# DEVELOPMENT OF AN AI-ROBOTICS 3D PRINTED CIRCLE OF COMMAND FOR ENHANCING ACCESSIBILITY AND MOBILITY IN INDIVIDUALS WITH MOBILITY ISSUES

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***ABSTRACT***

*According to the CDC, 13.7% of adults in the United States have mobility issues, which is about 42 million people who have that issue. The purpose of this paper is to utilize artificial intelligence and robotics packaged in a 3D printed Circle of Command to help make the lives of those 42 million people easier [5]. A raspberry pi is used to power and process the voice control commands and turn the voice commands into actions that respond to the commands [6]. The voice control is achieved through three microphones that are embedded from the inside of the Circle of Command using holes to listen to any potential voice commands, and as the raspberry pi can't input analog output which is outputted from the microphones, the microphones and the raspberry pi are connected to an analog to digital converter that allows the raspberry pi and the microphones to exchange information smoothly Robotics is used in the stepper motor and the gear that is used to turn the top of the lazy susan, which is 3D printed so that there are gears on the inside of the top. There is also a home switch that will home the lazy susan. There is no practical application of this AI Robotic Circle of Command as it is just a prototype, and so there are no results, but it is hoped that it will be able to change some of the 42 million lives once the production of the production model begins, the production model will be larger than the prototype as the prototype serves as only a proof of concept and shows that this idea is actually doable [7].*

***KEYWORDS***

*Artificial Intelligance, Circle of Command, Mobility Issues, Voice Control/Command*

## 1. INTRODUCTION

Mobility issues are becoming more and more prevalent and will only become even more prevalent as people age and as the birth rates decrease as seen in countries like Korea and Japan [8]. Mobility issues are partly caused by a loss of muscle which occurs as people age, and can start as early as when one is thirty years old but do not become as prevalent until one is at least fifty years old or older [9]. The benefits of not having as many mobility issues if not at all are that one can be healthier and more independent and continue doing one's favorite hobbies. On the flipside, the consequences of mobility issues are that one is more dependent on others, can not do one's favorite hobbies as much if at all, and becomes less and less mobile which will only get worse over time. There is some usage as there are some people who are still very mobile despite their age. Mobility issues are very common among a portion of society as about 42 million

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Americans have such issues according to the CDC, while it is not very common among other Americans. The topic of mobility issues is very important as the older people become even older and usually have more mobility issues as they age which means that they gradually get more and more dependent on others for assistance in doing things which may increase the likelihood of them being cared for at a senior center or even at a hospital.

Existing methods or tools are things like ramps for wheelchairs, which are common sights around various stores, hospitals, and other places or elevators, which are a very common sight amongst buildings with multiple floors. Every method or tool that exists today are all commonplace and common sights outside the home. The foremost issue that exist in existing methods or tools is that there are no method or tools that exist within the home on a wide scale, all there is have all been outside of the home which can be a problem for people with mobility issues as they might not want to go outside of the home due to having mobility issues or due to some other reason, and thus none of the existing methods or tools will be used, which is why the fact that all of the existing methods and tools are all outside of the home is the foremost issue that exist in existing methods or tools. The second issue with existing methods or tools is that it is very rare and not to mention very expensive for existing methods or tools to be seen in private homes and there is also the fact that there might not be enough space in the home for the existing methods or tools to be implemented, and thus it is unusable for people with mobility issues who do not want to go out of the home due to said mobility issue or some other reason. The third issue with existing methods or tools is that it is not as efficient within a room and would perhaps take up too much space within said room for the room to even be counted as a room anymore, this is an issue as when people age their mobility issues worsen and so they are more and more likely to stay in a single room or stay in bed instead of trying to exercise and retain their mobility, which is only a small portion of all the people with mobility issues.

The Circle of Command is an AI Robotic lazy susan, which is aimed at making the lives of people with mobility issues easier [10]. The Circle of Command features Voice Control/Command, an automatic homing system for the top of the Circle of Command, and triangulation of the user's voice through the three microphones embedded in it [11]. The Circle of Command is different from existing methods or tools by that existing methods or tools are commonplace and common sights out of the home, while the Circle of Command is meant to stay within said home. The Circle of Command is also able to be efficient within a room without said room becoming something that does not count as a room anymore, and can be located anywhere within the room or the home to make life easier for people with mobility issues in general but also to make life easier those people that do not want to leave the home or the room due to mobility issues or whatever reason [12]. The strengths of the Circle of Command are that it is able to stay efficient within the home or the room, can be voice controlled, and can automatically home the top of the Circle of Command, as well as locate where the user is from triangulation using the three embedded microphones.

