ABSTRACT

Physical therapy is difficult and expensive to administer. It requires interaction with trained medical professionals and, for most people, it is only feasible to have a couple of hours of therapy per day. Doctors also collect very little data around the therapy they conduct, which has left the medical community with a large knowledge gap. This document proposes a therapeutic tablet application called Gesture Gym that is used as a form of physical therapy. It presents visual cues for the patient to respond to, and the process of responding to these cues improves the patient’s physical abilities. The application collects data about the patient’s responses, allowing Gesture Gym to analyze patient performance. The difficulty level adapts to the patient’s response to recent visual cues in order to further facilitate improvement.

1. INTRODUCTION

Stroke survivors are often forced to spend the rest of their lives suffering from significant motor disabilities. One of the most common and devastating forms of these disabilities is medically referred to as hemiparesis [7]. Hemiparesis is impairment in movement production. Treatment of such disabilities usually involves physical therapy, which is costly and labor-intensive. This is true for both chronic and acute stroke patients, many of whom often fail to receive any treatment because of limited insurance coverage, or for whom rehabilitative therapies are delayed until the diagnostic evaluation has been completed. As a result, these patients often do not receive the care they need, and are stuck in a state of incomplete recovery.

An emerging alternative form of rehab is the use of computer tablet technology in the form of therapeutic applications to aid in the administration of physical therapy. Tablets have emerged as an effective medium for delivering personal, easy-to-use self rehabilitation; modern tablets are sleek, light, and intuitive. Therapeutic applications simulate the steps of physical rehab within the setting of a touchscreen based application. Such an application could present the patient with visual cues and ask her to interact with some part of the screen based on these cues. The goal is to make the patient effectively replicate the process of therapy by themselves without needing the attention of a therapist. By fostering independence, patients have the opportunity to practice at their own pace, making the therapy last longer and be more meaningful. If effective, the development and use of therapeutic applications would greatly improve access to rehab for patients from all kinds of financial backgrounds.

Therapeutic applications are an emerging field at the cross section of health care and computer science. To date, there is no standard or state of the art example; much of the current literature and research is forthcoming and ongoing. Our application, Gesture Gym, is heavily inspired by the previous work of neurology professor John Detre. His project was an application based on the popular game Fruit Ninja [7], and attempted to use Fruit Ninja’s gameplay elements in the context of a therapeutic application. The developers of the application called it Sushi Samurai. Since this project was a preliminary investigation into the topic of therapeutic applications, it did not make it to a stage where it was presentable to patients. However, Sushi Samurai served as an excellent proof-of-concept for future applications in a similar mold.

Gesture Gym is the next step in the research on therapeutic applications in the form of video games. Drawing from many ideas in Dr. Detre’s project, Gesture Gym advances therapeutic applications by incorporating a significant data collection component. The data collection will be primarily used for:

1. An adaptive difficulty algorithm which uses patient data to customize the difficulty to each patient.
2. Tracking a patient’s progress throughout rehabilitation and making that information easily accessible to his doctor.

The goal of Gesture Gym is to serve as the next step in the research on applications that can help patients with impaired motor capability.

2. RELATED WORK

This section explores related work in the intersection of technology and health care. It begins by exploring the concept of using video games as a therapy tool. This section then delves into the psychology of the patient, which informs our development of the game with a specific audience in mind.

2.1 Video Games as Therapy

Traditional and conventional rehabilitation and physical therapy is regarded as both time consuming, monotonous and inconvenient. Physical therapy also has numerous inadequacies – inadequate facilities, staff, treatment, outpatient services and inadequate funding [9]. In order to make the process more entertaining and self-empowering for the patient, researchers have turned to the appealing and engaging
environment of video games. For example, physical education and health education games have been successful in capturing the player’s interest while also seeing the player learn and improve [11]. Furthermore, video games can be programmed in a way that allows for individualized feedback and adaptive gameplay, creating additional personalized therapy; making mundane and mindless tasks seem fun and challenging greatly engages the patient and encourages their participation.

