Robot and You

By

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Abstract

As robots become more advanced and more integrated into today's societies, it has become more important than ever to research these increased interactions and understand them. It is here that games can be useful, for their unique ability to build relationships between players. Likewise, games have also been used to push new technologies, like chess playing robots being used to push Artificial intelligence. With that said, this thesis will explore new forms of interactions between humans and robots, through the medium of games, building upon the existing technology to better understand and even establish human robot relationships. The project portion of this thesis utilized iterative design and game design to create robots that can play games with humans. These games include Tag, as well as a custom game called Robo Chicken.

Keywords: Robots, Games, Relationship, Joy, Friendship

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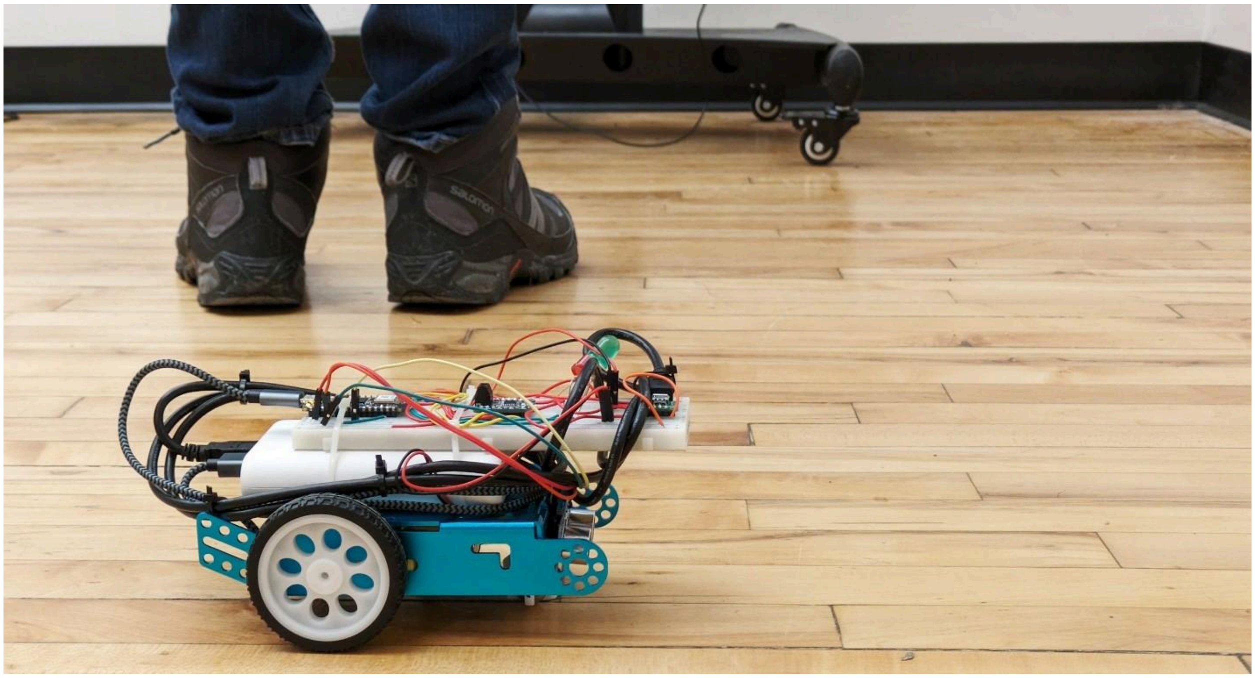
Introduction



(Figure 1. Picture of Robo Chicken during final testing)

For many decades, robots have played a specific role in society. Robots worked in factories completing repetitive tasks with no complaints, or drilling holes in drywalls over and over again. In general, the main purpose of a robot was to do jobs that were considered by humans to be dull, dirty, or dangerous. However, things are starting to change. With rapid advancements in robotics and Artificial intelligence, robots are now starting to actively work with nurses in hospitals to manage patients, or they're assistants for elderly people in aged care facilities, all the while directly interacting with humans with a level of intelligence comparable to a human. These social robots, as called by roboticists, have been part of an ongoing discussion about the possibilities robots have, and also concerns about robots taking jobs away from humans or becoming a substitute for human-human interactions. To this end, games offer a unique opportunity in both understanding and facilitating these interactions. Game designers can be considered "scenario makers", being able to create a number of scenarios for players to experience and play through, while also being a solid opportunity to build relationships along the way. As such, this thesis will go over how games can create new interactions with robots, build relationships with them, and even discuss the philosophies that could allow one to become friends with a robot.

I have constructed several robots that can play games with humans to explore the thesis topics in depth. There are two robots that have been constructed. Firstly, there is a Tagbot, a robot that is able to play tag with humans, which explores social relationships between humans and robots and how games affect it. Secondly, there is Robo Chicken. Robo Chicken is a robotic car used to play a game where players try to get Robo Chicken as close to a target as possible, without crashing into said target. Unlike Tagbot, Robo Chicken focuses a bit more on game design and how robots can change how games can be played.

Research Questions

Primary Question: How can games be used to facilitate new forms of interaction between humans and robots?

Secondary Question: How does the form and materials of a robot affect the relationship with humans?

Literature Review

As technology advances and robots start to become more social, the general view of robots has started to shift, leading to a greater debate regarding robots and their effect on society. This includes fears of robots taking jobs, replacing humans in social interactions, to even the classic science fiction fear of robots destroying all of humanity. To better understand this shift, this literature review will go over several topics regarding social robots and how people feel about them, mainly by discussing human-robot relationships and the possibility of being friends with a robot through Aristotle's friendship framework. This literature review will also examine games and joy, as those elements can also shift perspectives on robots positively.

Defining Robots and Social Robots

In *Robot Ethics: The Ethical and Social Implications of Robotics*; they define a robot as something that has sensors, a processing ability that simulates some form of cognition, and a method of moving through and interacting with the world. Beyond this, however, there are social robots. Social robot is a general term in robotics to describe robots that are designed to interact with humans specifically, having the attributes of a robot alongside having recognizable, human-like cues like visible eyes and hand gestures to be more readable to a human (Prescott, 2020). These kinds of robots also often look like people or animals for readability. For this Literature Review, I will be considering both of these definitions for robots and social robots. However, I will not be factoring in a specific need for social robots to have humanoid or animaloid forms, as human-like cues and gestures can also be observed in robots that don't have those particular forms. A noticeable example of this is the art piece "Can't Help Myself", in which a robot arm perpetually cleaning up a red liquid would do a "happy dance" whenever it was able to get the liquid within a minimum range.

Human Perception of Robots

Another thing worth talking about regarding social robots is perception. Perception is important as it plays a large part in how we view things like robots or even fiction. For example, much of the negative stigma surrounding robots is likely due to robots being presented negatively in pop culture (Prescott, 2020). Likewise, social robots will also play upon perception to fulfill their needs. Take, for example, Paro; a robotic seal meant to be a companion for patients in hospitals. Researchers have observed that people in contact with Paro felt happier around him, while also engaging in certain behaviours like feeding him or covering him with a blanket (Keurrish, 2016). The reason for this was how Paro was presented. To put it simply, Paro is meant to be cute, using design elements like large eyes and soft fur, as well as gestures like tail wagging and head movement (Keurrish, 2016). Sounds are also utilized to make Paro cute, with his many cries and coos being used to make seem helpless and something to be taken care of. When all of these elements are combined, they allow Paro to succeed in getting patients to feel emotionally attached to him. Another example of robots affecting perception is an art piece called “Can’t Help Myself”. I briefly mentioned this piece in the last section, but I want to talk more about it. As mentioned, this piece from 2016 involves a robotic arm that constantly cleans an ever-expanding liquid surrounding it, trying to keep it all within a specific range. When the fluid is within this range, the robot arm will perform a “happy dance” before cleaning any liquid that went past the minimum range. What is interesting about this piece, however, is the fact the arm was left running for years until it eventually stopped working in 2019. This fact, alongside other elements of the piece, lead to strong feelings about specifically the robot arm later on.

In the new article “‘No piece of art has ever emotionally affected me this way’: Artist’s viral post on robot” by Anwesha Madhukalya, she reports in a viral post by James Kricked Parr regarding his feelings on “Can’t Help Myself”. She mentions that James Kricked Parr felt emotionally affected by the piece, noting that as time went, the robotic arm struggled to keep the fluid in check as it succumbed to wear and tear. Even the museum that housed this piece mentions that “[the] endless, repetitive dance presents an absurd, Sisyphean view of contemporary issues surrounding migration and sovereignty” (Madhukalya, 2023). The point of mentioning this piece was that, despite the robot arm itself not having any sort of costume to help visitors relate to it, people still empathized with the robot arm. These people related to the arm's simple struggle, and were saddened to see the robot die; failing to complete its impossible task. Unlike Paro, which gains empathy from people through designed looks, touch, and sound; “Can’t Help Myself” opts out of those elements to show a robot through simple actions and a strong personality. These effects on perception become even more important when discussing more direct human-robot relationships, as it leads into why certain humans and authors are against human-robot relationships

Against Human-Robot Relationships

Due to how social robots are meant to work, there has been much discussion regarding the implications of these human-robot relationships and the potential for friendship with these robots. Specifically, there have been several authors that have spoken against human-robot relationships; particularly in how they affect humans and why they consider human-robot friendships to be unethical. For example, Joanna Bryson in her article, *Robots Should be Slaves*, has argued that humans only have a finite amount of time and attention to form relationships, and that robotic friendships are a form of “non-productive faux-social entertainment” that reduce the capacity to form relationships with humans. This point gets elevated further by Sparrow and Sparrow (2007), where they bring up a hypothetical future where robots have replaced humans completely, erasing human interactions:

“...imagine a future aged care facility where robots reign supreme. In this facility people are washed by robots, fed by robots, monitored by robots, cared for and entertained by robots. Except for their family or community service workers, those within this facility never need to deal or talk with a human being who is not also a resident. It is clear that this scenario represents a dystopia rather than a Utopia as far as the future of aged care is concerned."(Sparrow, 2007)

Similarly, these authors have also been cynical about human-robot friendship even being possible, seeing the whole relationship to be deceptive and not offering true friendship. This is due to how robots differ from humans and even animals. Essentially, humans and animals have different needs and desires that forces both parties in the relationship to engage with them (Sparrow, 2007). Robots on the other hand, only know what has been programmed into them or learned via machine learning, lacking those same kinds of needs and desires (Danaher, 2019). Robots can also be turned off if their friend is bored of them, meaning that the friendship doesn't demand engagement from both parties (Sparrow, 2007). What makes human-robot friendships deceptive is when people assume robots have characteristics that they don't possess overinvest resources into them (Sparrow 2007; Bryson, 2010). In order to prevent overinvestment, however, society needs to let go of the idea that robots can be like people and return them to their original role of doing jobs considered dull, dirty, and dangerous (Bryson, 2010).

Pro Human-Robot Relationships

We need to answer the question "is human-robot friendships possible, and can they benefit society as a whole"? Danaher in his article *The Philosophical Case for Robot Friendship*, attempts to answer this question by using the friendship framework established by Aristotle. According to Aristotle, there are three forms that an individual friendship can take; a virtue form, a utility form, and a pleasure form (Danaher, 2019). The virtue form is described as a type of friendship "that is premised on mutual good will and well-wishing, and that is pursued out of mutual admiration and shared values on both sides" (Prescott, 2020). The utility form and pleasure forms, on the other hand, are friendships based on instrumental gain and pleasure, respectively. Moreover, the utility and pleasure friendships are considered by Aristotle to be "imperfect", while the virtue friendship is inversely considered to be "perfect". It is important to note that Aristotle does not completely discount utility and pleasure friendships in terms of friendship, merely that they are "lesser" forms of friendships compared to virtue friendship (Danaher, 2019). It is important to know that this framework is based specifically on human-human relationships. When applying this framework to the human-robot relationship, contradictions arise, most of which refer back to those concerns I mentioned in the previous section. What this all amounts to is that, while human-robot friendships can be considered utility or pleasure based, the stark difference between humans and robots prevents any kind of virtue-based friendship from occurring. While there are some claims about robots that are definitively true, it is still possible for a virtue-based friendship to occur with a robot. The reason is simple, human-human relationships are rarely perfect in the Aristotle sense.

