Interactive Audience-Controlled Live Storytelling Technologies

by

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Abstract

When designing an entertainment experience, audience engagement in the event is a crucial aspect in its success. One way to increase audience involvement is by giving them a way to control an element of the experience. This can be facilitated through a variety of interactive technologies. While some forms of entertainment, such as theme park attractions, have used many of these technologies over the years, live storytelling events, such as theater productions, have made limited use of technology to facilitate audience interactions. The goal of this project is first to analyze how interactive technologies have been used to affect the stories told in theme park attractions. This will allow us to propose a method to incorporate more types of these technologies into the theater experience, based on the successes found within theme park interactivity.

Thesis Supervisor: Joseph Paradiso
Title: Director of Responsive Environments Group, Media Arts and Sciences

Acknowledgments

I would like to thank my family for their constant encouragement over the years to accomplish my dreams. This is particularly true with my goal of pursuing a career in entertainment technology, which they have supported for the past decade, and is finally set to happen once I graduate. I owe a lot to them for this dream being realized.

Also, a huge thanks to Joshua Higgason, who provided me with the wealth of knowledge necessary to accomplish the tasks I set out to complete within the world of interactive theater performances. Thanks as well to my thesis supervisor, Joseph Paradiso, for making the process of working on my thesis so smooth, and for providing useful research within the realm of interactive environments.

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Chapter 1

Overview

In any medium, when crafting a story, one of the most crucial elements in successful storytelling is how engaged your audience is. If the audience is not mentally involved with the world being created in the story, it's as if there was never an audience in the first place. This is especially important in the realm of live storytelling, such as theatrical productions with live performers or the immersive experiences created by theme park attractions. The live, physical nature of this medium makes it all the more vital that an audience feels like a part of the story, since the narrative is being brought to them both in real time and in real life.

Efforts to make an audience feel included in a story have existed in many ways over time. If we look back at the opening day of the original Disneyland in 1955, we can see examples of earlier forms of attempted immersion in attractions like *Snow White's Adventures*. When park guests boarded this ride, they experienced the story of Snow White told in the 1937 animated film, except in a physical form. But, there was one catch: Snow White herself was nowhere to be found in the ride. The goal of the original designers was that the person riding the attraction would *be* Snow White, rather than just watching her [19]. This example shows the goal of making these live storytelling experiences a unique, personalized event. However, as the riders only had a passive role in the story, with no way to have an effect on the outcome, this attempt fell flat as riders only ended up being confused that Snow White was missing. This confusion eventually forced the ride to be updated later on, in order to insert figures

of Snow White into the story.

This example goes to show the importance of technology in creating an immersive, interactive experience. The more primitive technologies available for entertainment installations back in the 1950's did not have the capabilities to give the audience a way to have control over how their story will go. As technologies advanced over time, there has been an increasing potential to create a more perfect personalized story environment, leading to some impressive developments in recent years. The goal of this project is to analyze the increasing achievements in interactive live storytelling technologies over time, looking at the successes and failures of each of them, allowing us to draw conclusions for the next best steps in creating these experiences. Based on these conclusions, I will be able to propose my own ideas for audience-controlled interactive storytelling systems, so I can implement and test prototypes of these technologies.

I have decided that I will focus my analysis on examples drawn from theme park attractions and environments, due to their higher reliance on cutting-edge and specially-created technologies to craft a complete, immersive story. I will particularly focus on some of the more recent developments to get the most up-to-date view on what the technologies are capable of. Then, for the proposing and implementing of new kinds of these technologies, as someone who has a background in Theater Arts, I decided to develop a setup where an audience will be able to affect a live storytelling performance with human actors, like in a traditional theater production, from their seating area.

In previous projects of mine, I designed and created multiple interactive elements for performance. However, these were developed from the perspective of the actor controlling the technology, rather than the audience. This is simpler due to the actor already having a good idea of what is supposed to happen in the story, and can guide it in an expected way. After analyzing existing ways of audience-controlled story elements, from the theme park attractions, I am able to understand more of what to keep in mind in order to develop successful interactivity from the other perspective.

1.1 Related Work

1.1.1 Prior Interactive Entertainment Analysis

One of the original inspirations for deciding on this project came from reading through the paper titled "Smoke and Mirrors to Modern Computers: Rethinking the Design and Implementation of Interactive, Location-Based Entertainment Experiences", written in 2003 [27]. In this paper, the author discusses how, at the time the paper was written, there was a lot of potential for interactive live entertainment, which has not been tapped into yet. He mentions some of the existing interactivity from theme park attractions at the time, and notes that the "... experiences provide the user with some ability to modify and customize what he can do, but they are crude at best." The author envisions much more immersive entertainment experiences and spends a lot of the paper discussing the various technologies that could help enable such an experience.

Since 2003, there have been many impressive developments in interactive live entertainment technologies, which lines up well with the vision of the author. While this author wrote about the potential technologies that could be used to create an enhanced interactive experience, I want to take apart the designs and technologies that have emerged in the last couple of decades, to learn about what these new experiences have that make them more successful. By doing this, I am able to have a more clear picture about where the future of these technologies may lead, which allows me to propose new ideas of interactive systems from these speculations.

1.1.2 Interactive Music Systems

A topic similar to the one I wish to explore is that of an interactive music system controlled by an audience. Work done in this area, such as in "An Interactive Music Environment for Large Groups with Giveaway Wireless Motion Sensors" from 2007, conducted by the Responsive Environments Group at the MIT Media Lab, posed the question of how to give a larger audience control over a single music output

[18]. Their solution involved giving each audience member a small, cheap wireless sensor that each audience member could wear or hold. Based on the movements of a person's arm in a group dance setting, the device would output radio-frequency energy pulses to stations within the room. These movements allowed the system to determine calculations, like the energy level in the room, which would alter the sound of the music playing in response. While these audience-controlled music systems have developed great ways to give their audience power over a more abstract output, which works for music, the goal for my work involves looking into ways for the audience to control a more defined narrative relating to a story being told.

1.2 Past Interactive Theater Productions

1.2.1 Audience Voting Measured by Humans

Previous attempts at allowing an audience to control what happens in a theater production from where they are sitting have been fairly limited. An early example of audience control existed back in the 1930s, for the production named *The Night of January 16th* [4]. Some members of the audience were selected to sit in a special area of the theater where they would effectively serve as the jury for the court trial that the plot of the show revolves around. Towards the end of the show, the audience jury would have to vote on the verdict of the trial, which would lead to two different possible endings of the show, based on the choice.

A more involved example of a plot based around audience choice came in the 1980s, with *The Mystery of Edwin Drood*, a musical adaptation of an unfinished murder mystery novel by Charles Dickens [16]. Since the original plot went unfinished, the audience gets to choose the ending of the show, which includes picking the identity of the sleuth, the murderer, and two lovers from seven of the cast members throughout the show, resulting in a large variety of possible permutations. The murderer is chosen by cast members going into the audience and manually counting up the votes for their section during a break in the show, while the sleuth and two lovers are chosen based

on which characters get the most applause when the time comes to make the choice. While these methods did give the audience a noticeable effect on the show, the more primitive ways of collecting the information was more cumbersome, in the case of the tallying, and hard to discern, with the approach of listening to applause levels.

1.2.2 Audience Voting Measured by Technology

Some more technology-based solutions to have an audience affect a production came later on, such as in *The Boomerang Kid*, a comedy production that premiered in 2007 [2]. For this show, each audience member is given a wireless, touch-screen PDA, and they are called upon multiple times throughout the show to vote on a choice that the main character should make, leading to many different outcomes based on the collective audience decision. At the end of the first run-through, the play starts from the beginning a second time, to allow the audience to make new choices and get a different story. This approach allows for a more efficient way of tallying up audience votes, as opposed to the previous method of manually counting.

A solution to calculate specific values from an audience's applause was implemented in a paper released in 2007 [29]. They proposed and developed a concept of a disposable wristband that would be able to wirelessly send out radiofrequency pulses when people clap their hands. These measurements, in addition to cheering levels being monitored through microphones placed throughout the audience, would be used to calculate a score to determine who the winner was. While the purpose of the paper was for this system to be used for judged spectator sporting events, it makes sense how it could be used for audience voting in a story event, like the applause-based voting used in *The Mystery of Edwin Drood*. These past few examples have shown ways that a theater production can be influenced by an audience, but they have just been limited to various ways of voting, rather than more interesting audience inputs. Exploring the ways that theme parks have implemented creative methods of audience control will allow for a new perspective on how theater productions can incorporate similar approaches.

1.2.3 Collective Audience Gaming

There has also been work done on letting a collective audience control a game, such as the "NewsBreaker Live" project developed in 2007 [3]. For this project, only a small modification was made to an existing movie theater audience layout, with a single motion sensor installed in the front of the theater. This allowed the audience to control a video game by moving their bodies as a group, where their collective bodies leaning left or right would control a platform that a ball was bouncing on, with the goal being to use the platform to have the ball break the blocks above it. This was created to give the audience a fun activity to do while waiting for their movie to start. While the goal of my project is to have the audience control a story-based experience, rather than a single game, the "NewsBreaker" Live project proved to be an engaging, social experience, showing that the idea of an active, technology-based audience input would be worthwhile to pursue for the interactive theater production approach.

