Project Deliverable J: User Manual

For the course

Introduction to product

development and management

for engineers and computer scientists

Group 4

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Abstract:

Can't Touch This is a spatial awareness system that alerts wheelchair users when obstacles are present in their blind spots. It is installed on the rear side of the wheelchair and provides vibrational feedback to the user. It is composed of ultrasonic sensors, servo motors, an Arduino Uno, a breadboard, and multiple vibrational coil cell motors.

1.0 Introduction

The problem to be solved is to design a discreet and robust device that alerts the client prior to any collisions, increasing spatial awareness and reducing effort and time. Can't Touch This is a spatial awareness device that can be installed on wheelchairs and is designed to provide users with vibrational feedback when an obstacle is present close to the wheelchair.

1.1 So What?

Spatial awareness can prove to be a steep learning curve for most wheelchair users, especially to those new to wheelchairs. Users often bump into people, furniture, door frames, and other obstacles which may lead to not only frustration and time loss, but also wheelchair damage. This problem is even more amplified by electric-powered wheel chairs due to their size and bulkiness. This creates a bigger challenge in maneuvering making it more prone to bump into anything.

1.2 Who Cares?

According to a recent study, there are approximately 288,800 wheelchair and scooter users aged 15 years and over, representing 1% of the Canadian population. The sample included 197,560 manual wheelchair users, 42,360 powered wheelchair users, and 108,550 scooter users." (Smith, Giesbrecht, Mortenson, & Miller, 2016) Anyone with a wheelchair, whether it is manual or electric powered, has access to install this device. This will help clients regain confidence in their mobility and provide peace of mind to the users' families proving them more independent.

1.3 Why Us?

Can't Touch This beats all its competitors because of its inexpensive, easy to adjust design. It features an optimized sensor detection program and instant feedback system. This product utilizes the ultrasonic sensors to their fullest. These sensors are placed on a servo motor allowing them to perform a sweeping motion to detect obstacles at every angle. The feedback system provides instant awareness to the user by vibrating small electric motors placed in a belt placed between the user's back and the chair. Device can be installed and uninstalled with minimal effort by user or by a friend. It also proves to be customizable and the sensors can be moved around and placed at the user's position of choice.

2.0 User Manual

2.1 How it Works

Can't Touch This is comprised of 3 ultrasonic sensors, multiple vibrating motors, Arduino Uno, servo motors, breadboard, and a Velcro belt. The 3 ultrasonic sensors are placed on the back of the wheelchair on top of a 3D printed base station. These base stations are mounted on a servo motor to allow the sensor to perform a 120 degree sweep motion to detect objects at multiple positions. This whole system is installed on a wooden plank the size of the wheelchair's back to provide ease of installation. The Arduino is placed in a 3D printed box placed on the wheelchair to provide coverage and ensure safety of Arduino. The ultrasonic sensors and the servo motors are connected to the Arduino which provide the code for how they both operate. The sensors send information picked up back to the Arduino indicating the distance between it and an obstacle. If a certain threshold is crossed, the Arduino then sends a signal to the small vibrating motors that are woven into the Velcro belt. The Velcro belt is installed around the back of the chair and can be adjusted to the appropriate size. The vibrations on the belt would alert the user that there is an obstacle in one of their blind spots and that they should proceed with caution.