Danaher makes this statement regarding his personal experiences with friendships; "I have very different capacities and abilities when compared to some of my closest friends: some of them have far more physical dexterity than I do, and most are more sociable and extroverted. I also rarely engage with, meet, or interact with them across the full range of their lives". To better understand what Danaher means by this, it's important to understand the conditions agreed upon by other philosophers to be needed for a virtue friendship to exist. Those conditions are mutuality (shared values and interest), honesty/authenticity (both parties present themselves as they are), equality (both parties are equal with no dominant party), and diversity (both parties must engage in a wide range of topics and domains of life) (Danaher, 2019). In principle, these conditions make sense, and a true friendship could easily fill all of them. However, in practice, a true friendship would struggle to meet these conditions for several reasons. As Danaher said, friends can't always engage with each other as equals in every domain of life. Most of the time, one friend will have more knowledge or skills in one area, or a friend will be more introverted or extroverted. As a result, you may find that most friendships will have some level of imbalance between the parties in some domains of life. Authenticity is also hard to achieve, simply because both parties will generally have no way of knowing what the other is thinking and must assume they are being authentic until shown otherwise (Danaher, 2019). Another thing to consider is whether the limitations of human-robot friendships are due to technological advancements. Which is to say, are the limitations with human-robot friendships something that can be solved as technology advances or not?

Virtuous Human-Robot Relationships

With that said, can robotic relationships become virtuous? Danaher presents a specific line of thinking for this. Essentially, the conditions for mutuality and authenticity are based on the assumption that both parties share a biological connection (Danaher, 2019). In Danaher's view "while the shared biological properties might give us more grounds for believing in our human friends it is not clear that these grounds are necessary or sufficient for believing in friendship". Another point by Danaher points out the fact the people already form close relationships with robots. Some examples from my research include Sony Aido dog robots being shown to help alleviate loneliness (Prescott, 2020), as well as paper called *The robot is present: Creative Approaches for Artistic Expression with robots* by Carlos Gomez Cubero, Maros Pekarik, independent artist Valeria Rizzo, and Elizabeth Jochum, where they found that letting the robot be an active participant in forms of artistic expression lead to more positive interactions with the human artist. While one can argue these kinds of relationships are not deep or genuine enough to be virtuous, Danaher would say that disregarding those kinds of relationships would just be a form of social stigmatization, and not very productive in the long run (Danaher, 2019).

It is also worth noting that, according to Danaher, if a robot consistently presents itself as a friend, then we should base our friendship on that. To me, I think this line of thinking is where you'll see most human-robot friendships. Going back to the Aido dog and the art robots in the previous paragraph, those relationships, while not virtuous, can still be considered utility or pleasure-based friendships. Also recall that Aristotle never discounted utility or pleasure-based friendships as real friendships, merely lesser forms of friendships compared to the virtue-based one. In my view, regardless of the classification, those relationships are still forms of friendships. Whether it's seeing robots as a simple means to stave off loneliness, or something you genuinely believe to be a friend, those are all forms of friendships in one way or another. We can dissect these relationships all we want and argue if it's a true friendship all we want. However, I believe that the people that are in these relationships, the ones that are not part of this current discussion, will see a robot and, if they feel a strong enough connection with it, consider them a friend regardless of what I or any other philosopher might have to say about it.

Games: a Brief History

When it comes to robots, games have been used to help push them further. In fact, games have always had a hand in pushing all kinds of new technologies, especially video games. For starters, there's the game *Tennis for Two* by William Higinbotham. This game was made back in 1958, when William observed that many of his lab's science exhibits at the time were very static and non-interactive (Abby, 2023). He felt that game people could play liven things up and show that their lab still held relevancy, and set about creating *Tennis for Two* using germanium transistors which were just then commercially available (Abby, 2023). Tennis for Two would debut to a rousing success, with hundreds of visitors wanting to try the game out, eventually becoming foundational to the game industry as a whole. There was also Ralph Baer, who believed that TVs at the time could play games, and would eventually develop the first video game console, the Magnavox Odyssey (Smithsonian Institution, n.d). Beyond this though, many game companies would use their craft to demonstrate the progress of technology, from higher rendering and processing power to even the ability to make games in 3D.

I would be remiss if I didn't acknowledge the advent of chess playing robots that used chess to demonstrate robots with artificial intelligence. Among these robots, Deep Blue is the notable, being completed in 1996 and would famously go on to beat world champion chess player Gary Kasparov (Goodrich, 2022). For a more recent example, there's AlphaGO. This robot was built by DeepMind Technologies, and its purpose was to play the game "Go". Unlike chess, Go is a lot more complicated for a robot to play at a high level, with AlphaGO struggling against human players, even at its strongest. However, after much trial and error, AlphaGO would go on to defeat Lee Sedol, one of the world's best Go players, in 2016 (Borowiec, 2016). One last piece of history that I want to talk about in this section is ROB the robot, mainly for being an inspiration for this thesis. ROB the robot was released in 1985 alongside the Nintendo Entertainment System, or just NES for short. ROB was able to play two kinds of games with a human player, those being Stackup and Gyromite. In both games, ROB and the player would both need to cooperate with each other in order to clear levels and complete tasks (Williams, 2023). To me, I see ROB as a vision of the future. Functionally, ROB is very basic, being a motorized toy that mainly presses buttons on the second player controller. Despite this, ROB was an early demonstration of a robot playing games with humans, something that would later be expanded upon in the future. Really, both ROB and Deep Blues were showcases of robots playing games with humans. Deep Blue was focused on pushing AI and showed that robots could handle complex games like chess. ROB, while not truly a robot, did have the purpose of being a companion to the player, something that the player would want to build a relationship with as they played games together. That's why ROB is actually an acronym for Robotic Operating Buddy. Regardless of the intention, both examples were showcases of robots being able to play a game with a human and the possibilities that fact can lead to.

In Pursuit of the Well-Played Game

Bernie DeKoven's book *The Well-Played Game,* as well as Jane Friedhoffs series *Games, Play and Joy*, offers some unique insights into this matter. In general, games are able to bring people together and make them more open to themselves and the world around them. This underlying process is referred to as "good play" by Friendhoff (2020), where players "tend to feel different: more alive, more energized, happier, more creative, more capable, closer to each other, and larger than ourselves". This can lead to another process called co-liberation, where the person's understanding of themselves and the world is changed (DeKoven, 1978). These processes are tied into what DeKoven calls a "well-played game".

A well-played game is not determined by winners or losers, or even score, but instead one determined by the people playing the game (DeKoven, 1978). Indeed, DeKoven's book heavily emphasizes the need for a proper play community in order to achieve a well-played game. What this entails is that a proper mentality is needed during any given game for it to be considered well-played. This includes a player's willingness to play, a belief that the players will be safe, and a mutual trust in the other players in the game community (DeKoven, 1978). An important note about these requirements is that a player's mentality is always shifting, even when playing. As a result, a player's willingness to play can change quickly, due to things like the game being too hard, constantly winning or losing, and how the play community responds to them. As a result, the play community and the game itself would need to adapt to these sudden changes, like offering hints, modifying the game somehow to make it fresh, or just finding a new game altogether (Dekoven, 1978). Ultimately, a well-played game is a result of a delicate equilibrium of all of those requirements and can be lost at any given moment.

The Power of Joy

As argued by Friedhoff, joy provides a fairly similar effect of co-liberation, in the sense of increasing capacity for ourselves and others around us. In particular, she tries to separate joy from emotions like happiness and fun by stating that joy increases one's capacity to affect the world and be affected by the world. Essentially, experiencing joy can be difficult, but it also presents new insights into ourselves and the world (Friedhoff, 2020). In the context of Friedhoff work, she situated joy into an anti-capitalist framework, where experiencing joy is a way to regain autonomy and undo the organized destruction we live in, also referred to as an "Empire".

When it comes to joy and games, Friedhoff emphasizes game designers are scenario makers that allow players to explore different possibilities, and experience new relationships with themselves and others.

One last thing that I want to discuss is Friedhoff's discussion on the rules of games. I bring this up because I find they tie into DeKovens work really nicely. Rules in games, as described by Friedhoff, are things that lead to brand new ideas and creative thoughts. The idea here is that by limiting what the players can do, you force them to think outside the box, or find strategies that exploit loopholes in the rules. Of course, rules do need to be carefully crafted in order for game designers to get the most out of them. If the rules are too loose, then the game becomes meaningless as winning is too easy, but if the rules are too constraining, then the game can become too difficult to play (Friedhoff, 2020b). Going back to DeKoven briefly, it is obvious that rules are also a factor in achieving the well-played game. In order to showcase how rules affect a player's engagement, Friedhoff uses an example from one of her classes, where she had the students draw a line on a piece of paper without lifting their pencils for a set amount of time. To her surprise, the students weren't staying in one place, but instead drawing wildly, stumbling over each other's arms, and even coordinating with each other to outsmart the rules. If DeKoven were to see this game play out, he would say the students are experiencing a well-played game.

When it comes down to it, what makes games so unique from other activities is the community that forms around them. Sure, there are games that can be played with only one player, where the requirements for being well-played can be easily achieved. Despite this though, there is still a community of people that want to share their experience with the game, especially today with social media. In general, games make you want to seek out other people, to make some kind of connection with them. They also provide an excuse to experience the world differently and gain a better understanding of it and yourself. In the case of building relationships with robots, games may be the thing that allows people to forget their worries with them and just enjoy their company.

Methodology

My methodology for this thesis was "Iterative Prototyping", which is to say that I built several prototypes that build upon each other, eventually leading to fully realized robots. These prototypes ranged from digital prototypes made in Unity to physical prototypes made using Arduino and other components. Using iterative prototyping here made sense as building both digital and physical prototypes were necessary in making scenarios that establish a connection between the player and the robot. Likewise, iterative prototyping also allowed me to work on the project in smaller chunks, refining individual components so that the final robot reaches its full potential.

Iterative Design

One part of iterative design that I really like is being able to build both the project and yourself over a period of time. In this case, if I tried to complete my thesis right away; building the robots and games without proper preparations, I definitely would not have made a satisfactory thesis. Iterative design helps here as it breaks down the overall project into smaller chunks that could be completed one at a time. This practice can also allow a project to be developed beyond its original idea. For example, the initial idea for this thesis was to build upon ROB (Williams, 2023) using modern robotics, mainly through the use of robot arms as I was the most familiar with those at the time. If I wasn't using iterative design, the overall thesis would have been based on that initial idea. However, iterative design forced me to re-evaluate and look past this idea, resulting in the current thesis.

The most important part of iterative design and why it works for this thesis is being able to make multiple, testable scenarios for individual aspects of the project. For example, I made two prototypes early in the thesis, a physical prototype and a digital prototype. These prototypes were used to test different parts of the project; the digital prototype was called TagBotTest and focused on robot behavior (Figure 5), while the physical prototype was focused on construction and maneuvering in the real world (Figure 6). These prototypes were also instrumental in establishing how the player interacted with the robot, especially later on when the physical and digital prototypes started to flow into one another.

