

Tele Rehabilitation: Improving Adherence to Physical Therapy

Using tele rehabilitation to get patients to consistently work on therapy session at home

Luke Paltzer, Pouyan Pourmirjafari, Mark Dabler, Abdullah Kidwai, Harsha Podapati

Computer Science 489

Professor Robert Kenyon and Professor Patton

May 10, 2019

Abstract

Virtual Reality has started to revolutionize the way entertainers such as filmmakers and video game developers create their products. Our research project decides to captivate the users and enhance current physical therapy methods through this new method. Utilizing a game in a virtual reality environment research subjects were asked to play a certain and give their feedback on their opinions on certain aspects of the device, primary their willingness of continuing to use the system and other aspects that encourage or discourage the use this system. Preliminary results indicate that with achievement and scores to motivate users they are more likely to continue playing on the system, as for the physical therapy aspect, we hope that continual usage of the system on a regular basis would improve the condition of the user.

Keywords: virtual reality, physical therapy, arm/wrist

In the last few years with the advent of new technology being accepted to help transform healthcare practices, tele rehabilitation focuses on reducing the costs involved for healthcare providers and patients along with creating advantages for patients who cannot make it to the clinic consistently. One of the applications to start outlining the use of tele rehabilitation was in physical therapy, physical therapy is heavily focused on the patient/therapist interaction and needs constant attention in order to help the patient recover. Our project would be trying to leverage and improve the communication needed between the patient and their patient. While telerehabilitation is not meant to replace traditional healthcare it is meant to be used as a tool to monitor patients.

While there would have been many different ways to improve the current physical therapy model our group decided to focus on the patient's interaction in the process. Our idea was to find a way to get patients to be more involved in the therapy process, currently some of the biggest problems are burnout through a lack of interesting exercises and another issue is the lack of patient-clinician interaction outside of the prescribed meeting times. There were two main goals that we identified while brainstorming the aspects of the project, turning physical therapy exercises into a game and then incorporating telerehabilitation aspects for the therapist to keep track of the progress of the patient.

When brainstorming different techniques and devices to use for the project we had decided to start working with the HTC Vive. This device would let the user immerse themselves in a virtually created environment. While we were set on the technological aspect of the project, there were issues in decided on what body part to focus our therapy method on. In the initial

stages, the biggest barrier was the focus point for the device being used and therapy exercise to create a game for.

Our team designed our virtual reality therapy game on the Microsoft Kinect 2. The game was specifically designed to be used on the Kinect 2 due to its advanced individual wrist and arm tracking capabilities. This specific tracking ability was the primary reason for our project to be developed for the Kinect 2 over other market-ready virtual reality systems.

Our work, the final project for CS 489 Human Augments at University of Illinois at Chicago, tries to be an alternate method for physical therapists to provide to patients who come for treatment. The primary audience target for this project would be patients trying to recuperate hand/arm movements. But the selling point and the main feature that advances our project from other similar projects is the ability for tele rehabilitation. Compared to similar virtual reality physical therapy projects, the difference this project gives to the user is the added benefit of having a social interaction during the therapy phase. The treatment staff would be able to monitor the progress of the patient and keep track of the continued exercising of the patients even outside of the patient's proposed meeting times. Interacting with patients and advising them through any issues remotely.

The project was developed by first looking from the perspective of enhancing the experience of the patient. The experience is enhanced as the user would be able to experience situations, in the virtual reality the patient would be able to pick up objects such as a ball, this would be something that would be extremely hard for these people in the real world. This type of experience helps compensate for the limitations set by regular physical therapy.

While looking at prior works and research, we had split research between the commercial space and trying to find different projects that have ventured into the same space we are looking at. Then we also looked at academic research proposals being done by other groups working on enhancing therapy. Home therapy and virtual reality interventions in physical therapy were the two main topics we research about. One specific device, VERGE, for home therapy was a starting point and was the basis for our development. Through testing, 85% of the subjects found the VERGE system to be an effective means of promoting repetitive arm movement (Triandafilou).

