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**Rockability**

This project was created to address the issue of the lack of accessibility in rhythm video games for people with physical disabilities. There are many rhythm games that already exist like Rock Band and Guitar Hero, which have controllers that would require two hands and arm movement. Other rhythm game controllers, like the standard Xbox controller or a tablet, require fine motor skills. These controllers allow for an immersive experience for people with these abilities, but not everyone has this luxury. I would like to address this discrepancy by creating a rhythm game that allows for a variety of controllers. These controllers will be created with differently-abled people in mind so that they can choose whichever controller they think would be best for their abilities.

Video games are a pastime that many picked up during the pandemic, making accessibility in games even more pertinent. According to Wiederhold, video game sales increased by 63% worldwide between the week of March 16th to March 22th, the first week after the WHO announced that COVID-19 was a pandemic. Furthermore, from a survey from researchers from the University of Glasgow, not only did 71% of respondents say they increased the amount of video game playing, 58% responded that it impacted them emotionally, with an overwhelmingly positive outlook (Barr and Copeland-Stewart). It became so popular that games like Animal Crossing: New Horizon became venues of events that people could not gather in person for anymore (Wiederhold). This massive increase in the use of video games as a medium to communicate with friends and family makes the push for video game accessibility even more important. The medium is so vast and powerful, so accessibility measures are not only possible but easy to add. These measures just are not always accounted for in development, something that needs to be changed so that more people can access these games.

For people with physical disabilities, there are already many barriers to many leisurely activities. Depending on the disability this can range from not having transportation. The subway isn't wheelchair accessible to not being able to partake in activities like roller coasters because a certain amount of limbs is required. For example, in 2019, more than 75 art galleries in New York were hit with a lawsuit that stated that they weren't following the laws of the ADA (Kinsella). This is just one story of many businesses that flaunt accessibility measures, making many options, like visiting an art gallery, unattainable for people with physical disabilities. The lack of accessibility in the physical world is commonplace, much more so than many people that do not have disabilities comprehend.

In previous research, I helped design a piece of assistive technology for a specific user for a class that focused on the types and creation of assistive technology. He had Guillain-Barre disease, which caused him to lose fine motor function in his hands. This made it impossible to do things that many people take for granted like opening doors with round knobs or unscrewing jar lids. We created a device that allowed him to grip the top of the jar so that he could actually twist off the top. Creating this device involved substantial collaborative effort with the user, a strategy which I brought to the development of these rhythm game controllers. Working closely

with people to make sure that you are actually accounting for all facets of the disability is vital. Without the lived experience, it is hard to make sure that everything is taken into consideration. The target audience for this work is people that have physical disabilities that make interacting with video game controllers difficult or impossible. More specifically, I am designing for people that are unable to hold the standard video game controller. Standard controllers are made for people with two hands that have the full fine motor function, so my game will be made for people without these traits. Able-bodied people will be able to use them as well, but they will be made with people with physical disabilities in mind. This project is important to them because it will help take down the barrier to entry for rhythm games. It will help people that can't use the standard controllers take part in a pastime that many enjoy, but could not before because it was not accessible to them.

The Keyboard by Google Creative Lab and Eyewriter both heavily informed my work because they showed me what is possible to do with machine learning, and how that can be translated into an accessible project. The Keyboard is an instrument that is designed to look like a keyboard that allows the user to hit different notes with just some movement of the neck. Eyewriter is a project created for a graffiti artist, TEMPTONE, that became completely paralyzed to the point where he could only move his eyes. So, a program was created by members of Free Art and Technology (FAT), OpenFrameworks, the Graffiti Research Lab, and The Ebeling Group communities so that he could draw using eye movement, allowing him to continue to make graffiti designs.

