of passengers, reducing the risk of accidental child or pet left behind. Simultaneously, the system contributes to the comfort of occupants by automating environmental adjustments based on seat occupancy. For instance, in a vehicle, it could automatically adjust climate control settings, seat positions, and other environmental factors. This personalized and automated approach enhances the overall comfort experience for individuals in these spaces.

It's important to note that the system, while specifically designed for seat occupancy data, serves as a foundational element. Its modular and adaptable nature allows for widespread applicability, addressing diverse needs. In making informed judgments, a comprehensive analysis of potential benefits and risks, adherence to regulatory standards, and consideration of societal implications played a key role, reflecting a commitment to responsible engineering.