Game Design

Alongside iterative design, game design was also utilized for this project. Now, general game development does use iterative design, for the same reasons that were presented in the last section. However, thinking in terms of game design led to some extra considerations that were needed for the thesis. Among those considerations, the games that would be played needed to be overall enjoyable by players, or else any observations that could have been made about human relationships with robots would be lost due to the games themselves falling short. Indeed, the most important part of this thesis was for the game to be fun, for a lack of a better word. It is in the pursuit of fun that certain ideas and results came about.

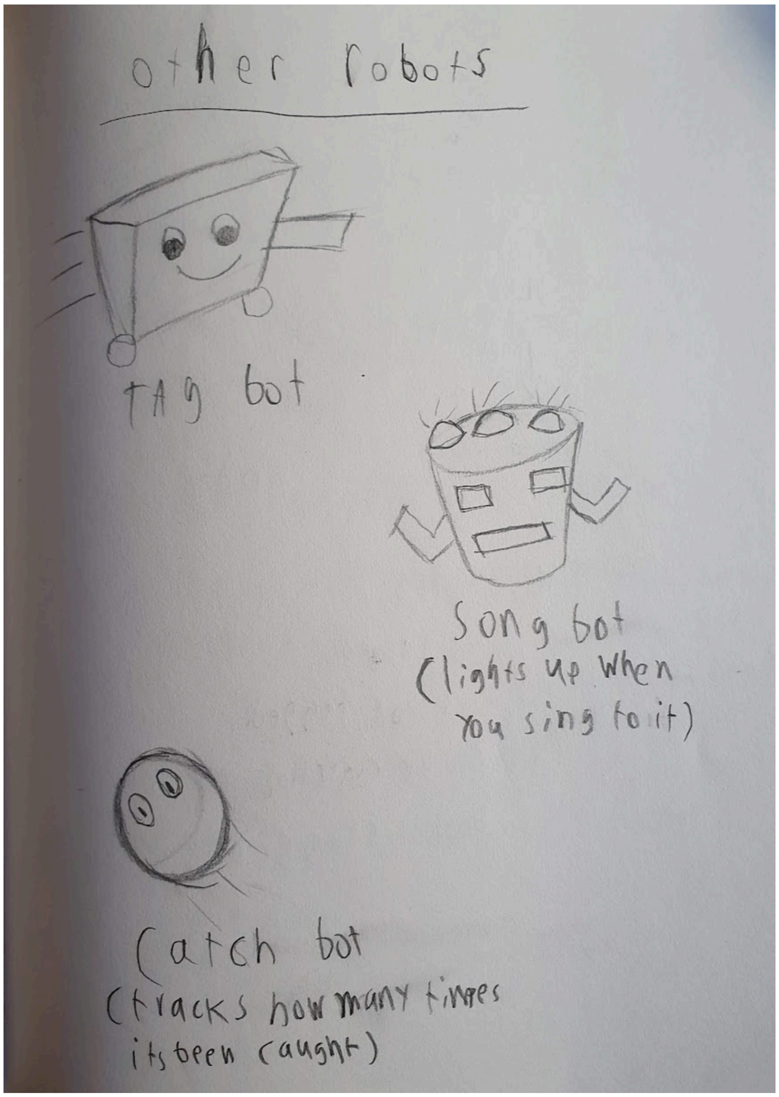
In the literature review, I mentioned Bernie Dekoven and his book *The Well-Played Game*. There, I talked about the well-played game, a state where all players are fully invested in the game without anything getting in the way, be it from the game or the players mentality. Much of the game design utilized in this project pulls from what was mentioned in Dekovens book. For example, Robo Chicken pulls on two topics from Dekoven in achieving a well-played game, safety and community. Dekovens discussion on safety is fairly simple. In the book, Dekoven states that “We need, in order to be willing to be willing, some guarantee, somewhere, that no matter what happens in our pursuit of the well-played game, we will not be risking more than we are prepared to risk. Even though I’m aware that I might die as a result of trying to climb this mountain with you, I can accept that as part of the game, part of the challenge”. This quote makes more sense when talking about the original game of Chicken, where players are driving a long road towards each other, knowing that they risk injury if they don’t move out of the way and get called “chicken”. With Robo Chicken, that overall risk is not there, but that doesn’t mean the quote isn’t relevant. With that same quote, Dekoven mentions that if their opponent attempted to cut his rope to get a lead, he would be less likely to play. All of this to say that safety toward each other must be ensured by both players, even if they agree that the game will potentially harm them in some way. That being said, the general risk inherent to the original game of chicken is still enough to push people away, which is why I feel Robo Chicken is more accessible in this regard.

Community from Dekoven’s perspective is a bit harder to explain, though not by much. Dekoven heavily emphasizes community in his book, situating it as a crucial element in getting a well-played game. While I think this is mainly due to the time period of when the book was made, 1976, I think Dekoven sees games as places where players can communicate with each other and form bonds, causing the community to be formed. Part of having that community, from my perspective, is for that community to be accepting of players of all kinds. This accessibility does need to be reflected in the game itself, which is why Robo Chicken has a camera adjustment screen, so that people of different heights could play the game. Community is also something that is reflected in Tagbot strongly, as here, Tagbot wants to initiate a game of tag and simply needs to wait for people to come and play with it. Ultimately though, it is up to the human players to decide to accept Tagbot’s open invitation for a game of Tag.

There were other game design elements that were used in the games for this project. For example, Tagbot’s version of tag has players moving around on scooter boards due to Tagbots relatively small size. Handicaps like this are how one can make a game enjoyable if the players are not on equal footing, as Dekoven mentioned in his book. Going back to communities one last time, I think the concept of communities, as expressed by Dekoven, are fundamentally important to the goals of this thesis. The best way that I can describe it is that this thesis wants to find play communities between humans and robots, as those communities could lead to new interactions between humans and robots. However, if a human can have a well-played game with a robot, especially an active one like Tagbot, then I think that would be a crucial first step in establishing cooperation between human and robot.

Prototype Development

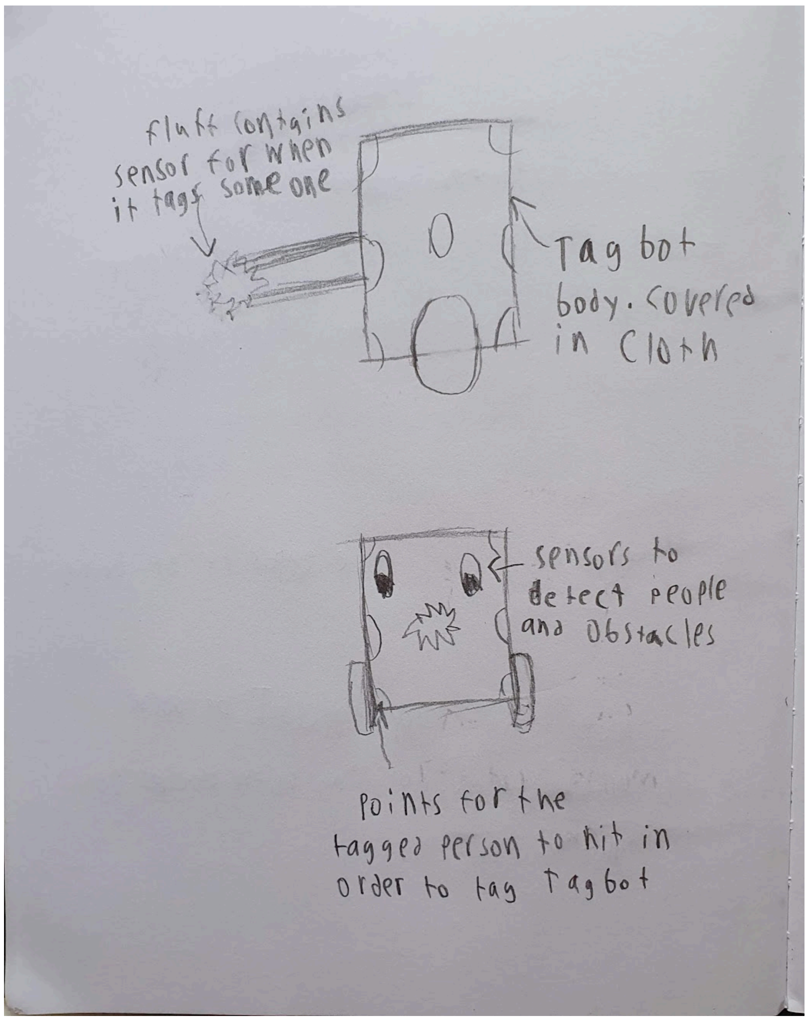
Since this project uses iterative design, the first step to take was to figure out what kinds of robots can be made and how they can be constructed. To this end, concept art must be made in order to visualize the end goal of the project. For this thesis, several concepts were made, showcasing different kinds of robots and how they may be constructed. The first of these concepts went into some very basic ideas for robots, mainly outlining what game they would play and how they would look.



(Figure 2. Concept page featuring Tagbot, Song Bot, and Catch Bot. Photo taken June 22, 2023)

TagBot-Concept Development

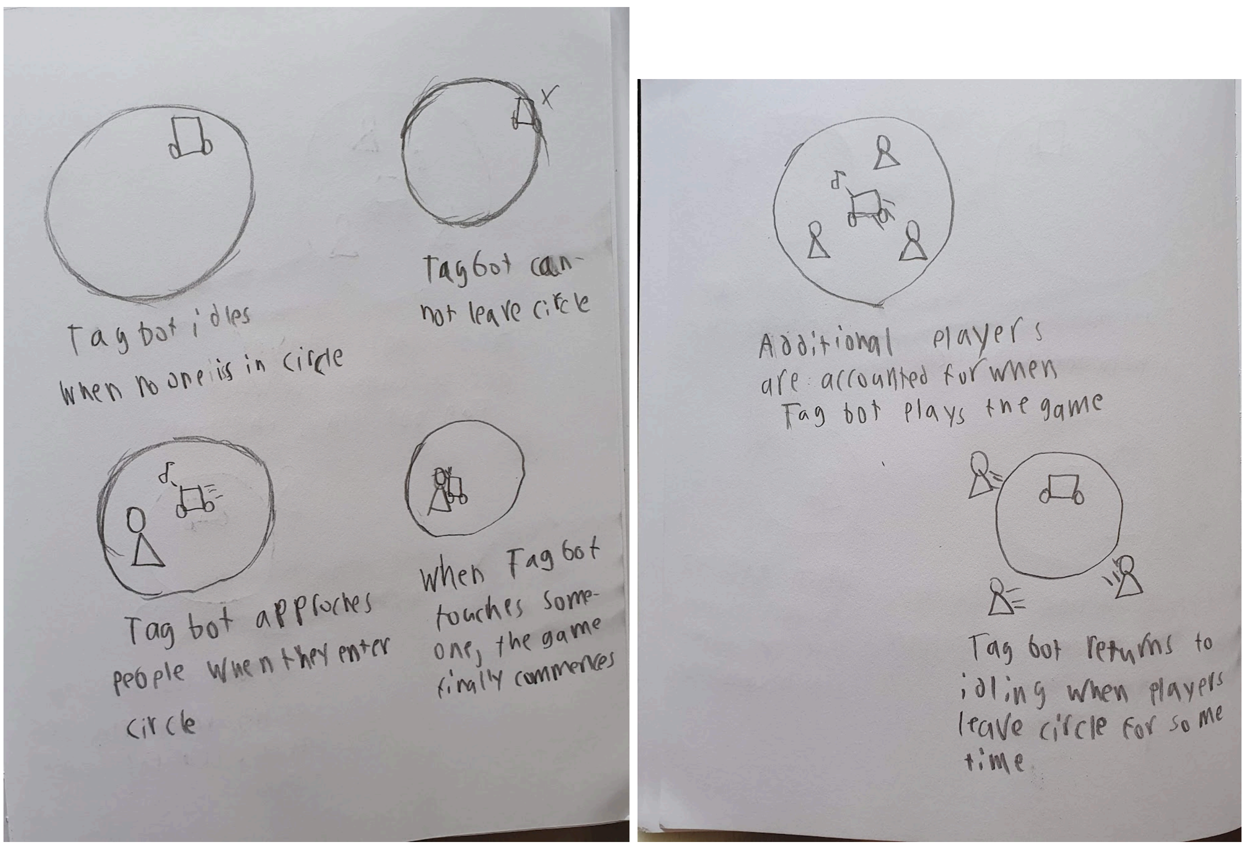
During this very early stage of production, I had three different ideas for robots. There was Tagbot, a robot that could play tag, Song bot which lights up when you sing to it via a microphone, and Catch bot, a ball that tracks how many times it's been caught. Among these basic concepts, Tag bot was the one to stick out. This is because the game of tag lends itself well to finding new interactions between humans and robots. Likewise, there was a better chance for Tagbot to connect with people due to Tagbot being an active participant in the game of Tag. Using the Aristotle friendship framework, both Catch bot and Song bot would have at best reached a pleasure based- friendship with a player, though Song bot could have resonated with people similarly to Paro. Ultimately though, Tagbot being more active than those other robots, on top of the game of Tag being universally known is what made me choose it over the other robots. I also really like the idea of Tag bot having the stick as a way to tag people.