It is not a foreign idea to use video games as a form of therapy. There was recognition and research into video game therapy as early as 1991; medical professional William R. Phillips used the original Nintendo Game Boy portable gaming device as a therapeutic tool [12]. In Phillips’ trial, the video game stimulation managed to positively alter the patient’s behavior, though his patient was an adolescent and developing brains are more responsive to stimulation and changes. Furthermore, there is recognition by numerous neurological experts of the potential benefits of video game stimulation on cognitive function and overall brain behavior [5]. However, this comes with the caveat that the improvement generally occurs only when video games were played in moderation. Spending too much time playing video games and subjecting the brain to excessive stimulation has been shown to have detrimental effects on the brain [5].

### 2.2 Sushi Samurai: An Attempt

The primary inspiration for this proposed concept is based on a group project from a course taught by Professor Chris Murphy. The original idea was a proposal by Dr. John Detre from the University of Pennsylvania’s Department of Neurology. Dr. Detre wanted to make tablet-based therapeutic application. His idea is based on the popular mobile game Fruit Ninja [13]. What Dr. Detre envisioned is a substantially modified version of that game, made to be playable and hopefully rehabilitative for stroke patients. Dr. Detre’s personal research emphasizes three aspects to pursue [7] in a therapeutic application:

1. Neurological improvement in patient
2. Engaging and impactful gameplay
3. Data collection and analysis by medical professional

Dr. Detre’s idea manifests itself into a tablet game called Sushi Samurai [3]. Christopher Chow, one of the project members, worked on Sushi Samurai with Dr. Detre. This game ultimately did not reach the stage where it could be deployed and used by actual patients and medical professionals; some of the original design and engineering choices, particularly the data storage together with the game model, were not scalable nor modular. Sushi Samurai was merely a proof-of-concept. Gesture Gym harvests concepts from this prototype and uses them to develop a more mature and professional therapeutic application.

The essence of Sushi Samurai and Dr. Detre’s research is not novel, as there is preexisting research investigating the development of an interactive game-based rehabilitation tool. Researchers at the University of Alberta are using multi-touch tabletop for upper extremity motor rehabilitation [4]. Less similar preexisting research is utilizing the Wii Fit Balance Board as a game-based tool to complement rehabilitation for stroke patients, particularly those suffering impairments in postural control [8].

Michelle Annett [4] and Belinda Lange’s [8] work is being heavily examined as it is conceptually similar to both Dr. Detre’s proposal and the general direction of Gesture Gym. Overall, video-games provide new opportunities for improving patient’s quality-of-life via empowerment through physical exercise and interactive feedback [6].

Therapeutic applications, based on all of this related work, should be able to rehabilitate the patient’s motor skills and also be appealing and entertaining for the patient to play. Furthermore, there should be an interface between the patient and medical professional, to allow the professional to gather information from patient gameplay.

### 2.3 Psychology of Physical Therapy

The success of physical therapy is greatly dependent on the psychology of the patient. Carolee Winstein, a professor of biokinesiology and physical therapy, stresses the psychology of self-empowerment and self-determination. Self-determination theory plays a significant role in designing and structuring rehabilitation, specifically the three motivational influences on behavior change: autonomy, competence, and social relatedness [15]. Autonomy is the need to determine or feel in control of one’s own actions, to be proactive. Competence is the need to perceive oneself as capable or competent. Responsive feedback fosters motivation and engagement. Social relatedness is the need to feel included, accepted, or connected to others, to feel satisfaction in one’s involvement with the social world.

Based on these three influences, Winstein states that rehabilitation practices must meet the following specifications:

1. Focused on a specific skill or task
2. Adjustable difficulty levels
3. Quantifiable in order to assess progress
4. Administered repetitively
5. Provides user feedback about success
6. Relevance to real world function
7. Motivates and engages the user

Gesture Gym incorporates these crucial concepts as a part of its core design.
The result of this research has led us to develop a therapeutic application titled Gesture Gym. The application features a game which involves the presentation of visual cues to which the user must respond by tapping the appropriate part of the screen. The target audience of players includes stroke patients and people with impaired hand and/or arm movement, and the goal of the application is to complement physical therapy. To facilitate this, the application tracks each patient’s performance and adjusts the difficulty of the game accordingly. Additionally, this application serves as a line of communication between medical professional and patient, as the application has an interface through which the doctor can view the patient’s relevant gameplay data.