1.3 Challenges of Interactive Attractions

In my analysis of each theme park technology, I will go over the successes and failures of the final product, as well as the challenges the designers and engineers had to work through to accomplish the experience. According to those who have worked in developing theme park attractions, some of the common major challenges that all interactive storytelling technologies must overcome is that of capacity and expertise.

1.3.1 Capacity

John Wardley, a theme park attraction designer, states that "...interactivity and capacity are always fighting each other. As soon as you allow your guest to interact with something, your capacity drops, and at bigger parks, where you need at least 1200 an hour capacity for an attraction, the pressure is put on..." [31]. If you have each person in an experience controlling the outcome of the story, there is a tricky

balance between personalization and capacity. If there are less people per experience, that means each person will have more individualized control, but much fewer people will be able to engage with the attraction overall. If the capacity allows for more people per experience, this will result in more availability or shorter wait times, at the expense of having to rely more on the interactions of the group as a whole, rather than the individual.

1.3.2 Expertise

This leads into the second common challenge with these interactive experiences, which is expertise. When you give much of the creative decisions for the storytelling to an audience member, they may make choices that will result in a less pleasant experience. When the interactivity is controlled by a group, this can lead to frustration if a person in the group is not happy with the choices or skills of another person in control. For example, research has been conducted by creative designers for attractions on how teenagers react to interactive thrill rides, which allow them to control the movements of the rides. They received feedback that many teenagers did not want to be sitting with someone who doesn't create the same kind of ride they would want, or doesn't make the ride as intense [31]. Additionally, if the interactivity is more involved, this could be good for the person who enjoys being thoroughly engaged with the story with more control. However, a more complicated system means that a person using the technology for the first time could be confused, as well as distracted from the story when trying to figure it out.

1.3.3 Challenges for Theater

These two challenges of capacity and expertise demonstrate the tricky balancing act that must be done when designing these interactive technologies, so that people are mentally stimulated without being overly frustrated. Analyzing the different examples of storytelling attractions will allow me to discover the unique situations that an audience can be involved with, and the design choices made to find the right balances

for the specific story trying to be told. When applying these issues to a theater production, some challenges to keep in mind for this idea will be figuring out how to give a large group control, since performances usually have sizable audiences, and how to keep the audience engaged in the story, rather than distracted by the use of the technology.

Chapter 2

Analysis of Theme Park Technologies

2.1 Personalization

This first method I will discuss allows an audience member to feel the influence of their presence in an attraction, whether it be through a visualization of themselves, the use of their name, or by their individual choices reflecting their personal character. This type of approach allows for the guest to feel included in the story around them, rather than just the passive onlooker, even if their direct control is fairly limited, like in some of the examples listed below. As opposed to the Snow White attraction described earlier, the audience members are distinctly themselves, instead of an existing character that is already defined for them, and can see their own self as a part of the story's world.

2.1.1 Physical Appearance

Some of the first examples of personalization we can look at involve some reflection of an audience member's appearance being used and manipulated throughout the attraction. This idea allows for the rider to directly visualize themselves as inside the story, since they are made aware of how the environment they are in can affect them. An early example of a rider's reflection being made a part of the story was unveiled in the *Haunted Mansion* attraction, which originally opened in Disneyland

in 1969. Towards the end of the attraction, the riders pass by a series of mirrors, and within the mirrors, the riders see themselves sitting next to a ghost that is hitching a ride with them. This effect was originally achieved by using a two-way mirror, with a chain of ghost mannequins on the other side of the glass moving synchronized with the ride vehicles. The ghost side of the mirror was brightly lit, while the audience side was less well-lit, allowing for the audience to see the ghosts through the mirror [31].

In 2011, more modern technology allowed for this effect to be updated. The change involved adding head-tracking cameras to the mirror room. By tracking the location of the riders' heads, the attraction is able to project a variety of animations with the hitchhiking ghosts onto the mirror. These animations could include the ghost removing the head of a rider and inflating it up like a balloon, or the ghost swapping the rider's head with its own head [31]. These effects allow the audience to be directly victim to the effects of what is possible within the rules of the created world their in.

Another attraction that used the rider's image within the experience was *Harry Potter and the Forbidden Journey*, from 2010. Within the story, the riders are attacked by beings called Dementors, which attempt to suck the souls out of the people they come across. Before the riders are saved, one of the Dementors attempts to suck out the rider's soul and they are able to see a cloudy image of them floating away from them towards the physical Dementor figure. To achieve this effect, as opposed to using a reflection, a picture is taken of each of the riders earlier in the attraction, which is later projected onto a wall of fog between the rider and the Dementor [31]. In these examples, the audience does not need to manually do anything, but they still have a specific influence on the story elements by having their own "character" be inserted.

2.1.2 Names

Similar to their physical depiction, a simple, yet powerful, way to have the character of an audience member appear in the world around them is by referring to someone by name, in a way that would not be expected to be possible in the real world. An

early use of incorporating names into a ride experience came in the *E.T. Adventure* attraction, which opened with Universal Orlando in 1990. At the end of the ride, an animatronic figure of the alien E.T. says goodbye to some of the riders in front of him, with their name. This effect was achieved by having each rider be given an "Intergalactic Passport" early in the line for the ride, where an attraction operator would encode the person's name into the card. When someone gets to their ride vehicle, another operator takes the card from them and scans it, so that the names on that vehicle would be synced up with the end of the ride where E.T. is [31].

The E.T. name effect works well, but involves a bit of work to get the names inputted. More recently, Disney has developed ways for a park guest's name to be collected and used, without needing any manual input. In 2013, Disney came out with the MagicBand, a rubber bracelet with an RFID chip in it, which allows for guests to have items like their park tickets and credit card loaded onto the band. But, the band is able to emit high frequency radio signals, which allows for long-distance communication with a variety of beacons throughout the parks [28]. Since the bands contain the names of the guests wearing them, they are able to transmit the names to spots in the attractions. For example, in the *Expedition Everest* attraction, as the guests walk through the queue of the attraction, which is themed to a Himalayan base camp, they will pass by posters for local businesses, such as tea vendors and tour groups. The posters serve as one of the communication points for the MagicBands, so they are able to detect a nearby person's name and put their name on the poster, such as by quoting them on a product's testimonial. Using this device with pre-inputted information for personalization allows for a seamless way to let the audience member know they exist within the story.

2.1.3 Ride Experience

Another method I will explore is allowing an audience member to add their own personal touch to a ride experience, based around the choices they make. One simple example of this can be found in the *Hollywood Rip Ride Rockit* roller coaster, which opened in Universal Orlando in 2008. The story of the attraction is that the riders are

the stars of a production shoot, where footage taken from them on the roller coaster is set to be used for an exciting new music video. Once the riders get strapped into the ride vehicle, they are able to use a small touch-screen in front of them to choose which song the music video is for, from a wide variety of famous songs [13]. This will allow the rider to pick which song they get to listen to for the duration of the ride.

Another example comes from the *Spaceship Earth* attraction, found in the Epcot theme park, which opened in 1982, but was updated to add touch-screens to the ride vehicles in 2008. Towards the end of the ride, after having learned about the history of communication throughout the ride experience, the riders are called upon to interact with the screen in front of them. They are able to answer a quick series of multiple choice questions, about their lifestyle and values, and based on their answers, a short cartoon is played depicting a fun visualization of what the future may look like [31]. The content of the cartoon is based around the answers given to the questions, such as a future based more around work or leisure. The faces of the riders are also placed onto the heads of the cartoon figure, using a photo taken at the beginning of the ride.

One example of a ride experience where the rider has almost complete control over what happens is in the *Sum of All Thrills* attraction, which opened in Epcot in 2009. This ride's story purpose was grounded more in reality, with the goal to teach people about the math and engineering that goes into creating a roller coaster [5]. As part of the experience, the riders enter a room with touch-screen interfaces where they get to design a roller coaster, with explanations based around real-life engineering principles given to explain what is possible. The design of the roller coaster is saved onto a personal card, which is then loaded into a capsule that is attached to a large robotic arm. The rider will then get to experience what their uniquely created roller coaster would feel like to ride, with the simulated motion from the arm moving in sync with a video rendering of their coaster inside the capsule.

The potential issue with having the audience alter the ride experience to increase personalization, as opposed to the approaches based around names and physical appearance, is that the audience may make choices that are not ideal for the most entertaining ride experience. This ties back to the overall challenge of expertise in

interactivity. For example, letting the rider choose which song they listen to could cause them to pick a song that does not line up well with the movements of the ride, as opposed to a specifically chosen song by the ride designers that matches the feel of the ride well. Furthermore, in the *Sum of All Thrills* example, the rider could accidentally design a boring roller coaster, if they are confused by what they need to do.

A solution to this could be to always make sure the audience will get a good ride experience, no matter how poor their decisions are. In the previous example, this could be by not allowing for any songs that are too mismatched from the coaster experience, or ensuring that all possible permutations of the personally designed roller coasters are still exciting, even if not the most thrilling possible. This balance allows for the audience to feel involved in the ride experience's development, without giving them too much power in making a worse ride. Also, in these examples, the personalized ride experience is limited to only one or two people in a ride vehicle, so there is no worry about sticking someone with a group of people that makes choices that do not align with what they would prefer.