In the commercial space there is a project being currently developed and being tested by KineQuantum. The device they developed is able to control each parameter of the virtual environment which allows the therapist to create specific assessment and rehabilitation exercises for your patients: balance, spine, vestibular, or upper limb (“Relieve your patient’s pain”, n.d).

In order to finalize the detailing of the project, we had consulted with Dr. Daria from the Shirley Ryan Abilitylab, we had read her paper and met with her in order to discuss about her research. Our project goals were to create a new prototype system that would let the therapy interaction between the patient and therapist extend beyond the regular session time. Another useful idea we gathered was the idea of adding achievements and scoring. During one of the meeting with the researchers we found an interesting detail which helped our project define an end goal to test with. Based on the previous subjects using the Kinect 1 project developed by the Shirley Ryan ability Lab there a demand from the subjects for a way to see their progress. Thus their own project was being modified to include a scoring along with a way for achievements to be included. This minute detail which our group had not thought about influenced our design of the game.

As a group we had internally discussed and then decided that our main focus for the project would be dealing with rehabilitation for the wrist/arm. The Kinect 2 was a device which was able to fit for our demands and thus we decided to start creating a game for this device. The overall game is that on a virtual table there would be multiple cups placed like a triangle on the table. The user would then be required to pick up a ball and then move their arm over to a cup and then drop the ball trying to make it land inside a cup. The purpose for this game was to have the user be extending their arm over a set distance along with an action of opening and closing their wrist when picking and dropping a ball. Motions used in playing this game try to mimic similar exercises currently given by physical therapists. After designing the rules of the game, the aim of the design would then focus on creating a game that would be engaging enough to the user to continue using the system even outside of their scheduled meeting time. Along with satisfaction, we understand that the most important measurement this project must test would be testing to make sure this system would help patients have an improvement in their arm mobility when compared to them doing regular exercises.

There were two main parts to the project, one was the development of the actual game and the user interfaces dealing with it. First Harsha and Pouyan had started working with the sensors to the Kinect 2. They tested out the tracking capabilities and different ways to be able to have the sensors integrate into the game. After having confidence that the hand tracking capability of the Kinect 2 was unto expectations for our game, Abdullah started designing the basic game on Unity. Then Abdullah and Pouyan collaborated in order to create a basic ball throwing game. Then after initial feedback on the lack of visual appeal to the game, they redesigned the game with a new user interface. During this time, Mark and Luke started trying to get UNet to connect to the kinectSDK. As there were issues with the SDK, they then resolved it

by creating a local multiplayer to the game. After Abdullah finished working on the game, both Mark and Luke then fixed remaining bugs and worked on the achievements. Finally a testing session was done by Harsha and Pouyan to get feedback about the satisfaction of the experience of the game.

Project Development

The development of the project was split into the individual ideas we researched about. The overview of the underlying work that was focused on was the multiplayer and gamification aspects. As discussed the first barrier that needed to be overcome was creating a game which would be satisfying for the patient to continue playing repeatedly even when not being forced by an external person, such as a therapist or a family member. The game also had to be strenuous enough for the patient to exercise the targeted part but also amusing for them to use the game in a consistent manner. The project first focused on creating the game on a Kinect 2, since the game was related to the wrist movement, as the Kinect 2 had an accurate body tracking capability to track the different movements of the wrist. Unity was used to create the entire project afterwards, from the virtual reality environment, to the physics needed to play the cup game, and even having all the internal scorekeeping capabilities.

As we were forging our game in unity, this was a development tool none of us had experience with, our ideal design diverged while trying to connect the multiplayer for Kinect through unity. Lack of experience was something we could easily tackle, slowly though various methods we had taught ourselves to create the necessary components in unity. The game was then created and only had a table with a stack of cups and this version of the game focused on just creating an environment to have the player interact with. In the initial stage of the game creation the lack of user interface made users and even ourselves get disengaged from working

on the game. Before moving forward in the project an additional step was added to the timeline. The interface of the game was created and a setting was added, the idea of a dance floor was used and thus the area surrounding the table was modified to be more visually appealing.