The block diagram in Figure 2 below shows the high-level design of Gesture Gym, and is provided for reference throughout this section.

There are two primary ways to interact with Gesture Gym: from the patient’s perspective, and from the doctor’s perspective. A patient interacting with Gesture Gym will be primarily playing a game. The underlying high-level layout of Gesture Gym’s game portion is presented in Figure 3 for reference. The game spans three minutes, during which the user is presented with sequences of colored circles which cue the patient to respond with tapping motions. The cues appear in varying areas of the screen, with varying speeds. Since the goal of Gesture Gym is that the user may ultimately translate their progress into real-world activity, the motions we select attempt to emulate activities a person may perform with their arm and hand. Gesture Gym includes a single-touch mode, which presents the patient with one visual cue at a time. In this mode, the patient will likely choose to use their dominant hand to attempt to hit all cues, perhaps employing their non-dominant hand if their original method was not fast enough. This preference for the dominant hand was confirmed by observation of users of Gesture Gym. In order to counteract this preference, the game also includes a multi-touch mode which presents the patient with two spaced-out visual cues at any time, which the patient must hit simultaneously. This encourages the patient to use both hands at once.

The game also features adaptive difficulty based on each patient’s individual progress. As the patient is playing Gesture Gym, data about their performance is constantly being collected and stored. This data allows the game to calculate the next set of cues to show the patient. The game raises the difficulty level – i.e. the speed at which cues go by – in areas of the screen where the patient is successful, and lowers it where they are not, allowing them to constantly improve. The System Implementation section will discuss in more detail both what data the application collects and how the application decides what cues to present the patient with. The goal of the adaptive difficulty feature of the application is to tailor Gesture Gym to each individual patient, just as an in-person physical therapy session would. The option of a difficulty level is often left in a gamer’s hands, but in Gesture Gym, the user’s motor skills make that decision via the past performance that they have shown. This becomes apparent in the System Implementation section. The difficulty is also more granular, not just a global easy/medium/hard, but varying in multiple dimensions – both area of screen and speed. Ideally, the next set of cues that Gesture Gym presents a patient with will be the set that makes them improve their motor skills the fastest.

Gesture Gym also includes elements of gamification. The more enjoyable and engaging Gesture Gym is, the more effective it is in improving patients’ motor skills, as cited in the Related Work section. There is already motivation for patients to use the application, in that it is a form of rehabilitation for them, but this can be enhanced by making the game motivate the patient on its own [10]. The game includes a system in which the user is awarded points for responding to cues, and a timer lasting three minutes which indicates when the game ends. There is a system for logging each patient’s list of high scores so they have a sense of their
Gesture Gym is implemented using an open-source library called libGDX \cite{1}. libGDX is a full-featured, well-documented Java library which allowed us to develop Gesture Gym in Java and then run our code on a variety of platforms, including the Windows and Android environments, which are the environments for which large surface-area touch-screen devices are most readily available. Creating more surface area is necessary in order to include the widest possible variety of arm and hand motions in the game. All user data is stored locally on the machine, in simple text files. Traversal of a file system directory hierarchy is a sufficient level of complexity for the functionality that we implemented; no complex database queries were necessary. We explored storing the data in a cloud database, off of the tablet, in order to allow database queries were necessary. We explored storing the data in a cloud database, of off of the tablet, in order to allow remote access to the data via a web interface, but doctors expressed concerns about the privacy of personally identifiable patient data, which further enforced the idea that data should be kept locally.