The remainder of this paper is arranged as follows: Section 2 gives some of the main challenges that were faced in designing and making this lazy susan which is called the Circle of Command for the rest of the paper; Section 3 is about the solution to the problem of mobility issues and explains the solution in depth; Section 4 details the results and the steps that were done in the experiment; Section 5 explores similar solutions to the one being described in this paper and highlights the similarities and differences between the solutions; and lastly Section 6 focuses on the future of this project and current limitations and solutions to those limitations as well as providing the final comments to this paper.

## 2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

### 2.1. Fix the Microphones

A challenge about this project is trying to fix the microphones and get them to work, weeks were spent on trying to fix the microphones as the microphones are a crucial part of this project as it enables the voice commands and it allows the raspberry pi to act based on vocal input which it can not do if the microphones do not work. The raspberry pi does not read analog signals which are the outputs of the microphones, and so an analog to digital converter was required to translate analog into digital, which the raspberry pi can read and act based on the outputs of the microphones. With the microphones not working, the AI Circle of Command was not able to function as intended, which was for the Circle of Command to be able to use the microphones for voice commands and to triangulate where the voice was coming from, and be able to turn the top towards the speaker.

### 2.2. Designing the 3D Model

The second challenge was designing the 3D model for the Circle of Command, which required me to learn 3D modeling which was made easier through the use of Tinkercad, a website that allowed me to do 3D modeling, but it was still a challenge as I had never made a 3D model of a Circle of Command before this and so I had to learn how to make a 3D model of the Circle of Commands I designed the model. As there were many parts to the lazy susan, I had to design each part separately and make sure that all the parts can fit together after 3D printing the parts. There were many variations on the design as the core features of a Circle of Command were added and after some trial and error, the final design was made. The final design was a combination of some variations on the previous designs, which all fit together.

### 2.3. Getting the Programming and the 3D Printed parts

The third and final challenge of this project was getting the programming and the 3D printed parts of the Circle of Command to work together properly. It was crucial that the programming and the 3D printed parts work together properly because the whole project would fall apart if the programming and the parts do not work together as the project was built on the assumption that the programming and the parts would work together [15]. In addition, if the programming and the 3D parts do not work together then it would not help those people who have mobility issues, in fact it would hinder them and may worsen the mobility issues which is the reason why it is crucial for the programming and the 3D printed parts of the Circle of Command to be able to work together, and which is also why the whole project would fall apart if the programming and the parts do not work together.