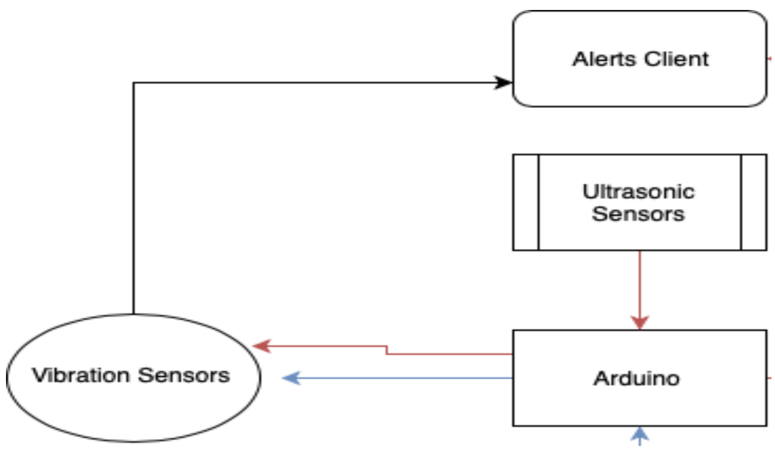

Figure 1: Basic Flowchart Demonstration of Prototype

2.2 3D Printed Parts

For this project, multiple parts had to be 3D printed. Most stands, protective cases, and housing units were 3D printed to fit exact dimensions and reduce cost. Below are some of the main 3D printed parts needed to complete this design:

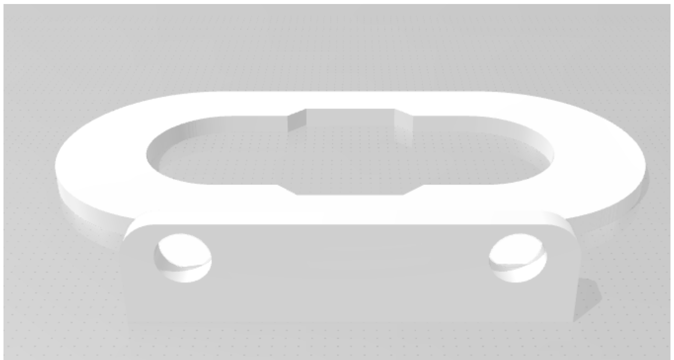

Figure 2: Ultrasonic Sensor Housing Unit

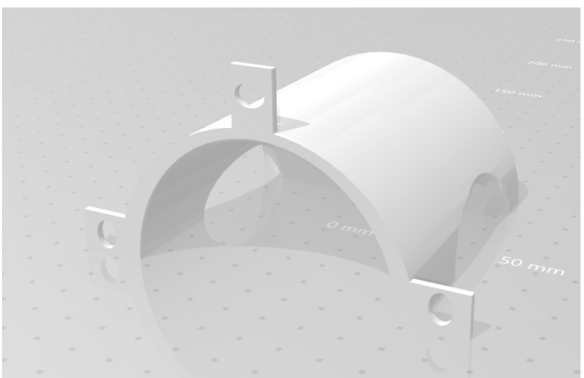

Figure 3: Servo and Sensor Casing

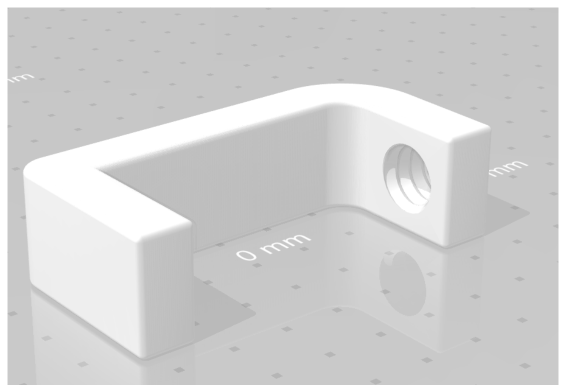

Figure 4: Longer Side of Clamp Frame

Figure 5: Arduino Housing Unit

2.3 Circuitry

Figure 3 below shows the circuit design for our final project. The ultrasonic sensors and the servos are connected to the Arduino. Both the Arduino and the vibrating coin cell motors are connected to the breadboard. The Arduino is powered by a portable battery charger.