As discussed earlier, a round of Gesture Gym is a three-minute window consisting of multiple gameplay segments. Each gameplay segment is a sequence of visual cues. The patient responds to each of these cues via touching the tablet screen. To formalize successful responses to cues, in the single-touch game, a cue is successfully hit if a touch is recorded within the area of the cue before its time limit expires. In the multi-touch game, a pair of cues is successfully hit if simultaneous touches are recorded within the area of both cues before their time limit expires. Players are awarded points for their successful responses to cues. A sequence of visual cues is parameterized by a number of different variables:

- The set of zones or zone-pairs of the screen in which cues will appear. See Figure 4. Each grid cell represents a zone of the screen. In a multi-touch game, zones will be paired so that at any given time, visual cues appear in both zones of a selected zone pairing.
- The duration (in milliseconds) for which the cue will appear on the screen and be touchable by the user before it disappears.
- The length of time (in milliseconds) between cue appearances. If this is less than the duration for which a cue appears on the screen, multiple cues may appear on the screen at once.

For any given gameplay segment, these parameters are chosen based on both randomization and the past performance data of a patient. The set of zones is chosen based on randomly generated values.

**Algorithm 1** Choose zone set for single-touch gameplay segment

\[
N \leftarrow \text{getNumberOfZones()} \\
\text{zones} \leftarrow \{\text{getRandomZone()}\} \\
n \leftarrow 1 \\
\text{while } n < \sqrt{N} \text{ do} \\
\quad \text{zones} \leftarrow \text{zones} \cap \text{getRandomZoneBorderingSet(zones)} \\
\quad n \leftarrow n + 1 \\
\text{end while} \\
\text{return zones}
\]

Algorithm 1 describes how the set of zones is chosen for a gameplay segment in single-touch games. Note that getRandomZone() picks a random zone on the screen, and that getRandomZoneBorderingSet(zones) takes in a set of zones and returns a zone that borders at least one member of the input set, but is not a member of the input set. Note that, for example, the zone that “borders” any zone on the left edge of the screen on its left side is the zone on the right edge of the screen in the same row. This selection technique often forces the user to reach across the screen quickly. The process is carried out $\sqrt{N}$ times in order to ensure sufficient coverage of the screen.

**Algorithm 2** Choose zone set for multi-touch gameplay segment

\[
N \leftarrow \text{getNumberOfZones()} \\
z_1 \leftarrow \text{getRandomZone()} \\
z_2 \leftarrow \text{getRandomNonAdjacentZone(z_1)} \\
z_\text{Pairs} \leftarrow \{(z_1, z_2)\} \\
n \leftarrow 1 \\
\text{while } n < \frac{\sqrt{N}}{2} \text{ do} \\
\quad z_1 \leftarrow \text{getRandomZoneNotInSet(zPairs)} \\
\quad z_2 \leftarrow \text{getRandomNonAdjacentZone(z_1)} \\
\quad z_\text{Pairs} \leftarrow z_\text{Pairs} \cap \{(z_1, z_2)\} \\
\quad n \leftarrow n + 1 \\
\text{end while} \\
\text{return zPairs}
\]
Algorithm 2 describes how the set of zones is chosen for a gameplay segment in multi-touch games. Note that getRandomNonAdjacentZone(zone) takes in a zone and returns a zone that is not adjacent to the input zone. The purpose of the multi-touch mode is to coerce the user to use both hands in interacting with the game, and this is done more effectively if the cues that they have to touch are further apart, so that the user cannot simply use multiple fingers on the same hand. Note also that getRandomZoneNotInSet(zonePairs) takes in a set of pairings of zones and returns a zone that doesn’t appear in any pairing in the set. The process is carried out $\sum_{i=1}^{N}$ times in order to ensure sufficient coverage of the screen.

The duration of each cue in a gameplay segment is chosen based on the past performance of a user. As such, some data collection must be taking place around user performance during gameplay. This will be discussed before any further delineation of how duration is calculated.

A patient’s performance is measured per zone of the game screen. We take this approach due to communication that we have received from doctors. Doctors have described patients to us who have trouble, for example, reaching the left side of a surface if they are right-handed, or reaching the right side of a surface if they are left-handed. It was important to these doctors that patient progress is measured by the physical areas in which they are performing successfully or unsuccessfully. As such, Gesture Gym captures a user’s hit rate in each zone of the screen that the user encounters visual cues in during a single gameplay segment. Data about the user’s hit rate in each zone at a fixed cue duration is stored to a text file under the user’s local directory. The text file also indicates if the data corresponds to the single-touch or multi-touch gameplay mode.