2.2 Collaborative Attractions

In this section, I will go over the methods used to encourage a group of riders to collaborate with each other, working together to fulfill a collective goal in the story. The two examples that follow give two different approaches to having a group pilot a spaceship on a mission, with the first involving limited actual control of the ship, and the second allowing for more involved control.

2.2.1 "Fake" Piloting

The first attraction is *Mission: Space*, which debuted in 2003. Within the story of the attraction, the audience is going through space training in a simulator for a semi-futuristic spaceship on a mission to Mars. The riders are split up into teams of four, with each team member being assigned specific tasks to complete throughout

the course of the flight. However, all the members have to actually do is press one of two blinking buttons when their time comes to do so. Even if the team member fails to press the button, the ship will do a "computer override" after a few seconds, and press the button for you [31].

As a result, even though each rider is given specific tasks to carry out, the ride will always be the same every time. This fake interactivity is furthered by there being many other buttons and switches throughout the cockpit of the simulator, that do not actually change anything, aside from turning some lights on and off on the control panels. Towards the end of the ride, the riders are asked to manually pilot the ship together with a joystick in front of each team member. However, moving the joystick does not actually change the video played in the cockpit simulator, and all the joystick results in is some haptic feedback [31].

From the perspective of the expertise challenge, there is some merit in the idea of fake interactivity, even if it does not actually let the audience do anything. The audience is still invited, and likely will, participate in engaging with what is presented in front of them, which keeps them mentally involved with the story. This allows for increased engagement without having to deal with designing many different alternative routes the story could take, including the less interesting ones if the audience is not great at working together to make progress.

2.2.2 "Real" Piloting

The second attraction I will discuss is *Millenium Falcon: Smuggler's Run*, which opened in 2019. The intended goal for this attraction is to tell a story where the park guests are given the opportunity to control the Millenium Falcon, the iconic spaceship from the *Star Wars* franchise, in order to complete a mission. This attraction lets the guests go into the cockpit of the ship, and use various buttons, levers, and switches in order to pilot and defend the ship. There are six positions in the cockpit, with two pilots steering the ship, two gunners firing at enemies, and two engineers repairing the ship damaged as you go [15]. As opposed to *Mission: SPACE*, the team does actually directly control the ship. The steering and damage done to the ship is reflected in

the movements of a motion base that the cockpit is on top of.

Like discussed with *Mission: SPACE*, there are a variety of issues raised with regard to expertise in an attraction like this. Since six people are in the cockpit controlling the ship, there could be frustration between the group members for not doing a good job. This frustration is further enhanced if multiple parties are paired together, which is likely since many groups would not have the full six people. One way of dealing with this issue is to ensure that even if someone is doing a bad job, the story is not drastically impacted. I have personally been on this ride in the past, and out of curiosity, I got my group to not press any controls throughout the entire trip. What we found was that even though the ship got very badly banged up, the story still continued not too far off from what would happen if you piloted it normally. Any important controls, like making the jump to lightspeed at the beginning of the ride, was automatically done by the computer if no one did anything. This helps ensure that the experience doesn't come to a complete standstill if someone is doing a poor job. While not perfect, this solution does mitigate the frustrations that could be had with a group controlling one story.

This attraction is also a good example of how difficult capacity issues can be when trying to make an immersive story event. We can look at the capacity challenges from the perspective of the quote by John Wardley described earlier, which deemed that a large attraction like this needs to go through at least 1200 people per hour. Given the popularity of Star Wars, a large capacity is certainly needed to avoid long wait times. For the story being told though, there is one major problem, in that there is only one Millenium Falcon. In order to fully immerse the guests into the story, they need to feel like they are flying and interacting with the real ship. The cockpit only holds a few people, so if there were actually only one ride vehicle built to simulate the ship, they would not be able to get even 100 people through in an hour.

The solution they came up with for this capacity problem was to create four large turntables with seven cockpit simulator chambers on each of them [12]. Each cockpit is on a motion base and encapsulated by a screen dome projecting the view outside the ship. An image from the patent for this turntable design can be seen in Figure

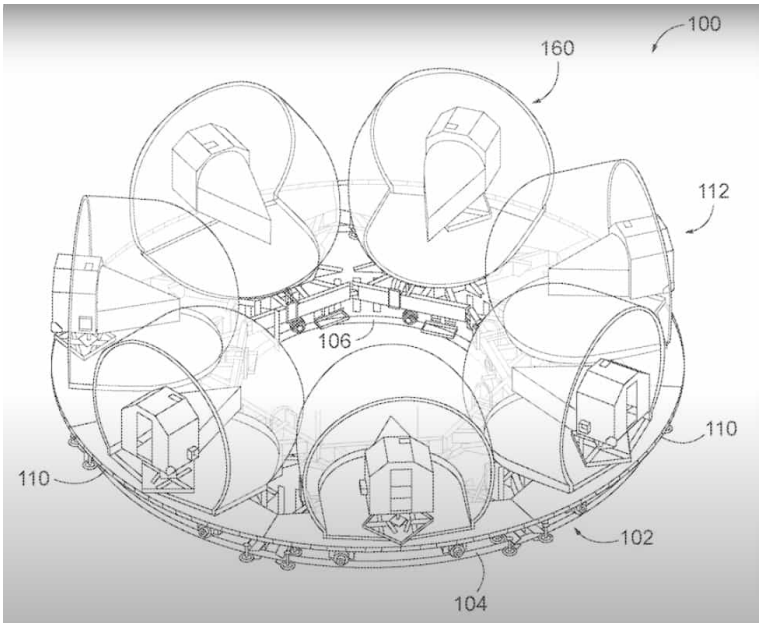

Figure 2-1: *Millenium Falcon: Smuggler's Run* Patent

2-1 [11]. When the guests enter the queue for the ride, they will go through a docking port where they will be split up down different hallways that lead to the four rooms. When they enter one of the four hubs, it is themed to look like one of the interior rooms of the Millenium Falcon, and since they do not see the other hubs, they think they are in the only one. Then another hallway in the hub has a door that leads to one of the seven cockpits. After one group boards and the door is closed, the turntable slowly moves in a circle while the ride is going on in each individual chamber. This allows another group to board the ride, while six other rides are going on. But, since the riders do not see any of the other groups boarding or any of these mechanisms, it creates a seamless experience that there is only one ship and one cockpit. So, despite giving each guest an extremely personal experience, having full control over the ship in a small cockpit, the ride is able to have a large hourly capacity of 1800 people per hour [12].

Another interesting feature of this attraction is the concept of a "reputation" that goes beyond the scope of the story found within the ride itself. For example, if you do a poor job piloting the ship and end up doing a lot of damage to it, this will be reflected on your personal reputation both immediately and a while after the ride

ends. As you exit the ride through the corridors of the ship, that look the same as the ones you entered through, the amount of damage you did to the ship will be apparent as you leave, such as by the lights in the hallway flickering, the sounds of sparks flying, and hearing recordings of people over intercoms talking about the damage done [15].

Furthermore, since many park guests are able to link themselves to the rides they go on, such as through the MagicBand technology discussed earlier, their reputation can be linked to their identity. This means that if someone were to go to a different spot within the Star Wars themed area that the ride is found in, such as a food stand, an indicator of their reputation can appear to the attendant when they use their information to pay [10]. This allows the worker, who is also supposed to be a part of the *Star Wars* universe, to start up a conversation revolving around their reputation, such as them hearing gossip about someone crashing the Millenium Falcon, if they had recently done that on the ride. This idea of having events that build off a person's previous actions is useful in keeping someone consistently engaged with and more careful about what actions they take.

2.3 Competitive Attractions

As opposed to the collaborative approach, the audience could also compete with each other within the built world they are a part of. For an entertainment experience, one of the main draws of a competitive event is the repeatability of it, since there is an incentive to replay the games in order to improve your skills, get better scores, and beat your opponents. In the theme parks, the main type of competitive attraction that has been developed over the years is a "shooting gallery" scenario, where as your ride vehicle moves throughout the scenes, you must aim at targets in order to earn the most points. Over time, these attractions have improved how they use their technology to make a better interactive experience for the riders, so they will be a useful study in what concepts work well for interactive events.

2.3.1 Technology Changes

An earlier example of a themed shooting gallery attraction would be *Buzz Lightyear's Space Ranger Spin*, which opened in 1998. In this ride, you board a vehicle that fits two people, where each person gets a laser gun to aim at evil robot targets. The technology to keep track of each person's score is simple, operating the same way as a game of laser tag, with encoded infrared beams of light being shot out of each person's gun, with IR sensors in the targets processing each hit [23]. One issue with this approach is that the only indication of where the shot from the gun lands is a small red dot. However, with so many thematic elements throughout the attraction scenes, and many other riders passing through the scenes that also have their own small red dots that look the same, it can be confusing and frustrating to know where you are aiming.