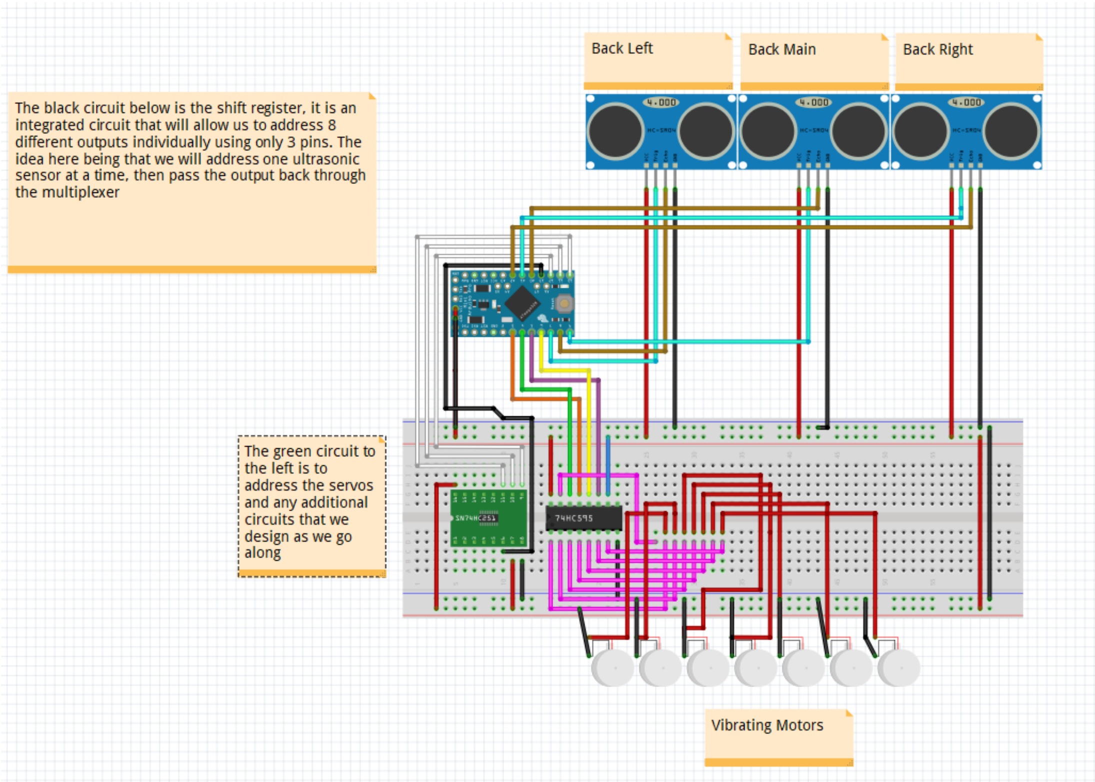

Figure 6: Circuit Diagram 1

2.4 Installation Instructions

Can't Touch This comes with wooden plank as a main mounting station for most the other parts. The installation of the sensors and the servos on the plank is a one-time instance since the plank can be easily attached to and removed from any wheelchair. The ultrasonic sensor is already mounted onto the servo and all the wires are already fastened and connected to the Arduino and to the breadboard.

To begin mounting, fasten the 3 ultrasonic sensors onto the plank in the desired location. Next, ensure that the breadboard and Arduino are secured in place on the wheelchair and that the wiring does not obstruct any motion. Afterwards, place the belt around the back of the chair and adjust to desired tightness. Finally, connect the battery charger to the Arduino to turn on the system.

2.5 Features

The main feature of *Can't Touch This* is the fact that it can detect objects up to 2 meters far. The threshold distance of vibrational feedback is set to 75 cm; however, this feature is adjustable to the user's preferences. Another key feature this device offers is that not only will it report back the presence of an obstacle, but it will also provide the user with the position of that obstacle. If an object is behind the user and to his right, then the right side of the vibrating belt will turn on. It vibrates depending on which sensor is triggered and vibrates in the appropriate location.