From this data, Gesture Gym calculates the duration of the cues in a gameplay sequence given the randomly chosen set of zones as well as the patient’s past performance data. If the user has been successful in a given zone at some fixed duration, the next time that they encounter that zone, it is made possible for them to encounter cues that go by faster (i.e. have a lower duration) than on their last attempt at that zone. More specifically, this means that Gesture Gym stores the duration by zone that it expects the patient will be able to handle at any given moment. Successful means that the patient’s hit rate is above some manually determined threshold. In our playtesting, this threshold was decided to be an 85% hit rate. If the user has been sufficiently unsuccessful, the duration that the game expects patient to be able to handle increases (i.e. the game goes slower). Unsuccessful in our playtesting was determined to be below 40%.

How much faster or slower to make the game given the patient’s successful or unsuccessful performance is a paradigm which required refinement over a long play-testing period. We began with the notion that a small decrease in cue duration (i.e. increase in game speed), in terms of number of milliseconds, than successful users at fast speeds. From this assumption, we adjusted the magnitude of change of cue duration based on feedback from users of the game over a period of play-testing, and the final result of this play-testing is shown in Figure 5. This component of the game is the adaptive difficulty aspect that makes the application therapeutic, presenting the user with cues that pass by at a speed that is simultaneously challenging yet attainable throughout their recovery process.

Once we have calculated these duration values that the game expects the user to be able to succeed at in each zone, the game must account for the fact that it has selected multiple zones. One zone in the zone set may be one where the patient is very adept and can successfully respond to a sequence with a very small duration, while another may be one where the patient struggles and needs a small duration to respond well. Given that physical therapy, at its best, should never discourage the patient, Gesture Gym takes a conservative route and always selects the slowest duration of the zones chosen for this gameplay sequence, and bases the duration of all cues in the sequence on that value, plus or minus a small random noise parameter.

The actual cues in the sequence are generated randomly based on the described parameters. For the single-touch mode, a zone is chosen randomly from the set, and the x- and y-coordinates of the cue are placed randomly in the zone. For the multi-touch mode, a zone-pair is chosen randomly from the set of pairs, and the x- and y-coordinates of each cue in the pair are placed randomly in their respective zones.

5. RESULTS

This section discusses the data that we collected about users of Gesture Gym, as well as some interpretation of that data. It begins by discussing our methodology for collecting this data.

5.1 Methodology

Our cohort of test subjects included 20 people of varying ages and skill levels, who played the single-touch and multi-touch modes of Gesture Gym for 15 minutes each over the
course of a seven-day testing period. In order to better simulate the motor skills of stroke patients in these people who had not experienced strokes, we designed a simple mechanism that impairs the motor skills of our subjects in accordance with a proposal made by Dr. John Detre, who has been mentioned earlier in this paper. A common, difficult task that stroke patients are asked to perform during therapy involves lifting a gallon of milk – challenging because it involves lifting a limb while it, effectively, weighs more than usual [14]. In order to simulate the motor skills of a stroke victim in normal people, we similarly challenged them by making their limbs heavier than usual and asking them to perform a task, namely playing the Gesture Gym game. The apparatus for weighing down their limbs involved filling multiple zipper storage bags with sugar and fastening them to each of the subjects’ forearms with rubber bands. Each arm was thus weighed down by approximately eight pounds of sugar, the weight of a gallon of milk.

It would have been absolutely preferable to collect data about the performance of stroke victims against the Gesture Gym game. However, while we were in contact with medical professionals throughout the duration of the project, none of them were able to provide us with access to stroke victims. This is due to a variety of reasons, including time constraints, strict medical regulation, and ethical issues, as discussed in section 7.

5.2 Aggregate Results

For each of our test subjects, after their 15 minute session with Gesture Gym was done for the day, we recorded their mean cue duration across all zones of the screen. We did this for all of our subjects after each day of the seven-day testing period. In an effort to visualize trends in the performance of all of our patients, we plotted the average of the mean success durations of all our patients as a function of the number of days they spent playing the game (Figure 6).