A major change came to this shooting gallery type of attraction 10 years later in 2008, with a new ride based on the same movie franchise: *Toy Story Mania*. The plot of this attraction involves boarding a ride vehicle that takes you through a toy-sized midway carnival playset, where each scene you play a different carnival game by firing your gun at the objects in front of you. However, this time, instead of moving through scenes with physical targets around you, like in the previous attraction, your vehicle takes you through rooms with different projected screens representing each game, where you must fire at the screen to hit the virtual targets. This attraction uses tracking sensors to provide the game control system the exact location of the ride vehicle, as well as the orientation of the rider's gun, to calculate the initial location and trajectory of the virtual ammunition [21].

The main benefit of the screen-based approach for these attractions is how it allows for a more dynamic nature in the game. For instance, since the ammunition is all virtual, this allows for what comes out of the player's weapon to change. Since you are going through carnival games, the projectiles could change from firing balls to break plates, shooting darts to pop balloons, or rings to throw at a ring toss game. The virtual firing also lets the projectiles in this attraction to be of a large size and

color-coordinated to each player, which makes it a lot easier to know where you are aiming, compared to the laser approach. Additionally, this digital method can make changes to the screens when necessary, such as how if there is a delay in moving the vehicles to the next scene, the screens can notify the players about the delay and let them shoot in a practice round while they wait. Another improvement with this attraction is that hitting certain targets can trigger physical feedback, like setting off a rocket triggering a blast of wind as it flies by [21].

Despite these new improvements, the main loss with the screen-based attraction, is that you no longer get to move through a physical world, which does a better job at making the story you are in feel real and tangible. A merging of these two approaches came recently with *Mario Kart: Koopa's Challenge*, an attraction that opened in Universal Studios Japan in 2021. The ride vehicle moves through physical sets that resemble the colorful themed tracks from the *Mario Kart* video game series. However, the riders are also given an Augmented Reality Headset, which projects additional features on top of the real world, including other characters from the video games racing around you on the track [26]. Each player is given a button that fires a shell-shaped projectile towards the direction that they are looking, with the goal being to hit the character vehicles around you to gain points. The AR approach allows riders to feel like the story environment is more based in reality, since it is not all a projection, while still using projected elements for the parts of the story that would be difficult to create physically, like the cartoon characters racing alongside the riders.

Another recent approach at shooting attractions removed the physical weapons inside the ride vehicles entirely, to create a more natural experience. This can be found in *WEB SLINGERS: A Spider-Man Adventure*, which opened in 2021. Guests in the ride vehicle move through scenes and have to fire webs blasts, like Spider-Man, at robots. Instead of pressing a button to shoot a web, riders are able to thrust their arm in the direction they want to fire a web, and a sensor in the vehicle will detect the arm movement and position in order to fire a web into the projected environment in front of them [22]. This method of shooting lets the riders feel more engrossed in

the story of having superpowers like Spider-Man, since the webs seem to be coming out of them, as opposed to the vehicle. Elsewhere in the theme park, there are also wearable web-shooter enhancements for sale that a person can put onto their wrist. If they wear them onto the ride and press the button on the shooter while aiming, they get to use the powers associated with the enhancement, such as firing multiple webs at once or electric webs. This customization is good at allowing the rider to build up their own character, as well as adding a more tangible element to the overall story that also exists outside the scope of just that ride's environment, such as how one could wear their web-shooters around the superhero-themed land that the ride resides in.

2.3.2 Expertise with Competitive Elements

While video games, another form of competitive storytelling entertainment, generally appeal to a certain demographic of people, theme park attractions need to be more accommodating to all types of people. As theme parks tend to be visited by family groups, young children and elderly people are likely to ride one of these competitive attractions, but may not be the type to be familiar with the video game mechanics that these attractions share similarities with. As such, these attractions need to make certain allowances so that everyone who rides can have an enjoyable experience, regardless of their ability levels. One method that is possible with the nature of a digital environment is by manipulating the projections to help out those who are struggling more. For instance, in *Toy Story Mania*, to help level the playing field, if a person is doing poorly at getting points, the game environment can change to that easier targets are on that person's side of the screen, while the targets that are more difficult to hit end up on the side of the person doing well [30]. Additionally, since the trajectories of the projectiles are all digital, there is a small "magnetizing" effect towards the targets, so that your aim does not have to be perfect for you to still hit a target.

Another important related element is how difficult it is to learn the rules of the competition. With a video game, if you do not know what you are doing at first and

end up losing, you can just restart the game until you get better. However, with a theme park attraction, there can be long wait times to board the ride, so if the rules are overly complicated, it would be frustrating to have to fumble through the ride experience trying to learn the technology, since you likely will not be able to retry right away. Therefore, the game needs to be simple enough to be understood in the first round, so that even if you are not great at first, there will still be satisfaction in getting a decent amount of success. The shooter games all previously described have minimal actions to do, such as aiming a weapon and pressing a button to fire a shot, so this will allow new riders to quickly pick up how to use their device. While the simplicity makes the game easy to learn for novices, it is still fun to try to improve your skills if you are an experienced player, making the game an enjoyable experience for all skill levels. As a comparison, while the latest installment in the *Mario Kart* video game series has over twenty items you can use against the enemy vehicles, the *Mario Kart* ride elects to only use one weapon, which is the shell projectile [1]. A rider is only given a brief amount of information before boarding a vehicle, to keep the line moving, so they would not be able to learn what every item from the video game does in a short time.

2.4 Interactive Characters

For a large entertainment company, like Disney, that has existed for many years and across many forms of media, one of the most powerful tools it has in terms of its branding and emotional connection with its audience is the assortment of characters they have created. Characters like Mickey Mouse are universally recognized and are an essential part of Disney's image. As such, being able to meet and interact with these characters is a useful tool for a more complete immersion into the world they are creating. Advancements in technologies within the past decade or so have allowed park guests to more convincingly interact with characters.

2.4.1 Costumed Characters

The most common and well-known way to meet a character in the theme parks is by an actor in a costume playing them. With Mickey Mouse, for example, for many years it was that an actor in a static fur suit would meet with the guests, but would have no way of communicating with them, aside from voiceless gestures. However, now park guests are able to directly talk with Mickey when meeting him, with an animatronic head capable of moving its mouth replacing the previously static costume head. A patent filed in 2012 gives insight into how this sort of technology works. Like before, a performer is inside of the character suit and is able to act out most of the movement and gestures of the character. But, now there is also a separate person in another room that acts as the controller of which pre-recorded audio is played [6]. By having the character's lines be pre-recorded by the actual voice actor, rather than an imitation, this contributes to the authenticity of meeting the "actual" character.

The specialized audio navigator software described in the patent allows for these interactions to be seamless and natural, rather than having a long pause before each response is chosen. This can be done due to the consistent structure of meeting a character, which will typically include a greeting, some form of play from the character, an autograph and/or picture, and then a goodbye. This software allows for well-organized buckets of dialogue that are easy to navigate through. Figures 2-2 and 2-3 show off example images from the patent filing, which demonstrate the organization of this character system, as well as some possibilities for what phrases would be in particular dialogue buckets [6].

While the park guest is not directly manipulating the technology, they still have a feeling of control over how the interaction will go. Even if most character greetings follow a similar structure, the guest can guide the flow of the meeting and the character will be able to respond. By having many possible dialogue phrases for the same purpose, the costumed character operators will be able to adapt more closely to the character of the guest, such as if they are more excited or shy, if it is their birthday, and how many people they are with.