(*Figure 3. Sketches of the refined design of Tagbot. Photo taken August 13, 2023)*

Eventually, Tag bot would get some more refined concepts as the idea evolved and more considerations were put in place. This updated design for Tag bot was meant to give greater consideration to how it would work in real life and what materials would be needed to create it. For example, I took the stick idea from the old concept and refined it to be on the front of the robot with some fluff on the end to soften the blow to avoid accidents, as well as hiding the sensor that would be needed for Tag bot to know if it is “it” or not. Likewise, the body would be made of wood with some cloth covered over it. This cloth would have some extra points on it, which are there so that players that are tagged can tag Tag Bot.

Another point of consideration for Tag bot was figuring out the space for it. Essentially, there needs to be a way for Tag bot to know when the game has started and ended, so that people are able to enter and leave the game as they please. This consideration would lead into a specified circle for Tag bot

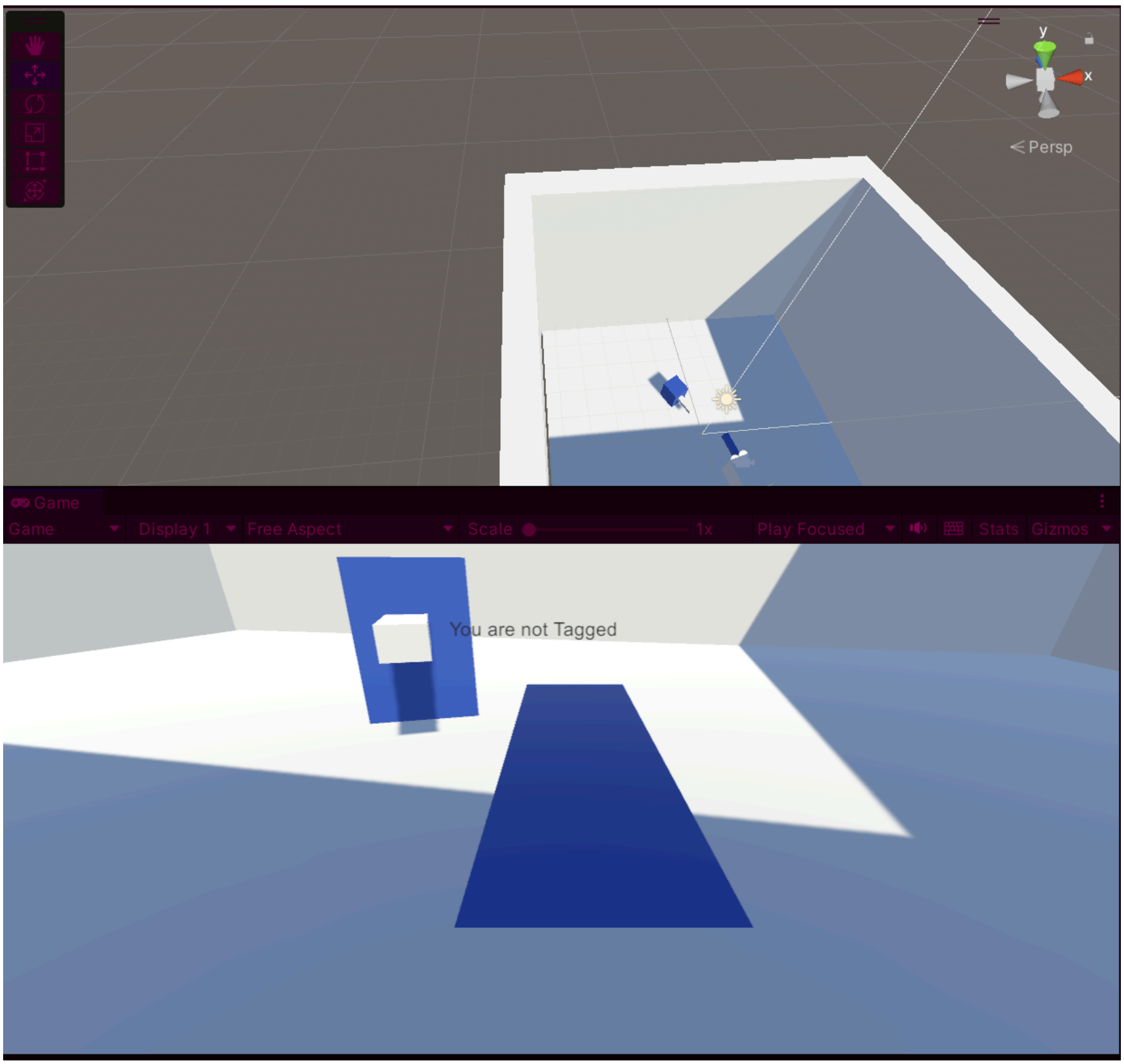


(*Figure 4. Concepts of Tagbot’s playzone*. *Photos taken August 13, 2023)*

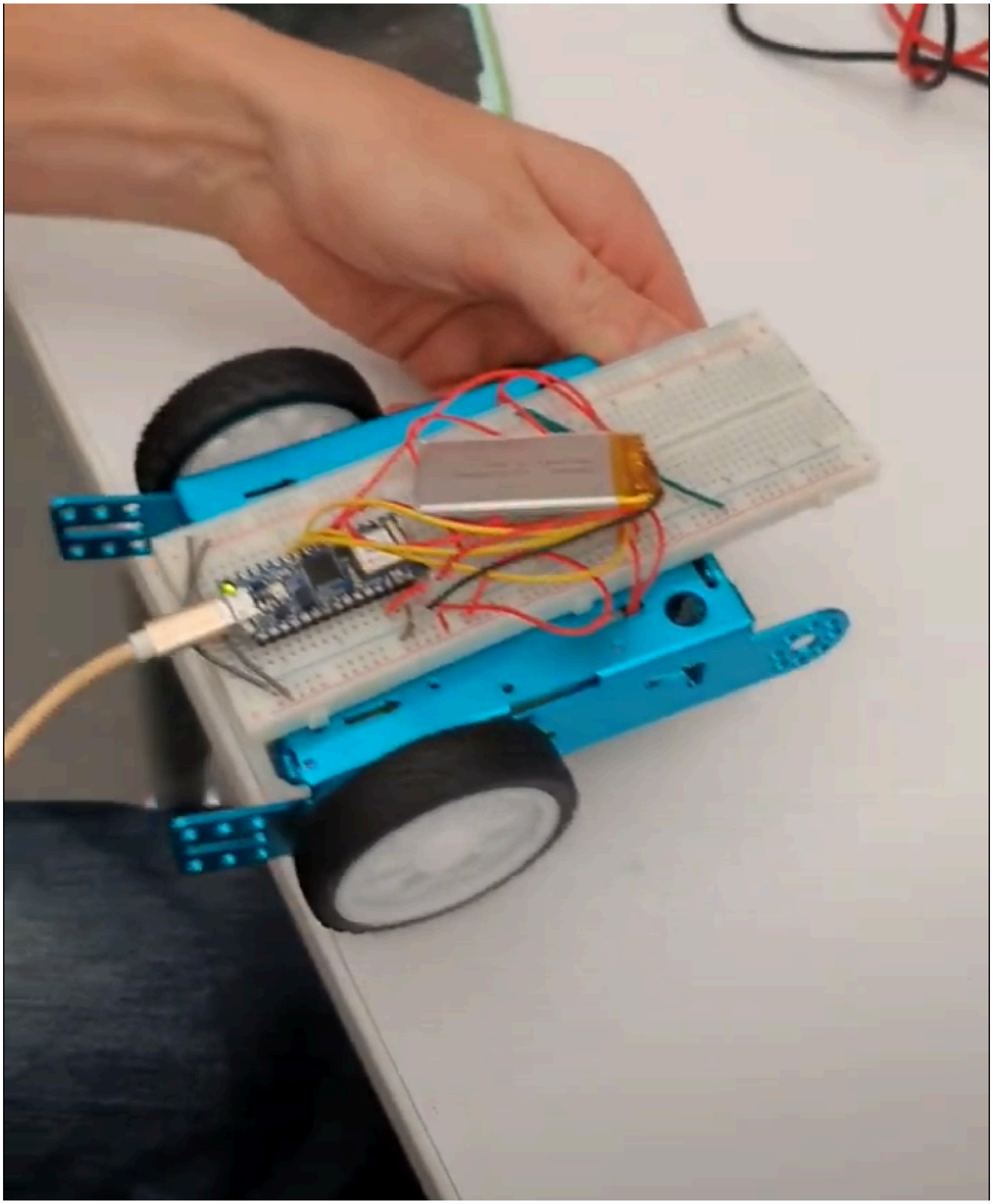
This circle works as a way to easily manage the states of Tag bot by following a simple flow of logic. If no one is in the circle, Tag bot will simply idle until someone shows up. In this case, Tag bot will approach the player. If Tag bot touches the player, the game of tag starts properly, with Tag bot adjusting for new players that join in. Finally, if all the players leave the game, then Tag bot will return to idling. This circle works not only in a technical sense, but also in a game design sense. Essentially, games are best enjoyed when players are able to freely enter and exit the game. By having the circle, players will have a strong idea of where the game is and can decide if they want to play or not by entering the circle.

TagBot-Early Prototypes

Following these concepts, two prototypes were developed, a digital prototype made in Unity and a physical prototype. The digital prototype was a way to develop and showcase Tagbots behaviour and how it could change the way tag is played. On the other hand, the physical prototype was a very basic car made with Arduino that could move forward, and as more to show how capable I was in following through with the thesis.