For the purposes of this plot in Figure 6, zone-specific success duration was not taken into account, and instead all measurements were with respect to average cue duration across all zones. The initial cue duration for each zone was set to 2 seconds before any gameplay is recorded, meaning the average cue duration started at 2 seconds for all of our subjects. As described earlier, successful play in a zone leads to the cue duration for that zone being lowered. So, the average cue duration getting lowered for a subject means that his performance improved in various zones. Effectively, the average cue duration getting lowered means that the player’s performance is improving. The plot for single-touch game performance shown in Figure 6 demonstrates a clear trend of the average cue duration decreasing as the number of days playing the game increases. Over the course of our seven-day testing period, the average cue duration decreased from 2 seconds initially to approximately 1 second by day seven. An interesting note is that the rate of improvement seems to get lower the longer the game is played. On average, it took our test subjects three full days to go from 2 seconds to 1.5 seconds. However, it takes four full days to improve from 1.5 seconds to 1 second.

The data collected for the multi-touch game mode followed a trend that was similar to that of the single-touch game mode. The main difference was the average cue durations for multi-touch tended to be higher than those of single-touch, despite following a similar decline as the game was played for more days. This difference can be attributed to the multi-touch game mode just being more challenging in general by forcing the player to use both hands instead of purely their dominant hand. However, just as in our single-touch mode, the performance of the play testers in the multi-touch mode improved the more days they spent playing.

Due to therapeutic applications being a fairly recent research topic, we did not have data from any similar projects to compare our findings with. However, the results collected from conducting the play-tests were mostly consistent with our expectations. We believed that prolonged gameplay time with Gesture Gym would result in the subject gradually improving at the game, and that hypothesis was ultimately consistent with our data. The progression of cue duration from repeated success felt a bit too conservative at times. In fact, a large number of our test subjects did not encounter much of a challenge playing the game until the third day. However, it is important to note that the eventual use case for Gesture Gym would be real stroke patients, who could face a more difficult time with our game despite our best efforts to create a realistic simulation by tying weights to our subject’s hands. Taking note of this, we decided that it is better to keep the difficulty “ramp-up” time in our algorithm fairly conservative for the near future. Overwhelming a patient by ramping up our game’s difficulty too fast is a crucial mistake that we want to avoid.

5.3 Case Studies

The use case for Gesture Gym is not only to examine aggregate data in order to build a model of how patients progress overall, but also, as a doctor, to monitor the progress of individual users. As discussed earlier, the doctor is able to view heatmaps which present patient progress by zone. In the heatmaps in Figures 7 and 8, the zones where the patient is most successful are displayed in darker colors, while the zones with lighter colors are those where the patient is struggling. The axes of the heatmaps are x- and y-coordinates of the gameplay screen.

We have selected two patients to serve as case studies...

Figure 6: Average Duration as Function of Days playing game
for the visualization of patient performance that we would expect doctors to use as part of the process of prescribing Gesture Gym. Figure 7 shows the performance of a patient who is clearly struggling with hitting the left side of the screen, but has no issue with the right side. Perhaps they are right-handed and trying primarily to use their right hand, but have trouble moving it across the screen in the amount of time provided. Figure 8 shows the performance of a patient having a similar issue - with the opposite hand - which presents in a somewhat different way. While Figure 7 shows horizontally-striped performance degradation, Figure 8 shows that the patient has more trouble as they move from the bottom-left corner to the top right corner. The cause of these problems would be something for the prescribing physician to diagnose.

6. FUTURE WORK

This section will outline several possible upgrades to Gesture Gym.

6.1 Gameplay Development

The current iteration of Gesture Gym includes single- and multi-touch game modes which test and improve the patient’s ability to touch cues that show up in varying locations across the screen. Future iterations could include more variety in the motions a patient must perform, which would test and improve other aspects of their motor skills. Examples of such motions include swiping a path across the screen with a finger, pinching a path between two cues with their thumb and finger, and multi-touch (or multi-hand) variations of each of these. The game could also add more dimensions to the sequences of gameplay cues that it presents to patients. We also envision varying the size of each individual cue, as well as - if other types of motions were included – the ratio between the different types of motions the patient must perform. Adding these dimensions and motions would also provide us with more data, which we could incorporate into the adaptive difficulty algorithm.