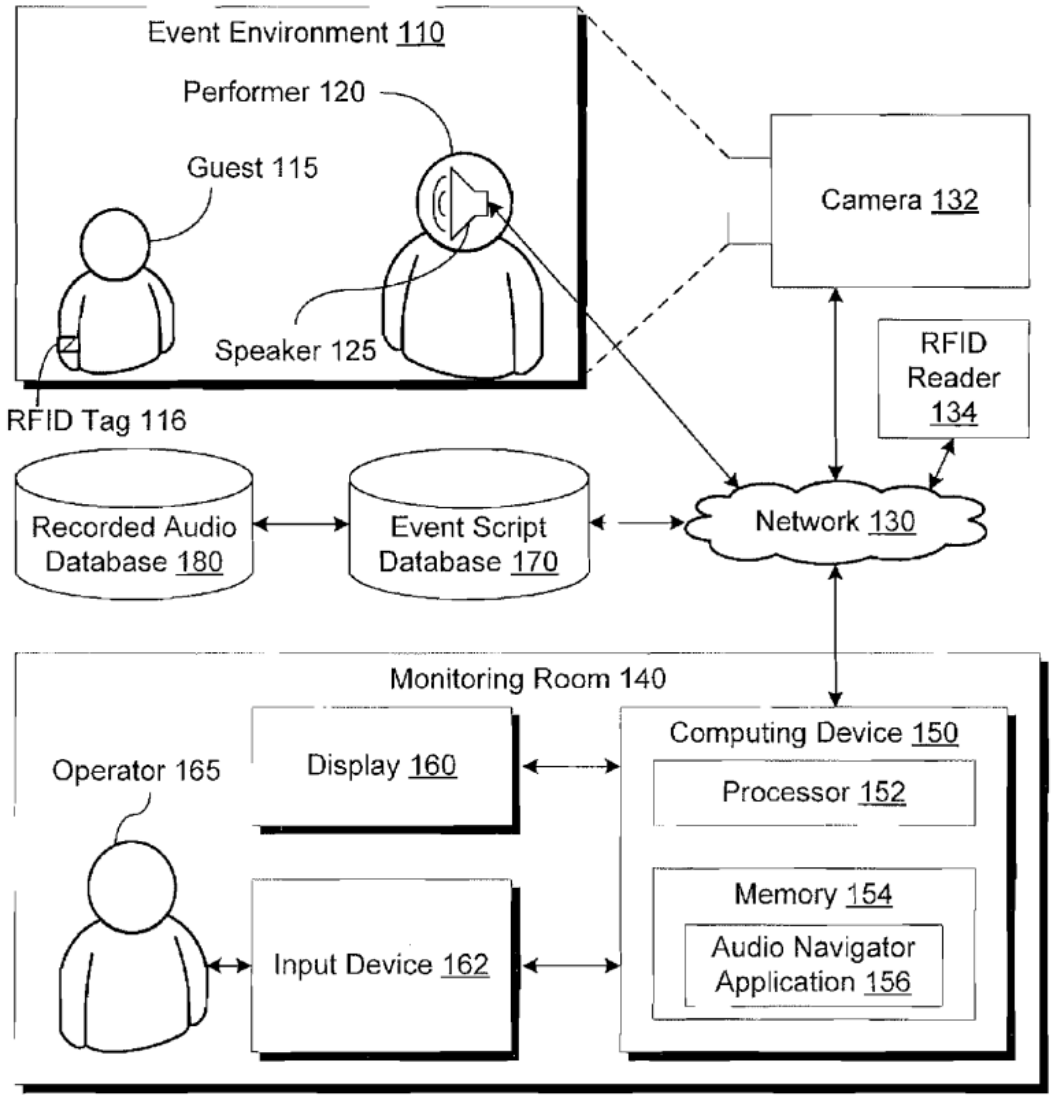

Figure 2-2: Audio Navigator Diagram

Line	Greet Bucket	
1	Hey Pal!	I'm glad you stopped by!
2	Hello there!	It sure is nice to meet ya!
3	Hiya!	Oh boy! Am I glad you stopped by!
4	Hi there!	I'm so excited to see you!
Beat	1	2

Table 385a

Line	Play Bucket
1	Are you having fun today?
2	So what brings you here today?
3	What do you think of my shirt?
Beat	1

Table 385b

Line	Autograph Bucket		
1	Oh, an autograph. I'd be happy to sign it.	(spells name)	There ya go.
2	I bet you'd like an autograph? You got it!	(hums)	Here ya go.
3	Oh, an autograph. I'd be happy to sign it.	(spells another name)	Just kidding. A-hyuck!
Beat	1	2	3

Table 385c

Line	Autograph+ Bucket		
1	Another autograph? Hmm... What should I write this time?	(spells name)	Here you go, pal.
2	One more? Sure!	(la-las)	Thanks, pal!
3	Hey, another one!	This is a great way to practice my penmanship!	There ya go.
Beat	1	2	3

Table 385d

Figure 2-3: Audio Navigator Buckets

2.4.2 Crowd Characters

The main issue that arises with the previous approach is related to capacity challenges. When a costumed character does a meet and greet, they will generally only interact with a small group at a time, like a family. This means that not many people get to experience the interactivity, since it is reserved for a more intimate encounter that follows the structure laid out before. One possible alternative to this is a character that can interact with a crowd in an area, rather than just one alone group in a room.

A great example of this comes in the queue area of the *Toy Story Mania* attraction. While a bunch of people are waiting in a section of the line, there is a large animatronic version of Mr. Potato Head at the front of the room, who is able to interact with specific people in the crowd. There is a live person in a control room with a video feed of everyone in the room, and a joystick to look through the crowd. The controller can then play the dialogue lines, with the associated animatronic character animations, based on what the people in the crowd look like [8]. While animatronic characters in most attractions only have about a minute of recorded dialogue, comedian Don Rickles, the voice of Mr. Potato Head in the *Toy Story* franchise, recorded around 20 minutes of dialogue to account for many different possibilities of what could be said [17]. The animatronic can call people out to talk to them, by referring to features like their age, gender, clothes they are wearing, or actions they are doing. He can have opening segments of dialogue like "Hey little girl", "You in the red shirt", or "This guy wants to take my picture!". This allows for a more personal touch to his interactions while still working with a larger crowd, with what he says being a direct result of what the composition of the audience is.

2.4.3 Digital Puppetry

There are some attractions in the parks that allow an audience to interact with characters rendered with computer-generated animation on a screen. Shows like *Turtle Talk with Crush* and *Monsters, Inc. Laugh Floor* allows their audiences to have conversations and play games with characters from the *Finding Nemo* and *Monsters, Inc.*

movie universe. In terms of the animation, the technology works in a similar way as the previous animatronic example. A behind-the-scenes operator has a control board with buttons corresponding to a large selection of pre-rendered animated movements [24]. However, instead of having pre-recorded lines, there is a voice actor who provides the lines for the digital character, with the rendered mouth moving in sync with the spoken lines. With the previous two character technologies, the guests are only with the character for a brief period of time, so using pre-recorded lines is more likely to be sufficient. But since this is a longer show dedicated towards talking with the characters, live voice actors are better to account for the more in-depth topics that could be had in the period of time.

Having personally experienced the *Monsters, Inc. Laugh Floor* attraction, I would say that many useful notes could be drawn from the show to apply it to an interactive theater experience. The show can hold hundreds of people during each performance, so it is a great example of how to deal with a large capacity audience. The show is similar to an improvisational comedy show, where skits are performed by the monster characters. In a typical improv comedy show, whenever audience participation is requested, some possible ways to go about it is to ask for suggestions from the audience, which they can call out ideas, or to have the actors go into the audience to bring up someone as a volunteer for a skit. Since the performers are really in a control booth rather than on stage, they can use cameras placed in the theater to look through the audience, similar to the animatronic controller. Whenever the performer wants to call on a particular someone, they can zoom the camera in onto the audience member, and project the camera feed onto another large screen adjacent to the character screen.

This simple technology-based way of selecting audience members to volunteer is a great way to easily facilitate interaction. Since there are multiple cameras that switch between different audience members quickly, it is very simple to put somebody up "on stage" with the performer, without having to have the audience member leave their seat. This lets the performers go through a much larger amount of people to interact with, as opposed to more traditional improv selection methods. Also, this ability to

suddenly choose a person to be on the screen allows for greater audience engagement. Of course, any person that is chosen to volunteer will be forced to pay attention to what is happening, but also since everyone in the audience knows they can be picked at any time, they are a bit more "on edge", so they will be more mentally involved with what is happening in front of them since they might have to become a part of it. This audience selection method is a great way to keep a large audience invested, without having to get input from every single person

2.5 Mobile Devices

2.5.1 Phones as a Tool

When looking for a technology to allow some audience members to interact with the world, it certainly makes sense to think about using phones to fulfill that role, since almost everybody has a smartphone on them. When dealing with a large capacity audience, it could be difficult to give each person a special piece of technology that would give them some control over the environment. But, if there is a way for the phone to emulate the goal of the technology, then larger groups could be supported.

As an example, in Disney's California Adventure Park, they have a nighttime spectacular show called *World of Color*, which involves many giant colorful fountains, projections, and pyrotechnics in a large lagoon in front of a ferris wheel. This show is the major attraction of the night, so it will always get a big audience around the lagoon. Before the show begins, audience members are invited to join a game by connecting to their local Wi-Fi network for that area, and logging onto their website. In this game, the ferris wheel is lit up in different colors in different sections, and the audience members must repeat the color pattern by pressing the colors on their phone, like a giant game of Simon [31]. Whoever has the fastest score among all the people in the audience gets to control the lights on the ferris wheel from their phone, for a limited amount of time, until the next game begins. This example shows a way that phones can be used to facilitate mass interaction with a show element.

2.5.2 Phones as a Distraction

The problem with encouraging your audience to use their phones for an interactive purpose is that going on their phone might tempt them to look at other things on the phone, like social media, effectively taking them out of the immersion of the world they are in. With the constant notifications and other stimuli that come from our phones nowadays, it is easy to get caught up in our screens for long periods of time. So, it may be desirable to keep people away from their phones as much as possible to limit this happening.

However, Disney seems to be leaning into the inevitability that people are going to look at their phones, particularly when waiting in a long line. Their solution is to give people an app to engage with on their phones that can keep them entertained while waiting in a long line, but still be looking at themed activities, which is called "Play Disney Parks" [20]. For example, while waiting in line for *Toy Story Mania*, the app will encourage you to play a variety of games themed to the *Toy Story* franchise. Or, while waiting in line for *Space Mountain*, the app will let you design a rocket ship, since the ride involves boarding a rocket ship.