Our initial approach was to use the internal multiplayer, UNet, provided by unity to get two independent Kinect 2 to connect to each other. But we were unprepared and found out in the middle of our development that unity does not provide a multiplayer SDK for Kinect 2. Due to the inability to connect the networks over internet the idea of multiplayer had to be retaught and we created a newer version of the multiplayer. So we then starting working on a local multiplayer component to the game. This version then lets two people interact and play on the same machine, each player would then take turns dropping the ball into the cups.

While in our demo of the Kinect 2, we had tested different motion to make sure the Kinect 2 would be able to capture the required movements needed to play our specific game. We had tested the Kinect 2 for actions such as closing the wrist to moving the arm around in different directions. While all these were necessary for the game we had forgot to account for the combinations of two or more actions. In the testing process of making sure the game was working as intended a bug had occurred. When the user was holding onto a ball and then throwing the ball the Kinect was not able to discern the action for throwing and would then drop the ball straight down. After repeated trials of trying to improve the physics, a slight modification to the actual game mechanics was changed. Instead of just throwing the ball the exercise was then changed to have the user extend their arm over the specific cup and then drop the ball into the cup. Each issue that we ran into forced us to modify the game a little bit, every change that was made was thought out and made so that the overall game was not affected and

the made so that the patient would be able to complete their physical therapy session using this product without any hindrance.

As we could not get actual patients who were already undergoing physical therapy we could not properly test if the game would help patients improve their arm/hand movements. So instead our test was modified from testing the improvement of the game to focus on the satisfaction the user experience and if they would replay the system again. Our initial sample of people were random people who were in the CS lounge in Science and Engineering building at University of Illinois at Chicago. Testing stages was split into two stages, the first stage involved the subject playing the game without any achievement and then after doing so the same subject would play the same game with achievement. The achievement and scores would update according to the level of gameplay the subject would do so.

After a user tested both types of gameplay they were surveyed about the satisfaction level between both modes on a scale between 1 and 10. On this scale 1 is least enjoyable and 10 would indicate most enjoyment. Out of the 6 people who completed both stages and the survey 5 of them had stated that the game mode including achievements was more satisfying to play.

From internal testing between ourselves while designing the game to other users testing the game we had discerned that the user interface was a major factor to continue playing the game. Our testing made us to add themes to the game in order to make the game look more appealing. Then smoother animations were implemented and tested to make sure the users would be able to enjoy the motion of the ball and the cups without any issues.

Conclusion

Overall, our project was able to create an enjoyable game for testers, based on the survey results received from the testers. Our original idea of adding achievement and scores was a major reason for testers to enjoy the game as they had stated that the gameplay with achievements was more enjoyable. Future work on this project would include fixing up the multiplayer to work as intended in our project idea. Lack of experience in unity caused us to find a bypass our idea of having multiplayer work on multiple systems, as our current multiplayer works on a local single multiplayer. Then after fixing up some slight mechanics in the animations of the game along with adding a slight increase in difficulty we would like to test the device on people actually undergoing arm/hand physical therapy. This would help us create a more market-ready product after having actual patients test the product.

Citations

Kristen M Triandafilou, Daria Tsoupikova, Alexander J Barry, Kelly N Thielbar, Nikolay Stoykoy, & Derek G Kamper. (2018, October 05). Development of a 3D, networked multi-user virtual reality environment for home therapy after stroke. Retrieved May 12, 2019, from <https://jneuroengrehab.biomedcentral.com/articles/10.1186/s12984-018-0429-0#Sec18>

Virtual reality technology I KineQuantum.(n.d.). Retrieved May 12, 2019, from <https://www.kinequantum.com/technology-virtual-reality>