Literature that also informed my work are the many pieces on how the world is inaccessible right now and accessibility is expensive like *Crip Camp* and "The Cost of Accessibility". Works like the TED talk by Neil Harbisson "I Listen to Color" will help inform how my project is received because they will show how accessible technology can change people's lives and how people with disabilities live. There are many pieces by disabled people that talk about how inaccessible the world is and that will help able-bodied people put my project into the perspective of the wider world of video games. For example, in *The Cost of Accessibility*, Kelly Dawson talks about how expensive it is to exist in this world as a disabled person. Another piece that tackles this issue is "Inaccessibility at SAIT". This article talks about all the accessibility problems at SAIT, a university in Calgary. These are things such as stairs without accompanying ramps, manual doors, and cracked pavement, many of which are things that people that are not impacted by disabilities may not even notice are a problem. Moreover, all the things that many people take for granted can cost a lot of money, something that not all people with disabilities have. Even if these accessibility problems can be alleviated with assistive technology, devices can be very expensive. For example, looking at Ben Heck's blogs and his one-handed controllers can help one understand how video games were not created for people that don't have two functioning hands. People that can't use the normal controller provided are paying for that controller but also have to pay extra to buy a controller that actually works for them, one that is much more expensive than the average controller. Furthermore, he is only able to ship in the United States, so geography can be a boundary that people come across as well. Another finding that informed my decision to make this project was a study on the effects of having a mobility limitation on people in Zambia. According to this study, an inaccessible environment gives individuals with mobility limitations fewer opportunities to participate in education, training, and employment, and limits their experience of positive life situations. So,

this means that environments that are not fully accessible have an array of negative effects on people with mobility limitations. Projects that allow people with disabilities to participate more in social activities are therefore very helpful because it helps increase positive life situations by making socialization much more feasible. Another study on people with disabilities in the Mid-Atlantic region found similar results, that physical disabilities negatively impacted a person's ability to participate in services due to physical barriers. So, this negative impact on participation is not limited to any one area, the same results were found in very different groups, people from Zambia and people from the Mid-Atlantic region of the United States.

With all this inspiration in mind, to create this project, I decided to work with PoseNet and Google's Teachable Machine to create controllers with machine learning. Using the ml5 framework and Posenet, I made controllers that rely on the movement of the body that is tracked by points on the face and body, which are found with Posenet. These controllers require differing levels of ability so that the user can choose which one is right for them. One requires the ability to hold up your arms to the camera and move your forearms, while the other allows users to play with only the movement of their heads from side to side. With these motion-sensing controllers, I created a p5 sketch that creates shapes corresponding to notes. When the shape is touched by the cursor, a sound is played. This sound corresponds to where the note is on the x-axis, as shapes in different positions play a different note. The series of notes that float across the screen makes a song, just like a rhythm game. My project will sufficiently address the issue I identified if I have people of different abilities attempt the game and feel confident in their ability to use the controllers. The point of the game is that people with mobility limitations in their hands can play video games, so if they can control the game well that means that I have accomplished what I set out to do. If I can also have able-bodied people play the game and think about people with disabilities in their life, this would be a success because it would bring attention to the accessibility of our world and hopefully inspire more people to create with accessibility measures in mind.

While there are many different types of controllers for rhythm games, most of these are inaccessible to people with motor control function issues or people missing a hand or arm. The standard controller for many other video games is either a console controller or a mouse and keyboard, both of which are not accessible controllers for this demographic. Rhythm games have a wide variety of controllers that make the interactions and resulting gameplay completely different. Some examples are the full-size guitar-shaped controllers for Guitar Hero and Rock Band, the dancing mats for Dance Dance Revolution, and the Oculus Touch controllers for Beat Saber. These controllers are all very different from each other and are part of the appeal of their respective games, proving that controllers are an important part of the rhythm game experience. Therefore, there needs to be a way to bring this experience of rhythm games with interactive and fun controllers to people that cannot use other controllers for accessibility reasons. Furthermore, video games can be very inaccessible due to the cost of the equipment and the game itself. For people with disabilities, there is the added cost of having to get custom controllers just to be able to play. And getting custom controllers can be even more difficult because not all custom controller makers can ship everywhere. For example, the PS4 controllers from Ben Heck can only be shipped within the US and are multiple times more expensive than buying the standard controllers. So, ability, cost, and geographic location can all be limiting factors for enjoying rhythm games for people with disabilities.