Disney has used some strategies to not have people become too engrossed in their phones. Many of the games in the app, like the aforementioned *Toy Story* games, require at least two people to play, so this encourages social interaction within the line rather than just quietly staring at the screens. Also, the app can let you interact with elements inside the line area. For instance, as you near the end of the *Space Mountain* line, you will come across a screen where you can see the rockets you designed on the app race against the rockets of other people in the line, with the designs connecting to the screen by enabling the app to use Bluetooth for communication with the park [20]. While having themed elements to look at on the phone during a potentially uninteresting queue does help keep the audience engaged with the story, this could be further encouraging the park guests to look at their phones more often throughout the entire park, rather than having less reason to pull out the phone in the first place.

2.6 Physical Feedback

Most of the examples of the interactive technologies so far have been primarily digital in their feedback, as features like screens, projections, and audio are more easy to manipulate than something physical. However, allowing the audience to get some sort of physical response, as a more "real life" feedback to their input, would help with greater immersion into the story, since physical elements are generally more believable as something that is actually existing, due to its tangible nature.

2.6.1 Magic Wands

A great recent example of a theme park giving their audience a tool to physically interact with the story environment can be found in Universal Orlando's *Wizarding World of Harry Potter* themed area. Guests have the opportunity to buy a special magic wand, like those seen in the movie franchise, that allow them to cast spells at certain spots in the land, triggering a physical response. How this works is that when a person goes up to a designated spellcasting spot, such as a shop window, there are instructions on the ground for what the name of the spell to say is, and what movement to make with the wand to make the spell work. Each spot is equipped with an infrared light emitter, and each wand contains a small reflective tip, which reflects infrared light back to an infrared camera that sees the detected light. If the measured light movements match up with the saved gesture data for the spell at that location, a signal is sent to trigger the spell's effect [14]. Figure 2-4 shows an image from a patent which conveys the visual organization of the wand technology [7]. Some of the possible wand spells include repairing a broken suit of armor in a blacksmith shop window, triggering a fountain to spray water, and causing a feather quill to appear to levitate in a writing shop window.

While this tool is a great way to immerse guests into the *Harry Potter* world by giving them believable feedback to make them feel capable of magic, there are some limitations to its design. For one, the materials that are able to be used in the wands themselves are fairly limited, both due to not wanting to make the wands too

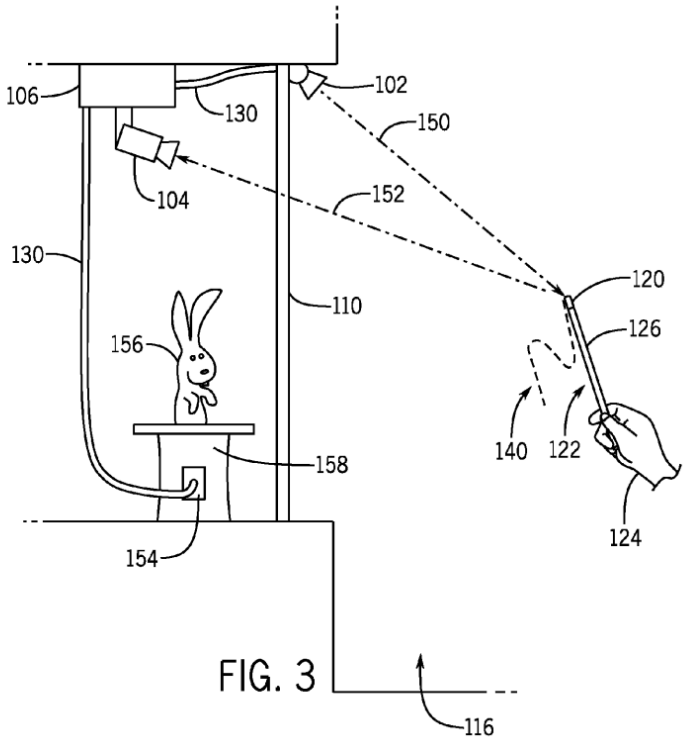

Figure 2-4: Wand Sensing Patent

expensive to purchase, and because there is only so much that can fit into the narrow stick shape of a wand. As such, it would be difficult to put electronics into the wand, and it is probably not desirable to have to charge or replace batteries to make the wand work. So, the approach to use an infrared reflector is both cheap and blends well into the wand design. But, it can be troublesome to get the sensors to recognize the spell gesture as a result of the more simple technology, as opposed to another method like having the wand itself emit the infrared light instead of reflecting.

This limitation making it more difficult to have your spells recognized means that, in many cases, people may have to keep repeating the spell movement a few times before it works. This can be a bit frustrating and take people out of the immersion of the world. Furthermore, while the ability to cast spells would be popular among park guests to try out, there are less than twenty spell spots in a land [14]. If there are a lot of people that want to try the spells, and it takes a while for just one person to get the gesture recognized at a location, this hampers the efficiency of the activity,

causing lines to form for each spot. This also takes away from the immersion of the experience, and since the spell is the same each time, you will be able to see what happens when you cast the spell because of the person in front of you in line, hurting the surprise element of what happens when you do it yourself. One possible solution is that since it is such a low capacity experience, the action of making the spell should be as simple as possible to get people through quicker. Recognizing a gesture is too difficult, so perhaps just detecting that a wand is making some sort of gesture in front of the sensor, along with the person saying the spell name, would be a simpler way to trigger the effects.

2.6.2 Wearable Tools

As mentioned before, Disney has made use of their wearable MagicBands to let their guests use the RFID chips inside the bands to communicate with touch points within the park, which helps with tasks like entering the park or paying for an item. Since the park is able to keep track of guest information within the band, this has allowed for Disney to create story experiences where the person's data with respect to the story can be saved. For instance, Disney has an experience similar to a scavenger hunt, themed to the *Pirates of the Caribbean* franchise, where the participants must search around a section of the park for certain things to interact with. Once an item is found, guests can scan their MagicBand at a certain point near the item, which will trigger a thematic physical effect related to the story [28]. This can include having a cannon fire smoke and appear to hit a bell opposite it, making ships in a bottle move and fire at each other, and having a treasure chest open. The guest's place in the story is tracked in the MagicBand, so that they are only able to interact with an object when they are supposed to.

In Universal Studios Japan, they also have a similar wearable band technology in order to let their guests interact with objects in their land themed after the *Super Mario* video game series. However, their band also integrates with a phone app so you can keep track of certain progress you have made in the land [25]. There are a number of digital prizes and achievements you can earn from interacting with the

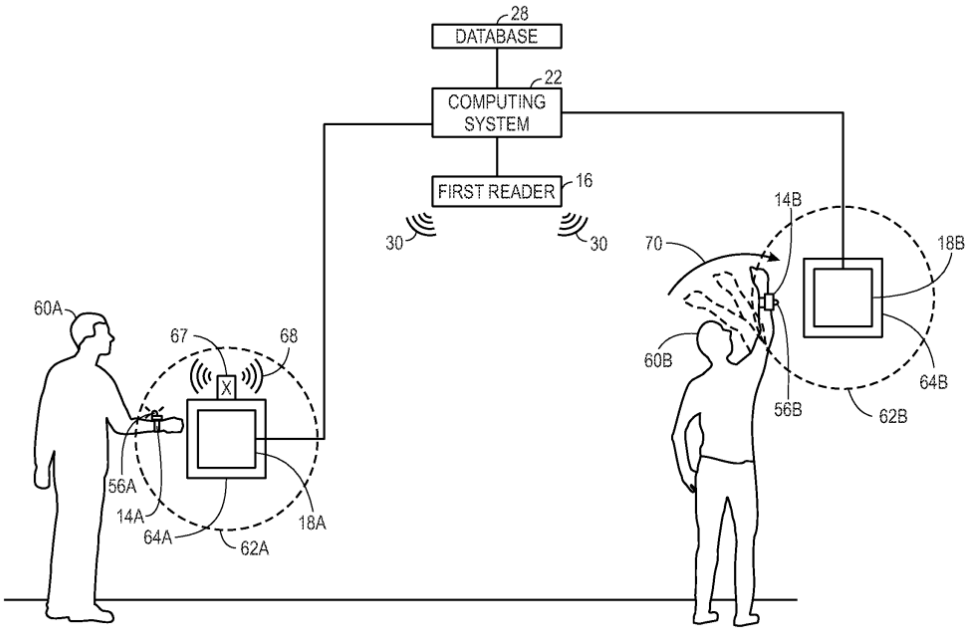

Figure 2-5: Nintendo Wearable Band Patent

land, which will show up through the app. For instance, a common way to gain an item, such as a coin, in the original video games is to punch certain blocks. There are item blocks to be found throughout the land, and if a guest punches it while wearing their band, the RFID chip will be able to communicate with the block, giving them the item within the block through the app. Figure 2-5 shows a diagram from the patent on their band technology, which shows a visual of the interaction with the item blocks [9]. Both Disney and Universal's wearable bands provide a great way to make the physical environment of the theme park a part of the story, allowing for a more immersive world that goes beyond what is inside the rides and shows.