## 3. SOLUTION

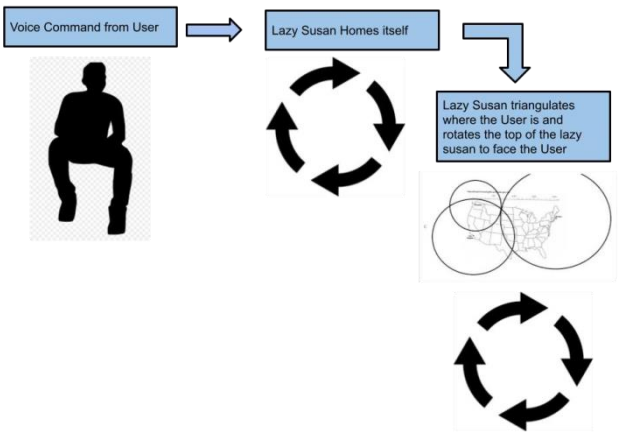


Figure 1. System Overview of the lazy susan

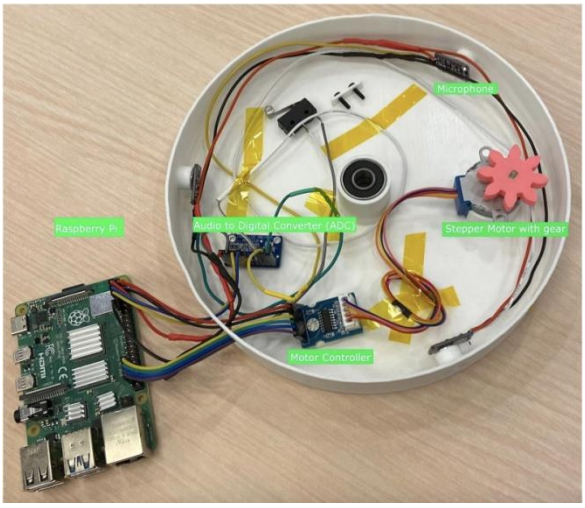


Figure 2. Overview of the components of the Circle of Command

The AI Robotic Circle of Command waits for a voice command from the user, once it hears a voice command, it automatically homes itself through the use of a switch and a bump, the Circle of Command knows that its homed when the bump presses the switch, and then it triangulates where the user is using the three microphones embedded within the walls of the lazy susan. After the triangulation, the Circle of Command then rotates the top, the top is able to rotate due to a couple bearings connected to a pole on the center of the top, and an outer gear on the inside of the top using a stepper motor with a gear attached to it, to where the user is. The components are as follows: a raspberry pi, a stepper motor with a gear attached to it, an analog to digital converter, three microphones, and a motor controller. The microphones are to listen to where the voice of the user is coming from and to triangulate where the user is, which is outputted to an analog to digital converter to convert the analog output of the microphones into digital output so that the raspberry pi can understand the output from the microphones, which is then outputted to a motor controller which allows the raspberry pi to interface with the stepper motor, the motor controller then outputs the information from the raspberry pi to the stepper motor, which uses that

information to rotate the top of the Circle of Command to where the user is, through the gear that is attached to the stepper motor, which is connected to the outer gear within the top.

These components were connected using quite a few wires and are held down using heat resistant tape. The implementation of the raspberry pi required me to change the design by carving out a hole for the multitude of wires to be able to go through as there was not enough space within the Circle of Command to place the raspberry pi so that is why it is outside and not inside. The implementation of the microphones required me to again change the design to again carve out holes and make the carved out circle into a cylinder on the inside in order to accommodate the microphones. The implementation of the stepper motor with gear required me to 3D model a gear that fits the outer gear that is on the inside of the top of the Circle of Command which allows the top to rotate, and it also required me to once again change the design so that there is a holder for the stepper motor as it might very well move with the top as it rotates the top which will lead to the top not rotating at all as there is not a central point to rotate from which will defeat the purpose of this project as the project is basically based on the assumption that the top rotates, so the design was yet again revised with the addition of the holder in order to hold the stepper motor in place as it rotates [13]. The implementation of the analog to digital converter did not involve any changes to the design, all that was involved was connecting all of the wires to its proper place on the raspberry pi and the analog to digital converter and the wires from the analog to digital converter to the three microphones, as well as some tape to hold some of the wires down. The implementation of the motor controller was very similar to that of the implementation of the analog to digital converter by that once again no changes to the design was required and it was only connecting the wires from the raspberry pi to the motor controller and then connecting the wires from the motor controller to the stepper motor with gear. The only algorithm that was used was python in the raspberry pi as there was no need for there to be other algorithms used in the other components as that is what the wires are for which is to transfer the information and the algorithm from one component to the other, which kind of negates the use of other algorithms, in addition no other component can have and use an algorithm except for the raspberry pi, and whatever algorithm that a component needs can be transferred through the wires that connects all of the components [14].

## 4. EXPERIMENT

The Circle of Command voice sensing system is a technology that is designed to help determine the user's position based on the direction from which they are speaking. To test the accuracy of this technology, I set up a simple series of experiments using three microphones arranged around the Circle of Command. The microphones were placed equidistant from each other, and a speaker was used to play a single audio file at the same volume.

For each experiment, the speaker was moved around the Circle of Command, and the system was retested to see how accurately it could determine the speaker's position. The goal of the experiments was to measure how close the Circle of Command came to the actual position of the speaker, and to evaluate the accuracy of the voice sensing system.