(Figure 5. Digital Prototype called TagBotTest. Screenshot taken February 7, 2024)



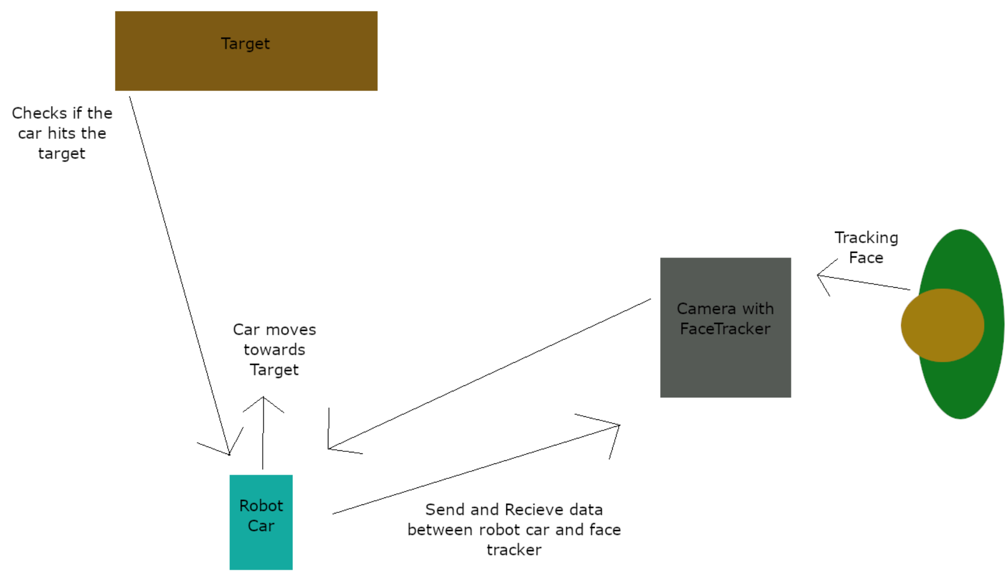
(*Figure 6. Physical Car Prototype. Screenshot of video taken on August 9, 2023)*

These prototypes show the project in its earliest state, while also being a foundation that other prototypes would build upon. Furthermore, these prototypes also allowed me to build necessary skills for the future. To be more specific, prior to this thesis, I only had limited knowledge of making circuits and arduino programming. Making the physical prototype allowed me to approach the thesis from an easy starting point and build myself up over time. I would eventually lead to the final prototypes being a hybrid of digital and physical, where digital objects control the physical robot.

Robo Chicken

(Figure 7. Testing Camera for Robo Chicken)

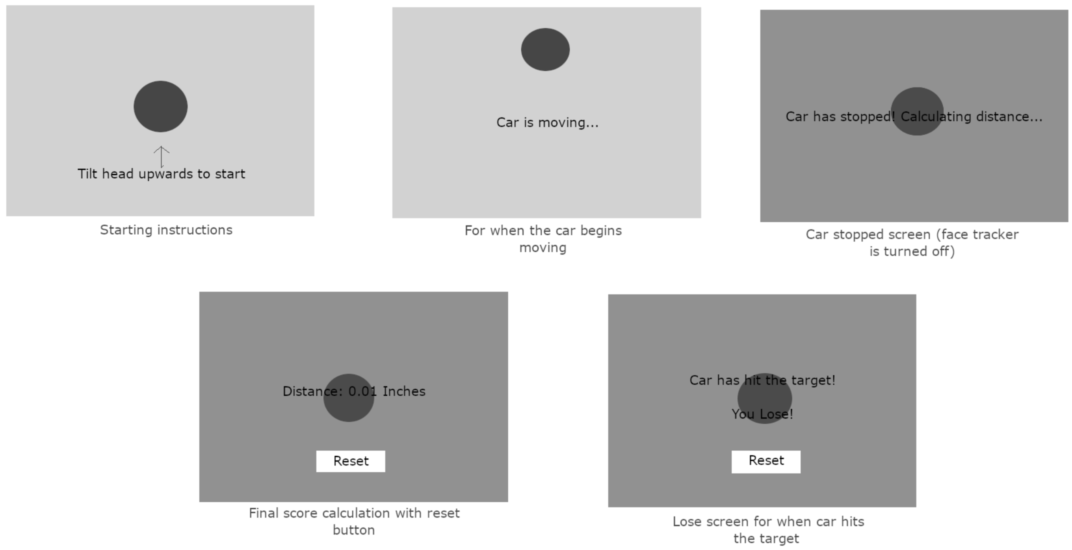
Indeed, there were several made that built upon both the early digital and physical prototypes, which were focused on getting the two to communicate with each other via OSC. Each one of these prototype's approach this task sequentially; first by testing the OSC in a basic setting, then having it send an input to Arduino, then controlling the arduino via code, etc. These sequential prototypes would eventually lead to the development of Robo Chicken, the first major robot of the project. The gameplay Robo Chicken is simple; using a facetracker, the player attempts to get the robot car as close to a target as possible, getting a score based on how close they were to the target. If the car crashes into the target, the player receives no score. This is a somewhat simple premise that considers the fact that the current car could only move up or down.



(Figure 8. Feedback concept of Robo Chicken. Image made December 5, 2023)

The following concept shows the relationship between all the necessary items for Robo Chicken to work. To explain, the face tracker communicates with the car and vice versa. When the player looks up past a threshold, the car will begin moving forward towards the target. Looking down will cause the car to stop moving, which will prompt unity to give the player a score based on how close they are to the target. When the car crashes into the target, the player will give the player no score, as mentioned before.

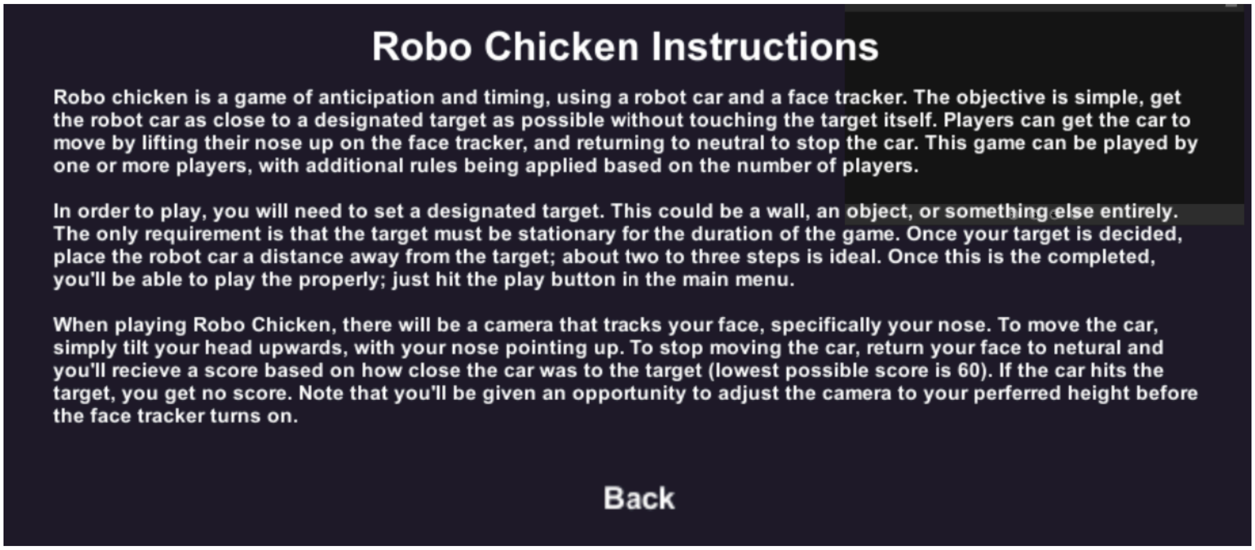
Core to this game is the use of Unity in conjunction with Arduino. While Arduino mainly handles aspects of the car itself like movement and distance, Unity handles all other aspects of the game. This includes game states, sound effects, scoring, and even the face tracker that the player uses. Since Unity is forward facing in this game, there needed to be some User Interface, so the player had some way of directly interacting with the game. As such, this set of concepts were developed.



(Figure 9. GUI concepts for different states of Robo Chicken. Image made December 5, 2023)

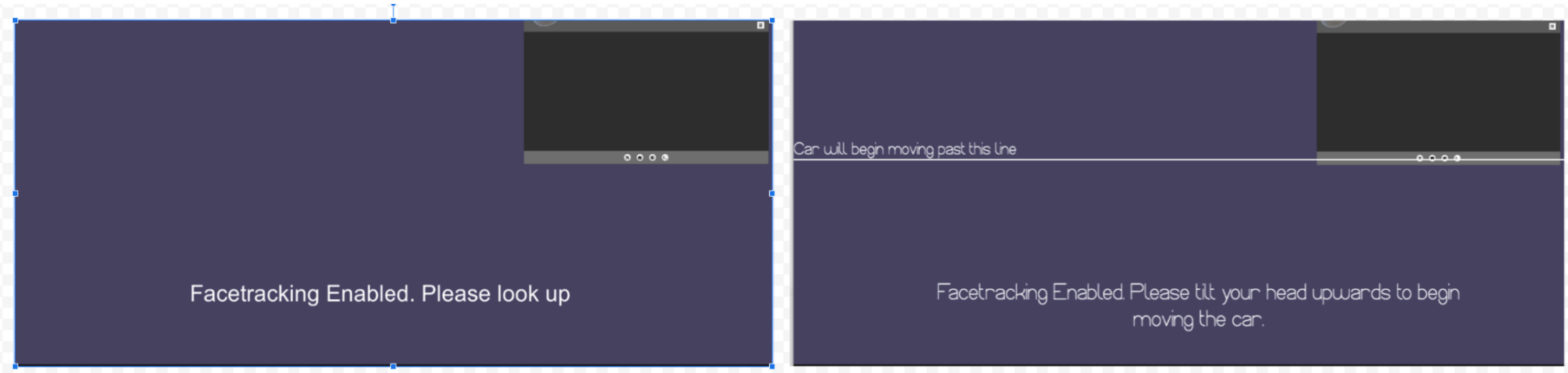
This concept Graphic User Interface shows the general gameplay loop of Robo Chicken. Starting the game, the player will be prompted to tilt their head upwards to bring a unity gameobject past a threshold. Once the gameobject is past the threshold, the car will begin moving with text stating as such. When the car stops, either by crashing or the player putting their head down, the game will turn off the face tracker to calculate the car's distance from the target. Finally, the player will receive their score, or get a game over screen if the car crashes. As Robo chicken was developed, the GUI for it would evolve past what was conceptualized.

Working on the game design for Robo Chicken had some design consideration. The game itself pulls inspiration from the original game of chicken, where players would be on a collision course with each other, and swerving away would make that player a "chicken". With Robo Chicken, the stakes are far lower as it's the robot that would crash into things, not the players themselves. Likewise, having a robot car to play chicken lends itself to different types of games to be played. For example, I thought about Robo Chicken as an elimination tournament, with players that crashed the car or got the worst score would be eliminated from the game, and the game would keep going until only one player was left. Ultimately, I ended up focusing on Robo Chicken as a single player experience, where the object was to get the best score possible.



(Figure 10. Included instructions on how to set up and play Robo Chicken. Screenshot taken December 27, 2023)

Future developments of Robo Chicken would focus more on the design of the game rather than the technology itself. This meant that future iterations of Robo Chicken would focus on making the game as fun as possible, leading to decisions that would, ideally, enhance the fun of Robo Chicken. For example, I would add a “Camera Adjustment” screen to the Unity side of Robo Chicken, giving the player an opportunity to adjust the camera to their liking. While this screen was important in making the game accessible, it did also highlight a clarity issue as players would often activate the car right away before even realizing what was happening. Among other clarity issues like players not realizing they need to use the mouse to navigate menus, and it was clear I needed to provide additional information. For example, I added a line during the main gameplay screen and camera adjustment screen to show when the car will start moving. Adding on to the clarity issues, players felt that the game lacked feedback on the players actions, which is to say they were not sure how to excel at the game. They suggested that players should see the car, even though the game was designed around not seeing the car. The compromise to this was to instead give the player three tries to get the best score with a given target.