Chapter 3

Proposal for Interactive Theater Events

3.1 Overview

I will now go over my idea for how to incorporate more interactivity from the audience within a theater production. My goal is to have the audience be able to interact with the story on stage in front of them, without having them need to leave their seating area. To accomplish this, I propose a style of production that incorporates interactive story events sporadically throughout it. Similar to the examples of past interactive theater shows in my introduction, there will be times within the show where the audience will be called upon to engage with the performance. Each event could include a single audience member, multiple audience members, or the entire audience. Then, based on their actions, this will affect the course of the story after the event is over. The past theater productions that attempted this only had one style of event, which was a simple collective audience vote. However, with my proposed implementation, there will be a wider variety of more interesting ways that the audience can interact with the story, with inspiration taken from the methods of interactivity used in the theme parks.

3.1.1 Challenges

There are a few issues that could arise with this approach. For one, developing a production like this would be a lot more work than a traditional theater show. Both due to the fact that a lot more technical work would need to be done to program the show and install any hardware needed into the theater, and that if there are many branching paths as a result of the event outcomes, this will be a larger undertaking than usual for the actors. However, I believe that the greater effort into making the show will ultimately result in a more interesting and engaging piece, so it would be worth it. As far as the actors, if the script for each branching path is not completely fixed in place, this could allow for less strain on the actors. This would essentially mean incorporating more improvisational bits into the work, but since some of the inspiration for this idea is based on improv comedy acts, like with the *Monsters, Inc. Laugh Floor* example, there is evidence that this will work well for this style of production.

Another challenge could be that there are people in the audience who would not want to be chosen, so if they were picked, they may be uncomfortable or choose not to participate. One solution to this could be reserving a section of seats for people who want to see the production, but not participate in it. On the opposite end, it could be that since the audience will be fairly large, it may not be possible for every audience member to have their own interaction with the story. This can me mitigated by having events where the entire audience must participate, so that every audience member will have something to do at points in the show, even if they do not have a more personal event that gives them greater control over the story.

3.2 Tools from Theme Park Attraction Analysis

In this section, I will go through some of the inspiration for what methods could be used to make this production a reality, based on the tools that theme parks have employed over the years to achieve audience interactivity.

3.2.1 Interactive Character Shows

Firstly, the use of interactive characters performing for an audience has shown how we can have a theater with a sizeable capacity engage with a central story. In particular, the *Monsters, Inc. Laugh Floor* has tools that will be useful for my purposes. The attraction has the ability to choose people quickly by pointing a camera on them and putting them on a screen, as discussed before, as well as using multiple cameras and fast switching to put multiple people on the screen for a skit. This idea of selecting audience members, and having a separate screen to show the image of them, can be used for the interactive theater events as well.

For each event in the story, operators will be able to choose audience members to perform the action required of them. They will easily know they have been chosen since the feed of them will be projected for the entire audience to see what they are doing. The instructions for what they need to do for the interaction can be placed on the screen as well, so that the actors on stage do not have to tell the instructions. This method allows for a quick and easy way to find people to interact with, as well as lets the rest of the audience be engaged with the interaction by getting to watch what happens, even if they can not participate themselves for that event.

3.2.2 Collaboration and Competition

In my effort to develop a more diverse set of events, looking at how theme parks have incorporated collaborative and competitive interactions into their stories is useful. These kinds of activities would encourage a more social aspect to the production, which makes it more engaging than each person just dealing with their own inputs. The ability to select a subsection of the audience via the camera choosing will help with the competition aspect, as audience members can be pitted against each other to fight over an element of the story. Also, being able to select multiple audience members, or involving the entire audience, will allow for collaborative events to occur, as they can collectively work together towards a story goal. I will go over the technologies I used to enable some forms of competition and collaboration in the later

section on my example implementation.

Also, a lesson learned from the analysis on collaborative attractions is that "fake interactivity" can still be useful to engage the audience. In the theme park examples, whether you did a certain action well, or at all, sometimes did not have any bearing on the plot. Similarly, it could be so that in the theater production, some of the different inputs from the audience could lead to the same outcome. Since the audience will likely not know every possible outcome of a given event, they will still feel like their input more specifically changes what happens, even if the set of possible options is not that big. This approach will help reduce the amount of work that would need to be done to design every branching path.

Another principle that was discussed with regard to the competitive attractions is that the actions the audience needs to perform must be simple enough to understand quickly. In the proposed theater implementation, the audience members will be given instructions on what to do when they get chosen for a story event. In order to keep the show flowing smoothly, the audience members need to be able to pick up what they need to do quickly. This will ensure that the rest of the audience does not get bored waiting for them, and that the audience members chosen do not get frustrated or overwhelmed trying to figure out what they have to do.

3.2.3 Personalization and Phones

Next, we can look at how an audience member can add their own personal touch to the story unfolding. While this idea has been done before in the older interactive theater productions, it would still be worthwhile to incorporate some form of audience voting into the production, as it is a way for an audience member to concretely give their input to the story. Collective audience votes can be obtained through a digital interface with buttons for each option to choose from. One difference with my proposed approach is that we can also include single audience member choices as well, since we can easily select a person with out camera method. This allows an audience member to have a more personal stake in the story since they alone decide an outcome, as opposed to making a decision that gets lost in the groupthink. Since

the audience member is projected for all to see, the rest of the audience can still feel engaged in the stakes of the situation. Microphones can be placed throughout the audience as well, to allow the chosen audience member to verbalize their thoughts as they make a decision.

Another approach to gather personalized audience data comes from the theme park attractions that gather information on what the guest likes or wants before the attraction takes place, such as those discussed in the earlier section on personalized ride experiences. One idea would be to have the audience take a questionnaire before the show to collect information on what this audience is like. This can be carried out by having the audience login to a website while they are waiting for to show to begin. This information can then be processed to determine what audience interests are, which can guide which audience members get certain types of story events or the choices that an audience member could get.

On the subject of using phones as a tool for inputs, my decision would be to not have phones be used at all during the actual production, in order to limit the possibility of distractions both for an audience member and the people around a potential phone user. Using the phone to carry out the questionnaire is a good idea since it would take place before the show, so distractions at this point would not matter. However, for any other digital interfaces that would be needed, such as the buttons to make choices, this would be done with a separate screen available to the audience member in their seating area. Even though that kind of function could easily be done by having the audience sign into a website or app on their phone, it is probably a good idea to have all phones away throughout the course of the show.

3.2.4 Physical Elements

As discussed before, the physical part of theme parks is a particularly powerful tool in making the story feel tangible to the audience. So, I believe it would be useful to incorporate a decent amount of physical elements to the interactive events to help keep the audience invested. For one, in addition to any digital interfaces or sensors that the audience could interact with, some members of the audience could have

physical tools they could use to control something. These could include items such as the wands, shooting weapons, or physical input devices, such as a small keyboard that uses MIDI or controls like tactile buttons, switches, and dials. It is likely not feasible to fit all of these technologies into a single audience member's space, so the variety could be spread throughout the audience to give people different options based on where they sit.

Another technique that could be used is some form of physical response to audience actions. The easy way this will be done is by having the live actors respond to the outcomes of the story made by the interactions. This live element will be effective in making the story feel real, as opposed to just having the audience engage with a screen like in a video game. A more ambitious approach that could be done is to have other forms of feedback both on stage and in the audience. This could be by having certain changes occur on stage, such as making items move or altering the lighting effects. Additionally, it is possible to have the feedback affect the audience, in a way similar to how 4D effects are triggered in *Toy Story Mania* when certain targets are hit. This can include sensations like wind being blown, mists of water spraying, and scents being pumped into the audience if an interaction leads to an outcome that could warrant those effects.

3.3 Example Implementation

To get a feeling of how well my proposed idea would work, I implemented some story events that could occur within an interactive performance. There are limitations in what I can do for reasons such as being limited to the types of technologies I have available, not having the space or amount of technology to carry out experiments with a large audience, and the fact that I am only one person, while a real production would be designed by a team of many people. However, my smaller-scale tests, using the resources I have available and a few volunteers to serve as an audience subset, allow me to gauge how well this concept works if it were to be scaled up.

3.3.1 Tools Used

To make my implementation, I used a software called Isadora, which is used to manipulate live media. This software has many packages that allowed me to collect data from a variety of input devices, which I could use to affect the projections on stage. The types of tools I used included video cameras, microphones, a Kinect body tracking motion sensor, a Leap hand tracking motion sensor, a digital interface with buttons, as well as an infrared camera to track a modified wand with an infrared LED I made. I will now go over how I used these tools to give my audience members control over interactive events.

My goal was to incorporate a variety of different topics concluded from the theme park analysis. The video cameras were able to capture the view of the audience to project them onto the screen when needed, and a microphone was placed in the audience in case any audio responses were needed to be heard from them. I developed interactive events for both single audience members and multiple audience members. For example, I created a story where an artist needed to paint his next work. When he sat down to create his art, this triggered an interactive event where an audience member was called on to create his drawing. This was done by instructing the audience member to draw in the air in front of them, which would make their hand move over the Leap sensor. The hand data was sent to Isadora which enabled digital ink to be drawn where they were pointing. The art being made in real-time was projected onto the stage so everyone could see the result. For fun, I also made it so that in order for the ink to be triggered at a given position, the audience member had to scream, as it was controlled by the volume levels coming in from their microphone. This made it so that something was not constantly being drawn as the audience member moved their finger to a different position.

