

Problem Statement/Research Question and Background

People in wheelchairs encounter accessibility issues with doors every day. It is difficult to get a door to open, and even harder to hold said door open as one goes through the door. In public spaces, there are sometimes automatic door openers, which are helpful to users but also quite expensive to purchase and install. In the home, many people who use wheelchairs have come up with some solutions for increasing accessibility, either by removing doors entirely, replacing them with sliding doors, or simply leaving their doors open at all times. These solutions are effective for inside of the home, but the front door of the home cannot be modified as readily. In addition, the cost of purchasing and installing automatic doors is too high for it to be a feasible alternative. Thus, we chose to investigate whether we could create an automatic door opener that is cost effective for use in the front door.

Methods/Approach/Solutions Considered



Doorstop on a stick

In order to narrow down the scope of our project, we brainstormed ideas with staff and patients at Rancho Rehabilitation Center. We were surprised that the frequent act of opening and moving through doors is quite cumbersome for users of wheelchairs. Currently, cost effective solutions to this problem do not exist. The door opening devices that are on the market are not readily used by the people we spoke with. Thus, we decided to target the problem of opening doors and getting through them.

Our first idea after assessing the problem was to design a door stop with a long handle, which could hold the door open while the user wheeled through the opening. This tool would be used in conjunction with a previously designed door opener that acts as an extension to the arm and allows the user to grasp and turn a door handle from a distance.

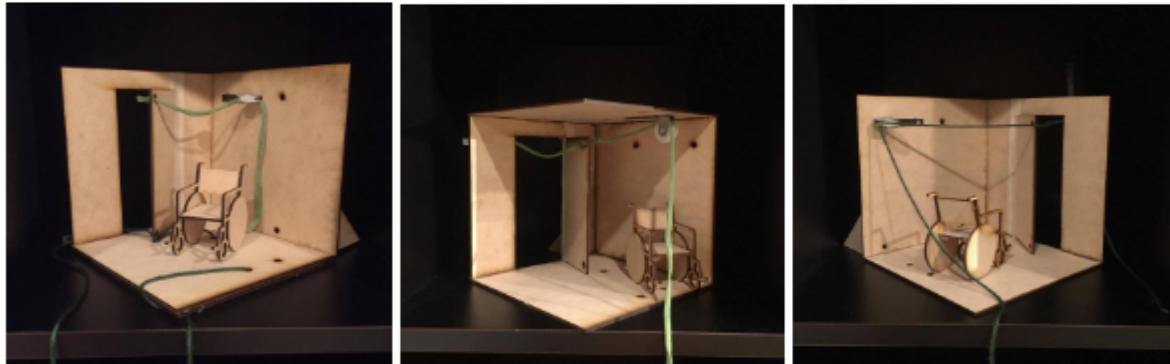
To explore this idea further, we spoke with the designers of the door opener, since they worked on the same problem we were tackling. We learnt that they initially tried the doorstop-on-a-stick kind of concept as well, but it was not effective. They found that many people have already found methods of wheeling themselves through doors, while using their wheelchairs as makeshift doorstops. Although a doorstop-on-a-stick would be a variation of this technique, it would not solve the core problem of struggling to hold an often heavy front door open with one arm, while turning the wheels of a manual wheelchair with the other arm. In fact, having to keep track of an extra tool might actually serve as more of a hindrance in this situation.

Thus, we decided against this idea, and began to develop a full-fledged automatic door opener.

We went to the Villa Gardens, a continuing care retirement community in Pasadena, to talk to its Executive Director, Dmitry Estrin. After speaking to Dmitry, we learnt that most people are able to adjust the doors within their home to make them more accessible.

This means that people either remove their doors, replace them with sliding doors, or decide not to bother with ever closing the doors in their home because in the residential setting, closing doors is less necessary. Dmitry proposed focusing on making an automatic door opening device for the front door, because the front door cannot readily be adjusted or switched out for a different type of door. In addition, this door would need to close for safety reasons. Our visit to Villa Gardens and meetings with Dmitry and residents greatly helped us narrow down our concept to be fitted onto a front door, rather than the doors that are within the home. We then started investigating ideas that are suitable for the front door. We realized we needed to account for the fact that the door will be heavier.

We decided that the final door opener should be powered by a motor. However, we wanted to start out by studying a simpler pulley system, and collect feedback from potential users of our product for feedback. We built miniature rooms with doors, and experimented with the location of a pulley system that would assist with the opening of the door.