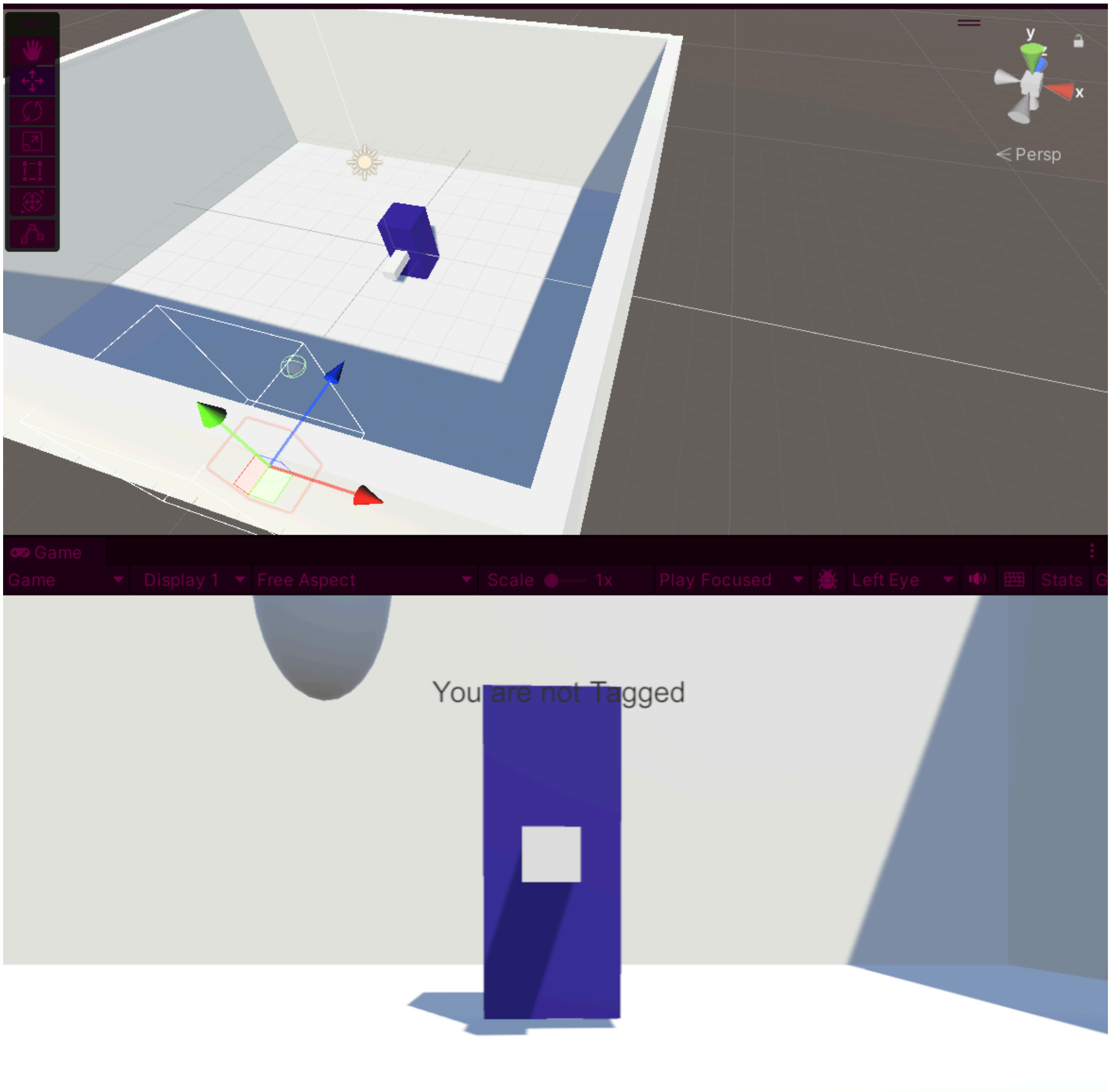
(Figure 11. Camera adjustment screen with (right) and without (left) threshold line)

As work on Robo Chicken reached its end, I started adding sound effects to the unity side of the game. Initially, the sound effects were added to add more clarity to the game, signifying when the player reached the threshold, or if they pressed a button on the menu. However, I also used sound effects to accompany certain game states, like adding a drum roll to the score calculation to add suspense. Using sound effects in this way led to some unexpected results, like a passerby laughing when they heard the failure sound for when the car crashes. This is all to say that sound effects are important not just because they provide feedback to the player. Indeed, sound effects can also enhance gameplay by highlighting events and actions, like crashing the car in Robo Chicken.

Tagbot Development

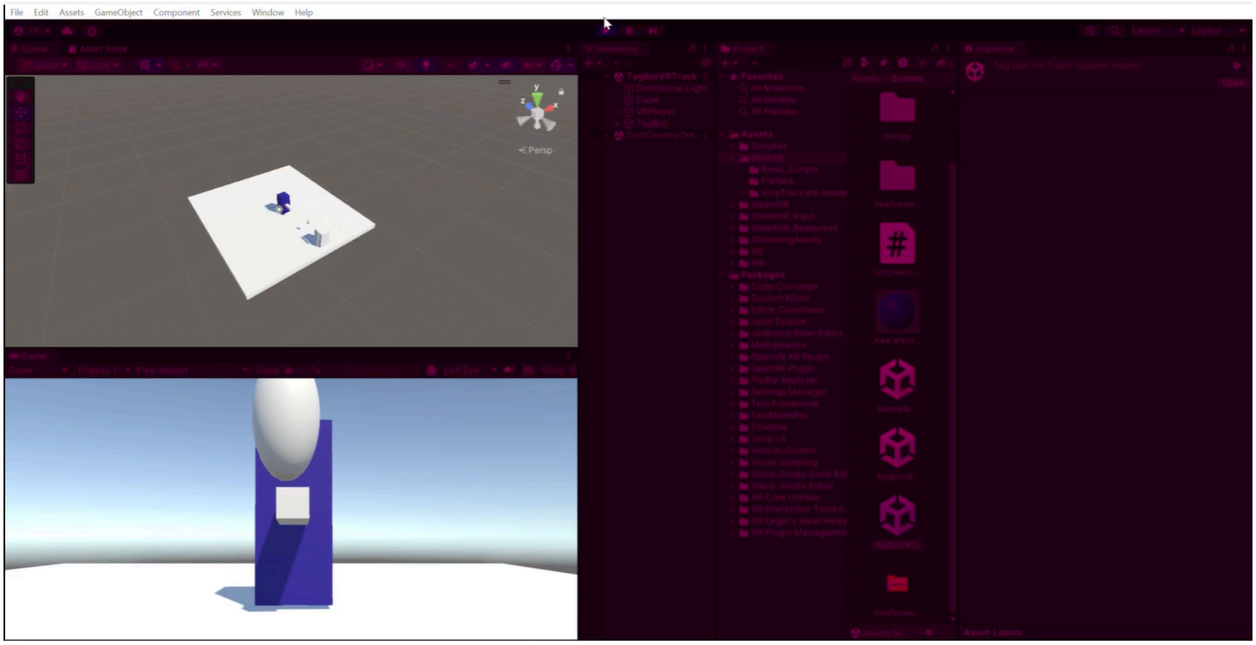
With Robo Chicken reaching completion, work would shift back to Tagbot. Given the work that was already done on Robo Chicken, most of it would be reused for Tagbot. However, there were some new considerations for Tagbot that needed to be addressed. Mainly, there needed to be a way for Tagbot to know the position of the players and its own position so that it could track the players and tag them. The solution was simple in concept; use Virtual Reality. Applying VR to Tagbot would work as such; we would use Vive trackers to determine the position of the players and tagbot, which tagbot will use to chase down players. The base stations of VR can also be used to define the play zone for Tagbot. Working with VR was tricky at first, but I would get better at it as prototypes were made.

The first major prototype for Tagbot using VR would be called TagbotVRProto. This prototype was a recreation of TagbotTest, reusing most of the code from that prototype and using it with new code that works with the VR. The purpose for this prototype was to simply get VR working with the TagbotTest version of Tagbot, where I would learn how the VR works and how to implement it with Tagbot.

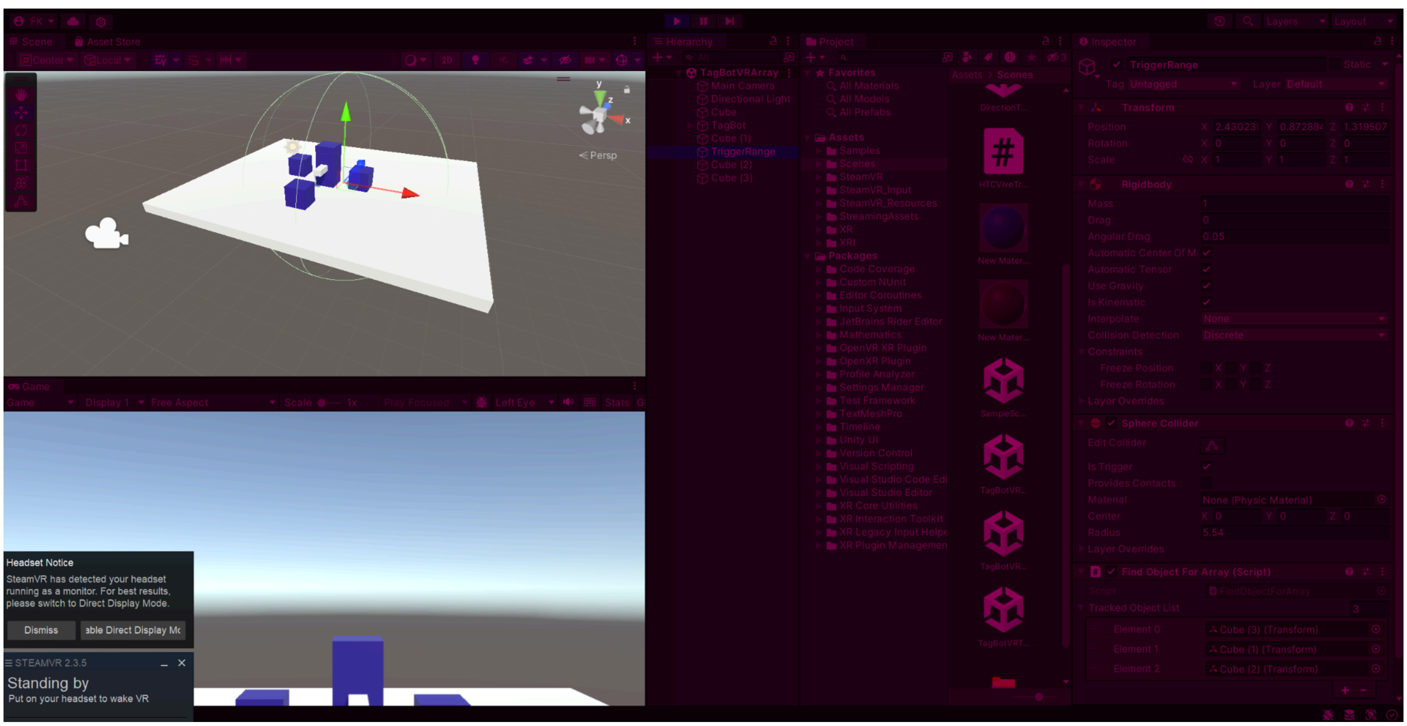


(Figure 12. Screenshot of TagBotVRProto)

Following this prototype, I would develop the other prototypes as separate scenes in the same unity file, to quickly access the VR components. There were three prototypes I would make in this unity file. Firstly, there was TagBotVRTrack. The goal of this prototype was to simply have Tagbot track the position of the player tracker; represented by a sphere. There was also TagBotVRArray, which tests the functionality of the playzone in terms of giving Tagbot the position of the players in the playzone. Both of these prototypes serve to work out a specific function needed for Tagbot. In these cases, the ability to track objects and know who's in the playzone are needed for the final build of Tagbot.

