The original goal of our project was to develop a game that could make boring but important therapeutic procedures more engaging for kids. Specifically, we observed in one of the videos we watched that kids were asked to perform simple motions, like raising an arm or standing on one leg, yet at the same time were not provided with any real motivation to perform the task. This gave use the inspiration to design a game that could be used to motivate kids to perform these therapeutic tasks.

Description

Our game is similar to tennis, except that it has a solely auditory interface and uses no physical balls or paddles. Players “hit” a virtual ball back and forth to each other; the challenge of the game is properly timing each hit. Each player wears one or more bracelets that contain a battery and infrared LEDs. We use the IR camera on a Wiimote to detect the IR LEDs on the bracelets, which in turns enables us to track the motion of those LEDs over time. In doing so, we are able to build a simple model of the player’s motion. The goal of doing so is to allow a therapist to “record” a desired motion (as modeled by the relative positions of IR LEDs over time) and require the child playing the game to mimic that motion in order to return their opponent’s volley. Using two Wiimotes (one for each player), we could allow multiple kids to play the game at the same time, adding a level of competition to an otherwise simple game. For this project, we implemented a very basic proof-of-concept of this idea, though we did develop basic motion capture infrastructure to support future development.

Thus, we divided our project into three parts as follows, with each of us focusing on one of these components. Hila worked on our game engine, Shaddi worked on the motion capture library we used, and T worked on designing and fabricating the IR LED wristbands.

The game engine was written in Python and was based on the Pygame platform. Since the interface didn't include any visual components, the main functionality provided by the game engine was handling events raised by the player's recorded motion and respond to those events by playing a sound (a ball hit, a ball coming, a missed hit). The game engine uses the time of the recorded motion to decide whether it occurred within an appropriate time frame and increased a player's score accordingly. If a player misses the ball, the other player gets a point. The game is played until one of the players reaches a certain number of points and this player is declared the winner of the game. The game also calculates the number of Good Hits passed between players, which is the number of times players are able to pass the ball without missing. As the number of Good Hits increases during the game, the overall time interval between passes significantly decreases. To create the full effect of decreasing time interval, the speed of the different sounds was manipulated using Free Audio Editor.

The motion capture library was based upon the Wii.py library provided to us by Dr. Bishop. While a discussion of this library is outside the scope of this document, the important capability that it provides is access to the IR camera on the Wiimote. The camera can track up to four IR points at a time, and provides each point’s x and y position in the camera’s field of view, as well as an intensity value. Using this, we developed an event-based motion capture library that kept track of what points of light were visible over time. The “Track” object represents the motion of a single point of light over the duration that it was visible by the camera. Every new point detected begins its own Track object, and subsequent position

updates to that point are added to this base Track object. We maintain active Track objects on a stack.

The library provides three Pygame events to allow Pygame developers to take advantage of its motion capture ability:

- TRACK_STARTED: Raised when a point of light is first seen, with some duration threshold to avoid reporting on erroneous detections.
- TRACK_CONTINUED: Raised whenever a point of light is seen at a new position, and is added to the base track object.
- TRACK_ENDED: Raised whenever a point of light is no longer visible, and a track object is popped from the stack.

For our game, we only responded to TRACK_STARTED events. Source code for our project is included with this report.

The I.R. LED wristbands initially started out as an I.R. LED glove but we very quickly realized that sizing would be an issue due to the fact that we would be encountering a range of hand sizes. T then decided to design a wristband that would have varying sizes to accommodate various wrists. Since we would be attempting to capture motion and motion can be unpredictable we selected LEDs that had a wide viewing angle, 120 degrees, and an appropriate wavelength, 950nm ,as to ensure that the Wiimote would see the light as the arms moved and changed angle. We considered placing a switch on the wristbands because placing and removing the batteries was cumbersome, but a switch small enough to fit the system would have been challenging to solder. So after a few permutations of LEDs and battery placement T came up with a design we were happy with: Elastic wristband with 3 snaps, 1 AA battery, and 2 IR LEDs approximately one inch apart. All electrical components were soldered together. The LEDs were soldered in parallel due to the constraints of the wristband. All components were sewn to a strip of elastic. The placement of an inch apart allowed us to be able to rotate the wristband to allow the Wiimote to see them based on where the player was standing in relation to the Wiimotes.

Some pictures of the wristbands:


Challenges

We communicated on a fairly regular basis over email, so coordination did not turn out to be a substantial problem. Instead, we faced a number of technical issues. The main challenge with the game was accurately coordinating between events and sounds. Pygame does provide a time module, but there was still much technical effort into capturing the times of all sound files and having the program wait for them to finish play while processing users' actions.

Motion capture tended to be a bit too sensitive. Players would accidentally register "hits" without meaning to do so. Part of this was a timing problem in our game engine – at first, all hits were pushed onto a global event stack, regardless of which player's turn it was. We fixed this problem by ignoring all Track events from the user whose turn it was not. We also had some issues with the wristbands, which contained multiple LEDs, being detected as multiple individual points – hence generating multiple Track events. This was a relatively rare occurrence, however.

The development of the wristbands presented several challenges. At first knowing how to place the LEDs seemed to be an issue but once we switched to a wristband design we were able to place the LEDs anywhere along the arm. The LEDs heated up fast and we thought that was going to be a problem but the elastic provided enough insulation. Our LEDs were very small so soldering them to a battery proved to be quite challenging. The lifespan of the wristbands was projected to be short due to the life of the LEDs. We actually didn't run into any problems because we had many wristbands, promptly removed the batteries, and rotated them out frequently. The wristbands were also quite fragile due to the nature of their design (soldered wires) so there was some concern that rowdy kids might break them but that proved not to be a problem.

Evaluation

We decided to evaluate our project based on how successful it was at maze day. After we worked out a few kinks, we had many successful groups stop by before lunch. These groups comprised mostly of younger kids who seemed to have fun either playing each other or playing T. Our hope was that the competitive nature of the game would create a fun environment and we were right. Whether playing each other or just playing (beating) T the children had a blast. We actually have one memorable kid on video saying that it was the best game at Maze day. The older kids that stopped by did not have as much fun as the younger ones. Also the more sight the players had the less fun it was. Our game was developed to use hearing alone so if a sighted person could see the Wiimotes, some of the challenge was lost. Based on the reaction of the players we can say that the older a player was the less fun he or she had. Since our aim was to make mundane exercises fun and competitive, the simplicity of our design allowed older players to figure it out fast and become bored.

Improvements

Overall, all three components, the game engine, the motion capture and the wristband, worked well individually and together. The idea of creating a competitive game turned out

to be a great source of attraction in maze day and most kids seemed to have a good time. We also worked well as a team while working on the project and during Maze day.

One of our biggest areas for improvement was our wristband design. The LEDs heating up was a problem. Also there may be better ways to accomplish the goals of the wristband through the use of other technology. Another major point for improvement in the game is resolving players' confusion regarding to players' turns. Since the same sound indicating that the ball is approaching the player was used for both players, it was often hard to keep track of which player's turn it is. Using a different sound for each player could easily solve this.

Our initial goals of therapeutic use seemed to be beyond the scope of this project so next time we would implement those goals. We wanted to be able to calibrate the game so that a therapist could input a desired motion. The player would then have a good "hit" if he or she appropriately mimicked that motion. Also, it would be helpful if there were a series of difficulty levels incorporated into the game so that new or weak players could have a descent error threshold on their motion: for instance, if the player came close enough to the desired motion it would count as a hit and then the allowable error would decrease as the levels increased.