Initial prototypes to demonstrate pulley mechanisms in various locations of room

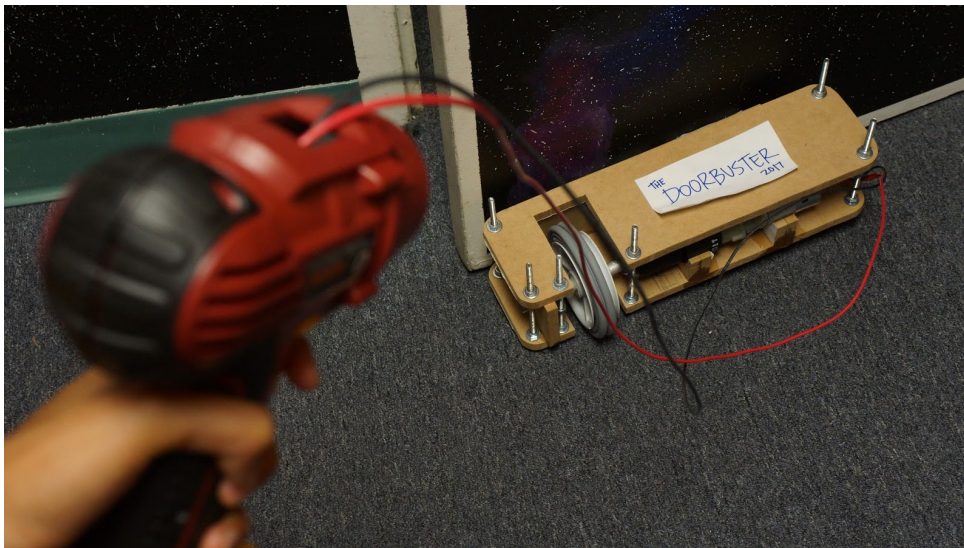
We spoke with Diego and Noom, experienced rehabilitation engineers at the Rancho Los Amigos National Rehabilitation Center about our prototypes. Diego uses a manual wheelchair, and he and Noom have seen many different products that are designed to help people in wheelchairs perform daily tasks. They are very knowledgeable about what makes the most successful products useful. They emphasized the importance of coming up with a solution that is not obstructive or visually intrusive. They also suggested that we look into building a product like the Doormatic automatic door opener, which doesn't require any changes to the door or door frame.



Discussing project ideas with Diego Rodriguez from Rancho Rehabilitation Center

Description of Final Approach and Design

Our final approach involved utilizing the technology of a drill motor in order to power our door opener in both the forward and reverse directions. A drill was deconstructed, and the motor and trigger mechanisms were kept; the motor was housed in MDF casing, and the wires connecting the motor to the trigger were cut. Longer wires were soldered to connect the two cut ends to elongate the distance between the device and the trigger mechanism. A half inch dowel was inserted into the drill motor, and the other end of the dowel was placed in the axle of the wheel such that, once the trigger was activated (directionality could be reversed), the motor would start turning, thereby causing the attached wheel to turn.



The Doorbuster 2017

Outcome

The final working prototype was presented at both Rancho Los Amigos Rehabilitation Center and Caltech, and overall, people were excited to see the product. Their main feedback was to switch over to a wireless system of operation so that one is not restricted by the length of the wire that we soldered between the drill motor and the trigger mechanism. The current model is also unrealistic because the wire cannot be wedged into the door; thus, we are currently working on making the system wireless so that a remote button, for example, could trigger the door to open. This innovation would also expand our market to people who use power wheelchairs, as a button would be more accessible for those individuals. Further, members of the Rancho community commented on the ease of installment of the door opener. We would like to ensure that users of the device have facility with its installment. The device will most likely be battery operated (using a rechargeable battery), so the position of the battery and battery life are important factors to consider. Having to recharge the battery multiple times a week/month would not be feasible for the user, but battery life depends on frequency of use.

In terms of testing, we have noticed some potential issues that can occur while using our current prototype. Since the drill motor is quite heavy relative to the wheel, one side of the Doorbuster can sag down; if one side of the Doorbuster is scraping against the floor, people need to use a lot more power to get the door to open. In addition, we need to incorporate a mechanism for allowing the door to open without use of the Doorbuster so that we can accommodate people who do not need assistance opening doors. Currently, our prototype slides if one opens the door without utilizing the system, but it would be better if the wheel could turn independently of the drill motor.

In order to address some of these problems, we are actively pursuing the idea of recycling the mechanics and electronics from a remote controlled car in order to make a Doorbuster that is wireless while still maintaining the power that we achieved using the drill motor. This solution will be more compact and easily implementable; no extensive programming would be required, since the mechanism of the RC car works exactly how we would like the doorbuster to work. The remote enables the motor to reverse direction, and the pressure sensor on the trigger controls the speed at which the motor rotates. In the upcoming quarter, we will continue to refine this design, while simultaneously determining how to attach the device to various types of front doors.

Cost

The cost to produce our first electronic prototype was \$60. This is from the drill (\$40) and the housing unit, wheel, and other materials (\$20). The product would be priced from \$150 to \$200 to account for increased cost of better materials and the need to profit from sales. This is significantly less costly than the Doormatic Door Opener, which would be a competitor for our product at \$300. Other automatic door openers such as Open Sesame, cost nearly \$2000. The lower cost of the Doorbuster would help make this product a more affordable yet effective solution.

The remote-controlled car for our second electronic prototype costs \$73. Additional expenses incurred will be from the 3D printing of the housing, the wheel, and other

associated dowels for connecting the motor to the wheel. Further, the screws or velcro used to attach the device to front doors will add an additional minimal expense. Together, the cost of the second electronic prototype will be much less than that of current models on the market.

Significance

Throughout this process, we have learned about the challenges those using wheelchairs face, including tasks which we take for granted, such as opening doors, reaching objects or buttons, and driving. Our conversations with members of the Rancho and Villa Gardens communities have greatly enhanced our understanding of the complexities associated with designing for disability. In the future, we seek to continually incorporate universally beneficial designs in order to take into consideration many different types of people, including those who are disabled.

The main significance of the Doorbuster is that it increases accessibility to the front door (which is difficult to modify) for people with manual and power wheelchairs in an affordable, easy-to-install manner. Opening doors is something that most people take for granted, and having to ask people to open the door for you, or hold it open, is something that increases the dependence of people who use wheelchairs. An affordable door opener like the Doorbuster allows users to feel more empowered and in control of their lives.

Acknowledgements and References

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Members of Rancho Los Amigos National Rehabilitation Center community

Members of Villa Gardens Retirement Community