2.6 Safety Guidelines

Can't Touch This relies on a Lithium-ion battery pack as a power source. All Lithium Battery Safety procedures are recommended when handling the battery. For more information, please visit the Canadian Government website on how to handle such products safely following this link https://www.canada.ca/en/health-canada/services/toy-safety/battery-safety.html

2.7 Troubleshooting

In a case of system failure, please follow the following steps to try and solve the issue.

1. Reset the Arduino by pushing its "reset" button or by unplugging and re-plugging the power source.
2. Ensure the wiring is intact and that there are no loose or touching wires. Refer to Figure 6 to compare to proper setup.
3. If problem persists, contact manufacturer for support.

2.8 Design Files

For more information on the Can't Touch This position warning system, please visit the link below:

https://makerepo.com/Sahil1127/cant-touch-this-position-warning-system-a4

3.0 Conclusion

3.1 Lessons Learned

Developing Can't Touch This, over the course of the semester led to a lot of lessons learned. Dealing with the maker lab, learning how to 3D print, how circuits work, soldering, coding, drilling etc. We learned all these things throughout the semester which we used to design and manufacture our product. Besides all the skills we acquired through this course, there was many life lessons learnt throughout this entire process. Firstly, we learned time management is crucial, managing a team effectively delegating tasks and deadlines play a huge role in a team's ability to determine success and failure. Also, we learned not everything is able to be accomplished, and a plan never works out to how it's supposed to be. There are a lot of variables and factors that will obstruct you from reaching all the tasks you want to have completed. This only serves to cause frustration and stress amongst the team. As a team we realized this quickly and assigned priorities for all the tasks we wanted to accomplish, this way we can ensure that our product's main abilities can be met, and we can worry about smaller things such as the aesthetics as a later date. These lessons learned will never be forgotten and help us in future team work once we are aspiring engineers.

3.2 Future Work

In terms of what we see next for Can't Touch This, the team feels that it would be an excellent idea to install a rechargeable battery to improve efficiency of the device. Another key aspect to work on is aesthetics and wire management as it did not live up to our expectation in our regards. Finally, a more powerful and versatile ultrasonic sensor would do wonders for the performance of this position warning device. All these changes will ensure quality performance and a long-lasting impact on users.

Bibliography

Smith, E., Giesbrecht, E. M., Mortenson, W. B., & Miller, W. C. (2016, Feb 4). Prevalence of Wheelchair and Scooter Use Among Community-Dwelling Canadians. *Journal of the American Physical Therapy Association, 96*(8), 1135-1142. doi:10.2522/ptj.20150574

Appendix

1.0 Need Identification and Product Specification Process

1.1 Client Needs and Problem Statement

After meeting with Charles several times, our team have summarized the key information into a list presented below:

- The client is looking for device that can reduce the number collisions he experiences that won't damage his wheelchair or his surroundings.
- The client is looking for a discrete system that won't attract attention out in public.
- The system can run throughout the client's workday (8 hours).
- The client is also looking for a durable system that can withstand multiple collisions and still operate normally.

Problem Statement:

To design a discreet and robust device that alerts the client prior to any collisions, increasing spatial awareness and reducing effort and time.

1.2 Benchmarking:

After a lot of research our team has come to realized that there weren't too many advancements within this space. Previous projects in the past have been able to accomplish more complex versions of this task using cameras using computer vision algorithms to detect objects, recommend smart paths, and alert when the user would approach an object. Another one done here at the University of Ottawa was installing a camera in the back in order to provide a rear view for the user.

1.3 List of Metrics

Metric Number	Need Number	Metric	Importance	Units
1	1,2,3	-Furthest distance/range detected	2	meters
2	1,2,3	-Closest distance/range detected	2	meters
3	1,2,3	-Reduction in doorway collisions	1	% + subj.
4	1,2,3	-Accuracy in object detection	1	% + subj
5	4	-Overall weight of the product	3	kg
6	5	-Amount of noise made during use	2	dB
7	9	-Time taken to remove and reinstall the product on another chair	4	minutes
8	6	-Time that the product operates normally before needing to be recharged	3	hours
9	8	-Lifetime of the product and the amount of force that can be withstood	5	Months and Newtons
10	1,2,3	-Angles and range of vision	4	Degrees + subj.
11	1,2,3	Sensitivity and range adjustment	4	subj.