I also created both collaborative and competitive events for multiple audience members. For an instance of a collaborative, I had one part in the story where the actor loses all his papers in the wind as he is on his way to show them to his boss. Two audience members are then called upon for an interactive event. One audience

member gets to stand up and wave their arms to control the flow of the wind as the papers fall back down, with the motion data being collected by the Kinect to visualize the position of the papers in the wind. The second audience member uses their hand to control the position of a digital basket moving around at the bottom of the screen, trying to catch the papers, with the data being collected by the Leap sensor.

A competitive event I created had two audience members chosen to try to hit the most targets in a period of time, with this being determined by their movements in front of the Kinect sensor. Based on who won the event, the winner gets to make the next choice in the story. This leads into the next technology I used, which were the digital interfaces. I used the interface to show a variety of buttons that would correspond to choices throughout the story, with Open Sound Control being used to communicate the inputs wirelessly from the device to Isadora. These choices allowed for simple decisions in the story, such as what clothes the character should wear, as well as more significant plot points, such as if the character gets a happier or sadder ending. Visual and/or audio feedback occurs on stage in response to the choice made, so that the actor knows what was picked.

Lastly, I made an attempt to develop a physical tool for an audience member to use. I created a wand prop with an infrared LED at the tip, which was powered by a battery near the base and wires weaved through the shaft, so the wand still looked mostly normal. Since the audience members were not keeping this wand, I felt it was fine to go with a more electronic approach, compared to the theme park wands. The infrared light on the wand will help the camera track the wand better, and since the battery could be recharged or replaced between productions, there is less worry for having to have the user deal with powering the wand. An infrared camera sees the wand tip as a bright white circle, which I was able to track in Isadora to make effects come out of where it was pointing on a screen, such as making fire or water appear.

3.3.2 Audience Feedback

At the end of my test performances, which I carried out by acting in front of a projector and having the audience use the technologies from a seating area, I asked

the audience members I used for feedback. Overall, the users found the idea to be very enjoyable, which is the main goal out of all of this, since the production is primarily an entertainment experience. Notably, the audience members were greatly entertained not only when they were interacting with the story event, but also when they were watching the other audience members work through an event. This is good to know due to the likely limitation where not every audience member will be able to have an interesting, personal interaction.

One issue that occurred was some misunderstandings of what to do based on the instructions given. As mentioned before, to keep the show flowing, the audience is given simple and brief instructions of what to do. However, this means that it is harder to have a more interesting event since there would need to be more instructions taken in at once. It is a bit tricky to find the right balance between ease-of-use and interesting behavior. Although, for most of the events, the audience members were able to figure out what to do, even if they had to play around with it for a little bit. For any future work in this, it is certainly important to keep in mind how easy the explanation of what to do would be when designing an event.

Another issue that arose was calibrating the technologies to account for different spots within the audience space. For example, in order to use the Kinect sensor, I had to convert the data from the Kinect's coordinate system into the projection's coordinates. However, the calculations to do this would change based on where the audience member is standing, such as how far to the left or right they stand in front of the sensor. A solution to combat this in a future work would be to have the system be set to automatically recalibrate the calculations needed for the conversion every time an audience member is called upon for an event using the sensor.

Chapter 4

Conclusion

Overall, I believe that my analysis into the world of interactive theme park technologies, to control a story environment, has provided useful and novel insight into how to enhance an entertainment experience through audience control. The proposed application for a theater performance seems like a reasonable way to implement engaging audience interactions into a live story told on stage, which there has been limited work done on in the past. While I specifically targeted my proposal for new work to be within a live theater event, the analysis of theme park interactive technologies could also be extended to think about how interaction can affect any form of entertainment experience. As a potential future work, it would be interesting to see my proposed method of an interactive theater event be implemented at a full scale, with a fleshed out story and large audience, as I was too limited in resources to do this myself.

Bibliography

[1] An assortment of items to turn the tables! Nintendo. Available: https://www.nintendo.com/ph/switch/aabp/item/index.html.

[2] The boomerang kid. TheaterMania. Available: https://www.theatermania.com/shows/los-angeles-theater/the-boomerang-kid_133258.

[3] Newsbreaker live. Communication Arts. Available: https://www.commarts.com/project/22702/newsbreaker-live.

[4] The night of january 16th. The Glasgow Harold, October 1936.

[5] It all adds up! raytheon's sum of all thrills experience opens today. Raytheon, October 2009. Available: https://raytheon.mediaroom.com/index.php?s=43item=1415.

[6] Simulated conversation by pre-recorded audio navigator. US Patent 20130226588, August 2013.

[7] System and method for tracking a passive wand and actuating an effect based on a detected wand path. US Patent 20140240102, August 2014.

[8] A carousel of progress. The Imagineering Story, December 2019.

[9] Interactive systems and methods with tracking devices. US Patent 20190332834, October 2019.

[10] Reputation readers added to star wars: galaxy's edge. BlogMickey, July 2019. Available: https://blogmickey.com/2019/07/reputation-readers-added-to-star-wars-galaxys-edge/.

[11] Ride system : Motion base on a turntable/segmented turntable. US Patent 010427059, October 2019.

[12] To infinity and beyond. The Imagineering Story, December 2019.

[13] Complete guide to hollywood rip ride rockit at universal studios florida. DiscoverUniversal, June 2021. Available: https://blog.discoveruniversal.com/things-to-do/complete-guide-to-hollywood-rip-ride-rockit-at-universal-studios-florida/.

[14] Interactive wizarding wands spell-casting in the wizarding world – complete guide. Orlando Informer, December 2021. Available: https://orlandoinformer.com/universal/interactive-wands/.

[15] Millennium falcon: Smuggler's run in star wars: Galaxy's edge at disney world's hollywood studios. Orlando Informer, August 2021. Available: https://orlandoinformer.com/disney/millennium-falcon-smugglers-run/.

[16] Leslie Bennetts. In 'drood,' the cast gives clues and the audiences give cues. The New York Times, January 1986. Available: https://www.nytimes.com/1986/01/05/arts/in-drood-the-cast-gives-clues-and-the-audiences-give-cues.html.

[17] DisneyParkVideos. Toy story mania and mr. potato head. Youtube, March 2009. Available: https://youtu.be/7dY4lC0AlNM?list=LL.

[18] Mark Feldmeier and Joseph A. Paradiso. An interactive music environment for large groups with giveaway wireless motion sensors. *Computer Music Journal*, 31(1):50–67, March 2007.

[19] Amy Jupiter, Dave Fisher, and Sara Thacher. Experiential storytelling with walt disney imagineering. MLTalks, October 2018.

[20] Arthur Levine. Play disney parks app relieves boredom in line. USA Today, September 2018. Available: https://www.usatoday.com/story/travel/experience/america/theme-parks/2018/09/07/play-disney-parks-app-line-waiting-boredom/1214012002/.

[21] Bill Lydon. Siemens contributes to toy story attraction's magic. Automation.com, September 2011. Available: https://www.automation.com/en-us/articles/2011-2/siemens-contributes-to-toy-story-attractions-magic.

[22] Brady Macdonald. Disney's avengers campus will sell 'web tech' to improve gameplay on new spider-man ride. The Mercury News, May 2021. Available: https://www.mercurynews.com/2021/05/20/disneys-avengers-campus-will-sell-web-tech-to-improve-gameplay-on-new-spider-man-ride/.

[23] David Mumpower. Behind the ride: Buzz lightyear space ranger spin. Theme Park Tourist, May 2018. Available: https://www.themeparktourist.com/features/20180526/33892/behind-ride-buzz-lightyear-space-ranger-spin.

[24] Seth Porges. The tech behind four new wonders at disney world. Popular Mechanics, February 2010. Available: https://www.popularmechanics.com/adventure/a5344/4346536/.

[25] Alicia Stella. The tech behind super nintendo world's power up bands and interactive games. Orlando ParkStop, February 2020. Available:

https://orlandoparkstop.com/news/theme-park-news/the-tech-behind-super-nintendo-worlds-power-up-bands-and-interactive-games/.

[26] Alicia Stella. How the mario kart ride works at super nintendo world. Orlando ParkStop, February 2021. Available: https://orlandoparkstop.com/news/theme-park-news/how-the-mario-kart-ride-works-at-super-nintendo-world/.

[27] Joshua Andrew Strickon. *Smoke and Mirrors to Modem Computers: Rethinking the Design and Implementation of Interactive, Location-Based Entertainment Experiences*. PhD thesis, Massachusetts Institute of Technology, 2003.

[28] Christian Sylt. Inside disney's internet of things. Forbes, June 2020. Available: https://www.forbes.com/sites/csylt/2020/06/06/inside-disneys-internet-of-things/?sh=133980577545.

[29] Martin Tomitsch, Wolfgang Aigner, and Thomas Grechenig. A concept to support seamless spectator participation in sports events based on wearable motion sensors. *2007 2nd International Conference on Pervasive Computing and Applications*, pages 209–214, 2007.

[30] Alex Wright. The imagineering field guide to disney's hollywood studios. Disney Editions, 2010.

[31] David Younger. Theme park design: The art of themed entertainment. Inklingwood Press, 2018.