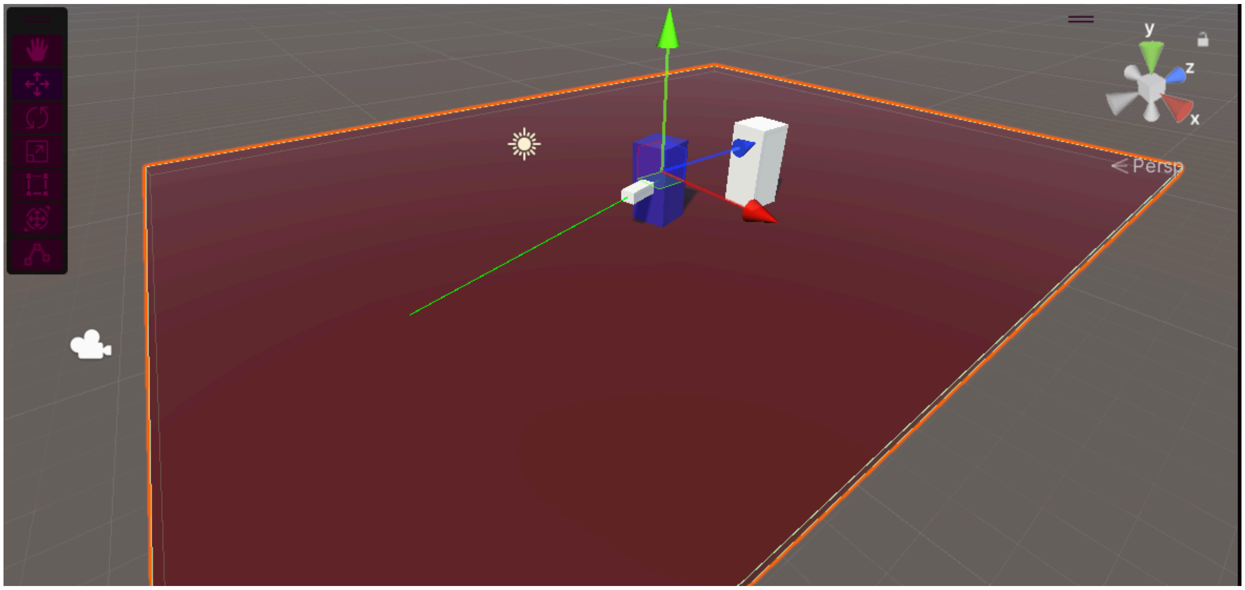


(Figure 13. Screenshot of TagBotVRTrack)



(Figure 14. Screenshot of TagBotVRArray)

This all culminates in the third digital prototype; TagBotVRFetch. This prototype combines code from the previous prototypes in order to create the base logic that Tagbot uses in the future. In this case; TagBotVRFetch has Tagbot go towards a player/tracker, tag them, and then move to a random position. With this logic in place, Tagbot would have the needed programming for the physical build.



(Figure 15. Screenshot of TagBotVRFetch)

The final step in getting Tagbot working on the programming side was to combine all of the logic developed from the prototypes into one scene. However, the process of doing this took a lot longer than expected, both due to issues that were tricky to solve and needing to implement VR with the previously established logic. This resulted in two more prototypes before the final scene was made.

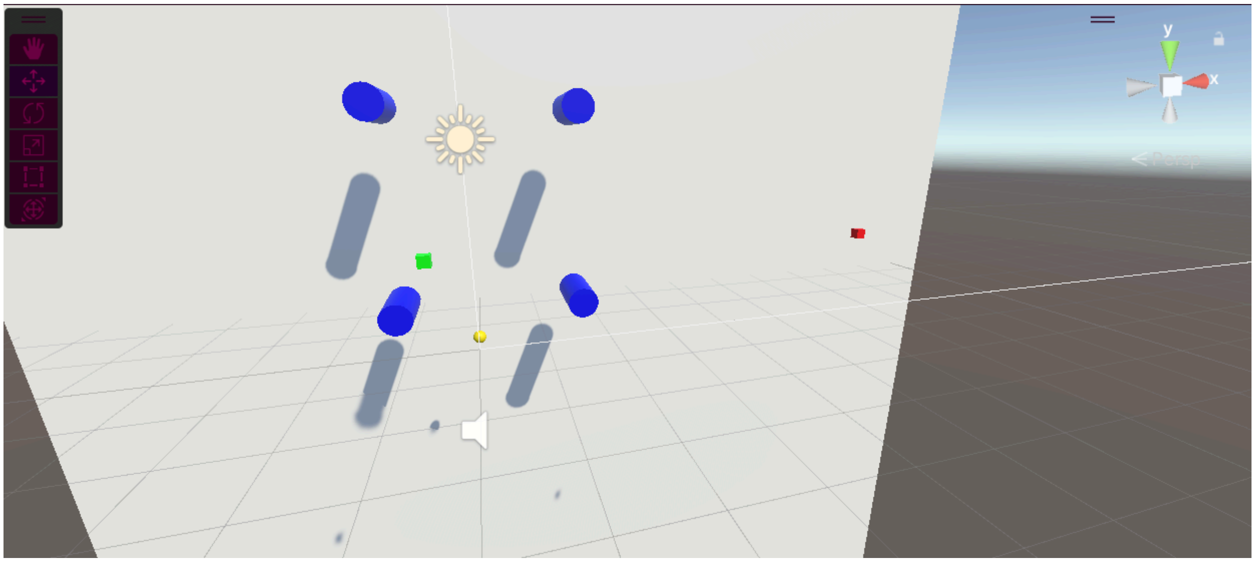
TagbotVRCulmination was the first attempt to combine all the prototypes to make the final scene. The goal was to get Tag to work between the human and Tagbot, get Tagbot to move according to who was "it" and to define the space to contain Tagbot. This works by using game objects to represent Tagbot and the human respectively, and if the one that was "it" got close to the other player, that player would become "it". However, issues would arise due to the gameobject representing Tagbot not moving properly in VR, which would ultimately necessitate a new scene to debug the issues.

Before that new scene, we needed a new car to serve as the base of the physical version of Tagbot. It couldn't be any car kit though, as additional considerations in how Tagbot mov needed to be made. As such, the car that was chosen for Tagbot had a unique quirk: it could move orthogonally. This meant that Tagbot could move left and right without needing to turn first, something which proved to be an asset as Tagbot finished development.

(Figure 16. Built car for Tagbot)

TagbotVRCulmination2 would rework Tagbot's logic, as well as implement it with the new car. Firstly, the reworked logic. Up until now, Tagbot would manage its own tag state; the logic being if Tagbot was "it", then the human was not "it", and the game could proceed normally without any extra coding. This was changed so that a gamemanager controlled the Tag state of each player, mainly for organization purposes. Moreover, how the gameobject in unity tracked to VR was changed. Due to issues regarding rotation and which axis the tracker faced, the tracked objects in unity would be split into two parts. The first part was an empty gameobject that pulled data from the tracker directly. The second part had the a square gameobject pull from tracked data from the empty gameobject via a separate code. This allowed us to manipulate the VR data, which would be important in the final scene. I also added sound effects to the game at this point, which were used when someone was tagged. Essentially, both the player and Tagbot were given a unique sound effect when one of them got tagged, in order to add clarity to the tagging system.

The final scene, TagbotVRFinal, finally brings everything made for Tagbot to completion. The major changes here mainly involve the fact the tracker is Z up instead of Y up in unity. This meant that in order for Tagbot to work properly, we needed to swap the y and z axis of the tracker in unity in order to get the right values. We also establish a proper boundary in unity that stops the car if the gameobject passes it. With these final adjustments, Tagbot would reach completion alongside Robo Chicken.



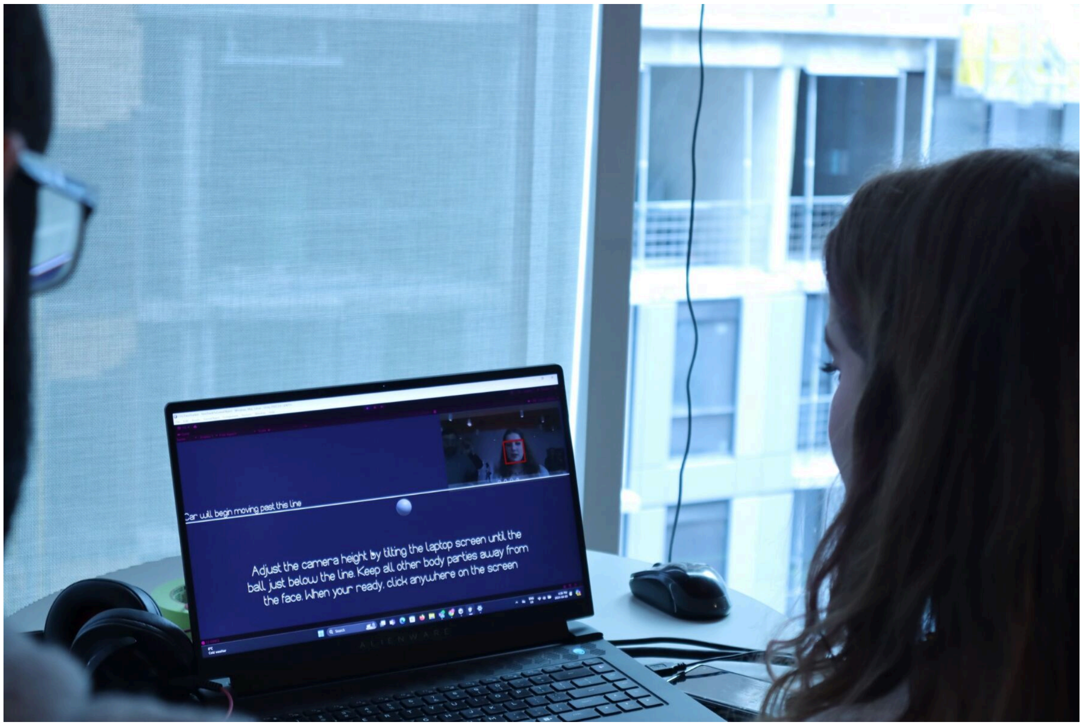
(Figure 17. TagbotVR Final Scene view)

Reflection

Robo Chicken

Having now finished the project, I want to reflect back on the robots I made and see how well they did in terms of answering the research questions. Firstly, there's Robo Chicken. In general, I think Robo Chicken did yield some interesting new interactions between humans and robots. This is mainly because of how the game of Robo Chicken works, allowing players to approach the robot in a way that's at least different from other human-robot interactions. I also think the game of Robo Chicken is designed well enough with the necessary elements that you can get a well-played game out of it. This aspect is thanks to game design elements like the added sound effects and the inclusion of the camera adjustment screen to be more inclusive to players of different heights. Overall, the act of incorporating a robot to a gameplay setting has left me satisfied.

However, there is one aspect of Robo Chicken that bugs me, and I feel that this aspect, or lack thereof, has led to Robo Chicken falling short in other areas of the thesis. This aspect that I'm referring to is the fact that Robo Chicken lacks autonomy and a personality. When the game of Robo Chicken isn't happening, Robo Chicken is simply turned off and is only turned on again when the game of Robo Chicken needs to be played. While this is concerning, I don't think this lack of autonomy is the main issue here. Indeed, even though Robo Chicken isn't much for conversation, there is a chance for Robo Chicken to have a pleasure or utility-based relationship with someone, perhaps even both. However, my concern stems from Robo Chicken being seen as a tool instead of a companion, and that is due to Robo Chicken's lack of a strong personality. Simply put, Robo Chicken's lack of a personality means it struggles to develop a stronger relationship with players, making a virtuous relationship unobtainable in most scenarios. The way I would remedy this is by simply giving Robo Chicken various sound effects that play during certain states, like when Robo Chicken is moving or when it crashes into a wall. These sound effects would help in giving Robo Chicken more of a personality, which can help players build a stronger relationship with it. A costume would also help in this regard, but that isn't completely necessary. Again, I refer back to "Can't Help Myself", and how the authors were able to make a robotic arm that had a personality that people could latch on to, despite the robot arm not having visual elements to support the personality.