Table 1: List of Metrics

1.4 Target Specifications

Metric Number	Need Number	Metric	Units	Value
1	1,2,3	-Furthest distance/range detected	meters	>1.5
2	1,2,3	-Closest distance/range detected	meters	<0.05
3	1,2,3	-Reduction in doorway collisions	% + subj.	50%
4	1,2,3	-Accuracy in object detection	% + subj	90%
5	4	-Overall weight of the product	kg	<1kg
6	5	-Amount of noise made during use	dB	<25
7	9	-Time taken to remove and reinstall the product on another chair	minutes	<10
8	6	-Time that the product operates normally before needing to be recharged	hours	>8
9	8	-Lifetime of the product	Months	24
10	1,2,3	-Angles and range of vision	Degrees + subj.	180 (total rear)
11	1,2,3	Sensitivity and range adjustment	subj.	85%

Table 2: List of Target Specifications

2.0 Conceptual Design

The figure below is a visual representation of our final prototype. It includes ultrasonic sensors fitted into a 3D printed casing placed on the back of the wheelchair. They are mounted on a servo motor that performs a sweeping motion. A vibrating Velcro belt with sewn in vibrating coin cell motors is placed around the back of the chair. They are all connected to an Arduino Uno placed in the back of the wheelchair that reads in the results from the sensors and sends a signal to the motors to start vibrating.