Beyond development of the game, Gesture Gym could expand beyond the purely touch-based model of gameplay currently employed and use more facilities of the tablet. It could, for example, employ the accelerometer to test the patient’s ability to balance the tablet, or use the front-facing camera to track some motions that it asks the patient to perform. This kind of therapeutic application could even extend beyond the tablet, using, for example, the Kinect to track the full-body motion of a patient performing a physical therapy task. Therapeutic applications can expand in a number of ways beyond the scope of this project.

6.2 Remote Access to Patient Data

Our initial plan was to store the patient gameplay data on the cloud using the Parse API [2]. However, after medical professionals expressed concerns about privacy of patient data and compliance with HIPAA regulations, we decided to make our database local to the device on which the patient was using Gesture Gym. Thus, the current use case for Gesture Gym is that the doctor gives the tablet to his patient for a certain amount of time, during which the patient’s gameplay data is collected and stored locally on the device. After the time period is over, the tablet is returned to the doctor, who can view the patient’s performance on a day-to-day basis.

While it was out of scope for us to develop a secure remote backend that could guarantee patient privacy and comply with HIPAA regulations, a secure remote database would be a great addition to Gesture Gym because it would allow doctors to constantly monitor their patient’s performance even before getting the tablet returned.

6.3 Algorithm Development

As mentioned earlier in this section, adding more modes of gameplay would allow us to collect different kinds of data. Some examples of such data are how well a was patient able to follow a presented swipe path or how their hit rate varies loop. There are not enough game elements that motivate or encourage the player to continue playing for the sake of playing.
as the size of a visual cue varies. Incorporating this kind of data into our adaptive difficulty algorithm would help get a better idea of the patient’s approximate skill level and more precisely adjust the gameplay difficulty level.

Additionally, being able to test Gesture Gym with real stroke patients would provide very valuable data that would help us understand how effective our algorithm is in its task of simulating the increasing difficulty of physical rehab.

7. ETHICS

The purpose of Gesture Gym is to serve as a supplement to traditional physical therapy for recovering stroke patients, and the primary use case of Gesture Gym is as an activity prescribed by the doctor for the patient. As such, Gesture Gym exists in a space with clear ethical imperatives, but also many liability issues. First and foremost, Gesture Gym must not bring harm to the patient; it must not actively inhibit the patient’s recovery from stroke. Of course, the goal of Gesture Gym is to actually aid the patient’s recovery, but an ethical issue only arises if playing the game actually makes them regress. Like any other prescribed form of treatment, Gesture Gym would need to go through extensive clinical trial before a large-scale rollout to stroke patients in order to ensure its effectiveness.

Gesture Gym would need to be validated through this process before doctors would feel comfortable prescribing it to patients. This explains the difficulty that we had in testing Gesture Gym with stroke patients; if Gesture Gym, for whatever reason, proved to harm the recovery of patients, not only would the doctors need to spend extra time to counterbalance this, they may face malpractice lawsuit in an extreme case. Clinical trials are should, as such, be necessary for any medical product – even therapy options, not just pills – to see widespread use.

8. CONCLUSION

Gesture Gym has demonstrated that touch-based games can emulate the physical therapy process. In traditional physical therapy, a patient is presented with a challenging task to perform. If they succeed, they are next presented with a slightly more difficult task, and if they fail, they are either told to repeat the task or given a slightly easier one. Gesture Gym performs in this same way by presenting patients with visual cues based on carefully captured and analyzed performance data.

There is a void in the physical therapy process today. Doctors are responsible for much of the burden of administering therapy, and routines that patients perform at home have no difficulty flexibility or data collection. There is a substantial opportunity for the introduction of therapeutic applications like Gesture Gym that will improve the therapy experience for both doctors and patients.

9. REFERENCES