(Figure 18. Visitor sitting in front of Laptop to play Robo Chicken)

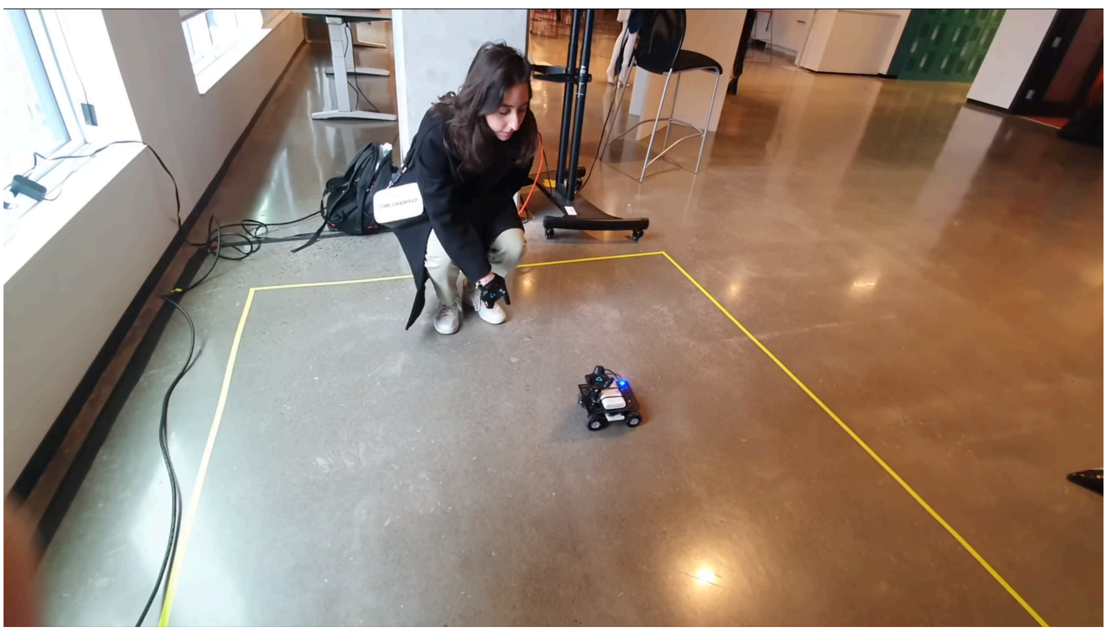
Looking back on the exhibit, I think it went well overall for Robo Chicken, despite numerous clarity and tech issues at the time. I did get one interesting observation that a visitor would notice. Basically, since you couldn't look at Robo Chicken while playing the game, you needed to rely on other senses to know if Robo Chicken was moving, like hearing the motors turn on. This led to Robo Chicken to have a level of embodiment that I never noticed till then. That being said, I found that looking at Robo Chicken while playing was more fun overall, but Robo Chicken having a element of embodiment is still something worth noting.

All in all, I'm satisfied with Robo Chicken. While the game of Robo Chicken was successful in making new interactions between humans and robots, Robo Chicken falls short in developing strong relationships, mainly due to the absence of autonomy and a personality. However, I don't think it's all bad, especially if Robo Chicken can be considered a tool. After all, one of the requirements of a virtuous friendship is honesty and authenticity. Even though Robo Chicken can very easily be seen as a tool, we still trust the tool to perform its assigned role, and become agitated when it can't do that. Given that, according to Danaher, friendships are rarely perfect even with the Aristotle friendship framework, I think there is still some kind of friendship to be found from a tool.

Tagbot

In contrast to Robo Chicken, I felt far more satisfied with the results of Tagbot, especially in answering the questions laid out by the thesis. For example, Tagbot has a stronger personality, mainly due the fact thet Tagbot moved towards people with it was “it”. This helped Tagbot to appear friendly and approachable, especially as it lacked a costume. Likewise, Tagbot was far more active compared to Robo Chicken, allowing for more opportunities for players to connect with Tagbot and build a strong relationship. Due to this, Tagbot does a much better job in handling the Aristotle friendship framework. Because of Tagbot’s general personality and autonomy, players have a strong chance to form a pleasure-based friendship, with the chance of even forming a virtuous friendship with Tagbot. I believe that with these elements, Tagbot can successfully change someone's opinion on robots.

The game of tag itself was also sufficiently changed thanks to Tagbot. While scooter boards weren’t available for the exhibit, squatting proved a useful alternative, and it did change how Tag was played by limiting the movement of the players. This resulted in Tag having an extra dimension when playing as players need to plan around their movement. This new way to play tag, alongside the inclusion of Tagbot, does allow for a new way to interact with a robot, as well as paving the way for a well-played game to occur. In fact, despite more explicit game rules, the simple joy of playing Tag with a robot was enough of a hook for people to be interested in Tagbot and start playing with it.



(Figure 19. Someone playing with Tagbot)

My only issue with Tagbot when I did the exhibit was a prevalent clarity issue when playing. Simply put, visitors didn’t know how to play Tag, which required I demonstrate how Tagbot worked personally before letting the visitors try. One visitor did note that needing to personally show Tagbot did add a dramatic/ artistic element to Tagbot, but I feel like I was trying to compensate for an existing issue. I also found a clarity issue when determining who was “it”. It was easy enough to know when Tagbot was “it”, but not when the player was “it”, even with sound effects. I think this could have been resolved easily as Tagbot had a light which determined which direction it was going in, which could have been used to show if Tagbot was “it” or not.

Conclusion

In general, I believe that robots, as they are right now, have a place in our society and that people have yet to see how robots can help us. This is why I'm suggesting games as a way to help build our relationships with these robots. We've seen how they can push robotics, with robots like Deep Blue and even ROB being a toy that plays with the idea of humans and robots playing games together. Likewise, games can bring people together and make ourselves more open to the world at large. We have even seen how robots can affect our relationships with them, with social robots like Paro using recognizable cues to make them more approachable. Even authors like Danaher have argued how robots can be our friends in a philosophical sense.

Looking back on the thesis as a whole, I did get some satisfactory answers. For example, games were able to facilitate new interactions between humans and robots by allowing new ways to approach robot creations and game design. For example, Tagbot ultimately changed the way tag was played by needing the scooter boards to keep things balanced with Tagbot. Likewise, the game of Robo Chicken was designed around using the car called Robo Chicken and vice versa. The point here is that both the robot making and game design ideation influenced each other, which led to different interactions between humans and robots in these games. I also saw how material and forms affected the relationship with a robot. Essentially, the use of cloth with Tagbot did help in establishing relationships with players. In contrast, the raw technical components seen on Robo Chicken made it harder to form a relationship. However, as I thought about this, I realized that one could form a friendship with a robot like Robo Chicken. Essentially, while visual elements can help in establishing relationships, a strong personality is what's needed to really make a strong relationship with a robot; something that Tagbot had but Robo Chicken didn't.

Regardless though, I can't predict the future. People like Bryson and Sparrow and Sparrow could have been right from the start, and that we should have reduced robots back to their original roles as strictly tools for humanity. In truth, the research questions I used for the thesis are incredibly broad, and I could research them for the rest of my life without coming to a conclusive answer. Indeed, there are certainly some questions about humans and robots that either don't have conclusive answers, mainly for being too far off into the future for an answer to be reasonably found. However, in these times, it is a good idea to take a step back and reevaluate things with an open mind. I think games are able to offer that kind of opportunity, and the thesis I did provided a good start I feel.

Future Work

Looking towards the future, I definitely want to focus more on the design of the robot themselves. This isn't just because robots like Robo Chicken fell short of its goals, but rather due to the scope of this thesis. Essentially, due to limited time and resources, I was restricted in terms of how I could make these robots. This meant the robots I made needed to be smaller and be overall simpler programming wise. In the future, not only do I want to make more robots that could play games, but for said robots to be larger and have a strong personality. Likewise, I want to incorporate proper AI models in these robots. As I said, a lack of resources meant I couldn't use proper AI models with the robots, instead opting for more reflex-based robot logic. However, robotics and AI development go hand-in-hand, and I believe incorporating AI models into any new robots I make could be beneficial in building relationships between humans and robots.

Bibliography

- Abby. (2023, July 28). *The complete history of tennis for two*. History. https://history-computer.com/tennis-for-two-complete-history/

- Abney, K., Bekey, G. A., & Lin, P. (2014). *Robot ethics: The Ethical and Social Implications of Robotics*. The MIT Press.

- Borowiec, S. (2016, March 15). *AlphaGo Seals 4-1 victory over go grandmaster Lee Sedol*. The Guardian. https://www.theguardian.com/technology/2016/mar/15/googles-alphago-seals-4-1-victory-over-grandmaster-lee-sedol

- Bryson, J. J. (2010). Robots should be slaves. *Close Engagements with Artificial Companions*, 63–74. https://doi.org/10.1075/nlp.8.11bry

- Danaher, J. (2019). The philosophical case for robot friendship. *Journal of Posthuman Studies*, *3*(1), 5–24. https://doi.org/10.5325/jpoststud.3.1.0005

- DeKoven, B. (2013). *The well-played game: A player's philosophy*. The MIT Press.

- Friedhoff, J. (2023, July 15). *Games, play, and joy: Part 1*. Medium. https://jfriedhoff.medium.com/games-play-and-joy-part-1-75991ff32e69

.

- Friedhoff, J. (2023b, July 15). *Games, play, and joy: Part 2*. Medium. https://jfriedhoff.medium.com/games-play-and-joy-part-2-e367cee61076

- Gomez Cubero, C., Pekarik, M., Rizzo, V., & Jochum, E. (2021, July 29). *The robot is present: Creative Approaches for Artistic Expression with robots*. Frontiers in robotics and AI. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8358596/

- Goodrich, J. (2022, March 14). *How IBM's Deep Blue Beat World Champion chess player Garry Kasparov*. IEEE Spectrum. https://spectrum.ieee.org/how-ibms-deep-blue-beat-world-champion-chess-player-garry-kasparov

- Kerruish, E. (2016). Perception, imagination and affect in human–robot relationships. *Cultural Studies Review*, *22*(2). https://doi.org/10.5130/csr.v22i2.4823

- Madhukalya, A. (2023, May 30). *"no piece of art has ever emotionally affected me this way": Artist's viral post on Robot*. Business Today. https://www.businesstoday.in/latest/trends/story/no-piece-of-art-has-ever-emotionally-affected-me-this-way-artists-viral-post-on-robot-383443-2023-05-30#:~:text=For%20the%20robot%20arm%2C%20they,liquid%20within%20a%20predetermined%20area.

- Prescott, T. J., & Robillard, J. M. (2020, December 26). *Are Friends Electric? the benefits and risks of human-robot relationships*. iScience. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7809509/

- Smithsonian Institution. (n.d.). *Video game history*. https://www.si.edu/spotlight/the-father-of-the-video-game-the-ralph-baer-prototypes-and-electronic-games/video-game-history

- Sparrow, R., & Sparrow, L. (2006). In the hands of machines? the future of aged care. *Minds and Machines*, *16*(2), 141–161. https://doi.org/10.1007/s11023-006-9030-6

- Williams, A. (2023, February 16). *Retro gadgets: Nintendo R.O.B wanted to be your friend*. Hackaday. https://hackaday.com/2023/02/16/retro-gadgets-nintendo-r-o-b-wanted-to-be-your-friend/