To ensure that the results were consistent and reliable, I repeated the experiments multiple times, using different speakers and audio files each time. I also made sure to test the system in different environments, such as in a quiet room and in a noisy room with background noise.

| Speaker Position (degrees) | Average Microphone 1 Loudness (dB) | Average Microphone 2 Loudness (dB) | Average Microphone 3 Loudness (dB) | Circle of Command Position (degrees) |
|---|---|---|---|---|
| 0 | 70 | 75 | 72 | 0 |
| 30 | 60 | 70 | 65 | 34 |
| 60 | 68 | 72 | 70 | 54 |
| 90 | 75 | 78 | 76 | 101 |
| 120 | 72 | 70 | 68 | 118 |
| 150 | 65 | 60 | 68 | 155 |
| 180 | 72 | 75 | 72 | 188 |
| 210 | 68 | 72 | 70 | 212 |
| 240 | 75 | 78 | 76 | 245 |
| 270 | 72 | 70 | 68 | 268 |
| 300 | 65 | 60 | 68 | 199 |
| 330 | 72 | 75 | 72 | 331 |

Figure 3. Table of experiment 1

The results of the experiments showed that the Circle of Command voice sensing system was able to accurately determine the position of the speaker in most cases. However, there were some instances where the system was not as accurate, particularly in environments with a lot of background noise.

## 5. RELATED WORK

Cinderby, S., Cambridge, H., Attuyer, K. et al focuses on the role of cities in helping people with mobility issues, in which typically older people maintain their mobility as they grow older [1]. They did experiments in three separate cities which led to them finding out the three problems for people who want to maintain mobility in the cities. The authors have a much broader vision as they wanted for people with mobility issues to maintain their mobility as they age with help from the cities that they live in. In contrast, this paper focuses on the role of the Circle of Command and how it helps people with mobility issues by making their lives easier. The strength of the authors' work is that it seeks to help people maintain mobility through partnering with cities. While the strength of the Circle of Command is that though it does not seek to maintain a person's mobility as they age like the authors, it is much smaller and does not involve much negotiating with city leaders as the main focus of this paper is on making the lives of people who have mobility issues easier and not on how cities can help with maintaining mobility as people age.

Robinson, H., MacDonald, B. & Broadbent, E. looks at how technology, particularly robotics, can be used to solve the needs of older people [2]. They focused on reasons for being sent to nursing homes and how to solve those reasons using technology. The Circle of Command is very similar as it also uses technology in particular robotics and AI to solve things for older people. The authors' idea of using technology to solve the needs of people is not new but it most likely is new in this particular topic of solving the needs of older people. The strengths of the authors' work are that it is practical and relevant, while the strengths of the Circle of Command are its utilization of AI in addition to robotics, and being able to use one's voice to control it.

Remillard, Elena T. and a few others investigate the challenges that people with mobility issues face everyday [3]. They did interviews on a sample of sixty participants, each at least sixty years old and at most seventy-nine years old and with at least ten years of having mobility issues. The Circle of Command is made to make life easier exactly for these participants. The authors did interviews which are not as persuasive as a graph of some cause and effect that having mobility

issues poses certain challenges to people. The strengths of the Circle of Command are that it is made with these people in mind and is solely built to make life easier for people like these participants. The strength of the authors' interviews is that it offers a fresh look at the challenges faced by people with mobility issues which is not covered in this paper.

## 6. CONCLUSIONS

We have created the Circle of Command to make life easier for those who have mobility issues. The Circle of Command is an AI Robotic lazy susan made with 3D modeling and printing and built via a raspberry pi, an analog to digital converter, three microphones, a stepper motor with a gear attached, a motor controller, and a lot of wires [4].

The current limitations are: the size of the Circle of Command, and the materials that make up the shell of the Circle of Command. The size of the Circle of Command is a limitation as it can only fit so many things on the top before being unable to fit anymore, and the raspberry pi is only outside because there is no more room to place it on the inside. The materials that make up the shell of the Circle of Command is also a limitation by that it is made of plastic, which can deform if enough heat is applied and that might cause the Circle of Command to not be able to rotate anymore.

We plan to solve these limitations in the future by enlarging the Circle of Command so that the raspberry pi can be placed within it, and so that there is enough space on the top for things to be placed on it. In addition, we also plan to remake the Circle of Command using metal so that it is more heat resistant and so won't deform as badly at higher temperatures.

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