To solve these problems of accessibility on multiple axes, I created a browser game that utilizes head and arm movements to control the game. The game is created in p5 and only requires a laptop with a webcam. So, the affordability is much better than most consoles and custom controllers. Also, it is not region-locked, meaning that anyone anywhere can play this game, unlike how some accessible controllers cannot be sent to some regions. The controller was made using ml5 and Posenet. Posenet is a machine learning model in TensorFlow, a javascript library. What posenet does is estimate where certain points are on the body, including the eyes, nose, shoulders, elbows, wrists, etc using a picture or video of a human. This is called pose estimation. Using these points, I was able to create the different controllers. There are two different controllers I made for this project, a wrist controller and a nose controller. The wrist controller was pretty straightforward, I used the points on the wrists found through posenet and added circles to where the wrists were detected. The game aims to hit the boxes that float across the screen, which plays a series of notes that makes a song. So, to make this controller dependent only on wrists, I made it so that when the circle on the wrists hit a box, it played the note. The nose controller was much more complicated because I wanted it to require as little movement as possible. To achieve this, I made it so that the only motion that the player needed to be able to do was turn their head from side to side. To start, I used the point on the nose and added a circle to it. Then, I added a vector with another circle on the end to that. The vector increased in size as the head was turned to the side so that when the head is turned 90 degrees, the circle is furthest away from the player. To find out when the head is turned to the side, I used the eyes as a reference. When the face is turned, from a straight-on view, the eye points are closer together than they are when facing forward. So, I created a formula that used the distance between the user's eyes at the beginning and the distance between their eyes at any given moment using the nose controller to decide how long the vector would be. The circle on the end of the vector is used the same way the circle on the wrists is being used; if they collide with a rectangle, it will play the note. To make the actual game, I based the gameplay on the game Rock Band. To do this, I created rectangles that started from the bottom of the canvas and slowly floated vertically until they were either hit or disappeared at the top of the canvas. Different notes start from different positions at the bottom. But, if it is the same sound played, it will start from the same position. To make sure that the player can hit all the notes in the right order, the notes are slightly staggered. Not everyone has played Rock Band before, or even a rhythm game in general. To account for this, I added an instructional video and written instructions to make sure the game was understandable. Both of these were added to the top of the page, above the canvas so that people were inclined to read the instructions before trying to play the game.

I tested this by sending it out to family, friends, and fellow students to try it out. With that, I created and sent out a form with a few questions about the usability of the controller, how clear the instructions were, and if the gameplay made sense. With the information I got from this, I edited my project to account for the feedback. After I made changes, I sent out the project again asking the same questions. This iteration was done so that I could get the most amount of feedback possible. The goal of this was to make sure that nothing big was missing for usability, especially in terms of accessibility. I also made sure to talk to people well versed in accessibility to make sure that I was following proper accessibility guidelines for web pages. That was also helpful in taking more of the controller mechanics into account.

I am gauging success by how easily people can use the controllers. Many other things go into making a good rhythm video game like how much people enjoy playing the game and having a variety of entertaining options. However, for this project I wanted to focus on just the success of the controller for people with disabilities. The controller is the most important part to me because this project was about creating something that works for disabled people and adding more to make the game more engaging and have more variety in the future. My project was successful because even if the game is not a well fleshed-out video game, it shows that it is possible to create a controller that is accessible to people with a variety of disabilities, which is the goal of this project. I was aiming to showcase the controllers first and foremost, and then work on adding them to a game that is fun to play, which this project did pretty successfully, albeit with some hiccups in the wrist controller, according to the user testing done so far.