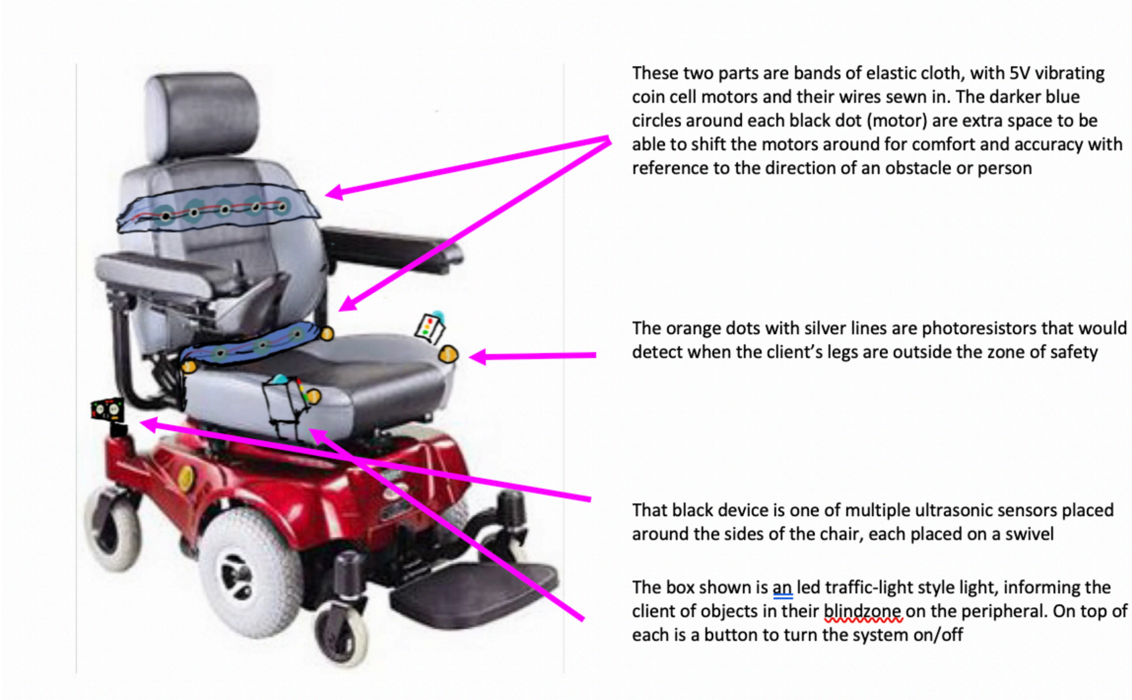

Figure 7: Visual Representation of Final Design

3.0 Project Planning and Feasibility Study

3.1 Gantt Chart

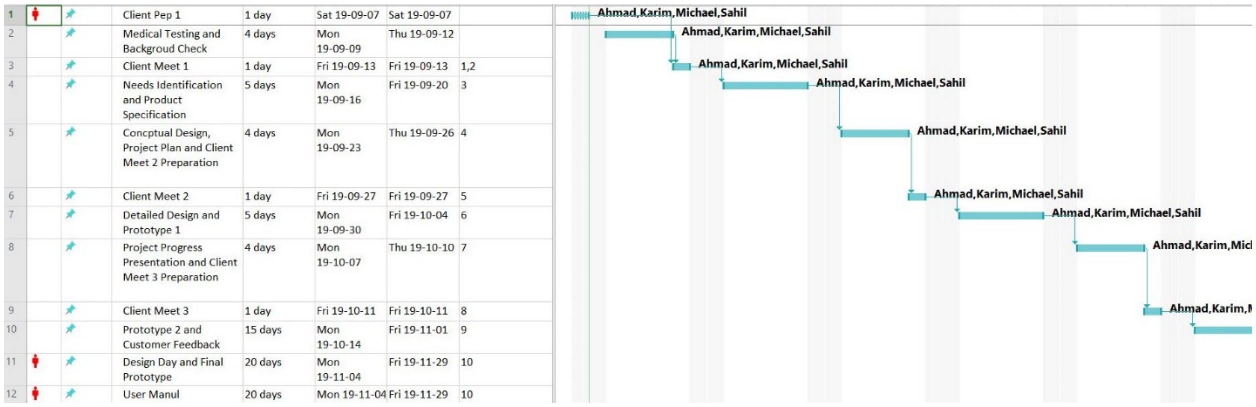

Figure 8: Initial *Simplified Gantt Chart*

Figure 8 Shows our initial and basic Gantt Chart that the team referred to in order to complete tasks and recognize who is responsible for what.

3.2 TELOS Factors

Technical: Our team has/can gain most of the expertise and technical resources required to do most of the prototypes designed for this solution. The technology that will be used in the prototypes are an Arduino Uno, an ultrasonic sensor, servo motors, and vibrating coil-cell motors. The team members have all have different educational backgrounds which gives us a variety of skills in many fields. Additionally, the teaching assistant and project manager have used these devices before and can assist us if required. Overall, the technology to develop a working prototype exists and we have enough help to design it, if need be.

Economic: The key components like the Arduino, both motors, and ultrasonic sensors can be used multiple times. For other parts, such as casings and mounts, they can be 3D printed. Also, the estimated cost of our final prototype is less than $100 so we have some financial wiggle room to adjust our plan during our prototyping. The man-power required for project is free, so there is no extra cost required.

Legal: We used an open source platform to generate our solution, therefore, we don't have any legal issues interfering with out project. There were also no patents or intellectual property that would interfere with the design of the product.

Operational: The only organizational constraint we had was the assigned deliverables and the progress reports. The deliverables took up a significant amount of time that could have been better spent working on the actual development of our product. Although the deliverables represent an important stage of product development and management, it would have been more efficient to spend this time on the creation of our device.

Scheduling: Our deadline for the final prototype was November 24th, the day prior to the final presentation. Our team managed to achieve that date despite to each of our varied and difficult to accommodate schedules. Despite the client's inability to show up at the previously set dates and times for our meetings, 3 out of 4 of our group members were able to adjust and show up. As for the reports and other deliverables, they were easily met at their respective deadlines excluding one where a misunderstanding occurred.