From the user testing, I found that the nose controller works very well, but the wrist controller can be spotty. That means that sometimes the points on the wrist start jumping around the page or disappear. This could be due to several factors such as distance from the camera and lighting. These things impact my wrist controller and not the nose controller as much because the nose controller only needs to identify the points on the face, the eyes, and the nose, to be accurate. The wrist controller needs to be able to identify the face, shoulders, and wrists to be accurate. This can be harder for the model if the player's elbows are not in the frame, which is the case for many at the distance that the player would be from the camera generally. Making sure that this project is played in a place with proper lighting and having the tutorial further explain the conditions needed to play the game properly would be a good way to make sure that people can use this controller more accurately. There were also a few bugs that created visual glitches, but these were not too consequential to the game other than making the song selection a little confusing. With the user testing, I was able to make some corrections that made the game a lot more usable. For example, I added a start button so that the player can look through the instructions first before the game starts instead of it starting immediately on launch. Also, I changed the song and controller selection from being buttons at the top to something more interactive, which led to the new selection screen. Furthermore, with the help of Themis García Cádiz, I was able to make some changes to the instructions so that the players knew how to play without it being too fatiguing, such as telling them to set up in a way that allows them to rest their elbows on a surface. This also is what inspired me to add written instructions as well as an instructional video so that people that would not be able to use the video will still have instructions. While there were a lot of suggestions for how to make the game better, the users also seemed to enjoy many aspects of the game. A lot of feedback mentioned that the game was enjoyable to play and the interactions were new and exciting. Also, the nose controller was working very well and they found that it was a cool and novel way to play a game.

What my project did well was create a controller that works, is easy to use, and is accessible to the average. My nose controller has been a success because it consistently works. It is also the controller that most people would be able to use, which is important to my project because I wanted a controller anybody could use. The accessibility in terms of affordability and physical accessibility was something that my project also did well because it only ended up needing a laptop with a webcam and some neck movement. Also, the other accessibility measures I took, like adding written instructions, alternate text, and minimizing buttons worked out well. My project could do better in the video game theory aspect because

there is much more to add if I were to make this a full-fledged video game. This would require a lot more work on the songs, for example making them more complicated and exciting songs to play and changing the sounds that are played so that they flow together better. The average rhythm game has a lot more songs and usually more contemporary songs. So, I would want that for my own game so that it's more fitting to the genre. Furthermore, there is work to be done on the wrist controller to make it work more frequently. In its present state, Rockability works when in the right conditions. However, it can be a little spotty depending on many factors such as lighting, distance from the camera, and where the person is positioned on the screen. The spottiness can be somewhat resolved by adding an algorithm to help stabilize, which I am interested in looking into in the future.

For the next steps, I want to further flesh out the game with more music options, accessible controllers, and user testing. Now, it is just a showcase of the controller with two simple nursery rhymes, Twinkle Twinkle Little Star and Mary Had a Little Lamb. In the future, I would add more popular music or a theme, something that is common among rhythm games. For example, Rock Band, a popular rhythm video game, was themed around having popular rock songs from the 80s and 90s. A theme would make this a more cohesive video game, which is something that I am working towards. To create controllers that work is one thing, but to make sure they are attached to a game that is even more enjoyable and replayable would take this project to the next level. Furthermore, I would like to add more controllers that require different types of movement in the future. One of the controller ideas that I was looking into was creating a model with Teachable Machine and training it with different poses to correspond to different notes. I did create a couple of models of this to test out what kind of poses would work and how they could be incorporated. However, because of changes to Teachable Machine and p5, this has not been doable as of now. I contacted people from the ml5 library to help me look into this, so hopefully, this will be feasible in the future. When I am able to do this, I think that a controller made with Teachable Machine would be a fun and creative way to add another interaction to the game that also uses different movements, so that people can try out more controllers to see what they like the best. Also, another technology I would like to work with would be eye-tracking technology. Creating an eye movement controller would make this project even more interesting and even more widely usable to people that are paralyzed, like the aforementioned Eyewriter. Finally, I would do more user testing with a wider array of people to make sure that the controllers continue to be accessible and that there are working options for everyone. Right now, this project's scope means that I'm only creating controllers for people with motor function issues. To expand on this project, I would like to work with people with other disabilities that would inhibit them from using even the accessible controllers that I have made so far. The eye-tracking controller is a good example of this. After all, it would reach a much wider audience because it would only require the ability to move your eyes. This would be a great way to circle back to my inspiration for this project, Eyewriter. To be able to make a game that TEMPTONE would be able to play would really take this project to the next level because he was one of my main inspirations.