The Innovation of Gamified Physical Therapy

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On my honor as a University Student, I have neither given nor received
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In the midst of a global pandemic, monitoring patient health via remote technologies is becoming increasingly prevalent. New wearable devices along with increasing data analytics with machine learning have revolutionized medical devices and the world of telehealth. More specifically, the need for these devices is also increasing in the world of physical therapy. After receiving feedback and hearing about the problems plaguing the physical therapy space, our research group identified a need for a solution to patient compliance, data sharing, and automation. For our capstone project we are developing a wireless motion capture suit that tracks, analyzes, and shares data over Bluetooth. Along with the motion capture suit, we are developing a web portal for physical therapists, and a mobile application for patients. This offers a platform for patients and therapists to communicate, share data, and receive feedback on exercises. More specifically, the focus of the mobile application is gamifying the process of physical therapy.

My goal is to make the mobile application as interesting and engaging as possible to encourage patients to do their assigned exercises correctly and on time. The idea that we have come up with is to make the app more like a game, to modify the way people view physical therapy. The stats collected by the app by gamifying it will also help physical therapists to see how productive a patient has been, and provides quantitative measures of progress. The overall hope is that this will make patients more inclined to do their exercises, which will increase patient retention rates, while also allowing patients to a quicker recovery. It will also hopefully reduce the risk of repeated surgery and prevent further injury in the

future. The following evaluates strategies for building at-home physical therapy interventions. An analytical framework builds on the merits and concerns when designing with gamification and user friendliness as priorities. The framework is then applied to a working prototype, and the prototype is compared to competition, to reveal more effective design elements and strategies for working with user needs.

Physical Therapy and Gamification

Issues Plaguing the Physical Therapy Space

Getting people engaged in physical therapy has been an issue for a long time. With patients suffering from a life changing event, the need to recover quickly and efficiently is placed at a greater importance. Yet, patients are overwhelmed by the number of visits per week to PT clinics, travel constraints, and the opportunity cost of time away from jobs and families. This causes patients to end their course of physical therapy well before successfully recovering. Research indicates that 70% of patients do not complete their prescribed course of treatment and never reach their full potential wellbeing (Klepps, 2015). This is because as patients begin to see even slight improvements in mobility and relief from crippling pain, their incentives to sacrifice time, work, and family obligations for PT sessions drop significantly.

Communication between patients and therapists have also been problematic. With telehealth becoming more popular due to the pandemic, physical therapists need a new way to communicate effectively with patients, provide in-home exercises with ease, and provide a safe and regulated environment (Grant et al.,

2005; Coppola & Collins, 2009; Tuncer et al., 2013). Most telehealth platforms that are currently in use do not provide routine check ins along with in-home exercise programs (Hensley et al., 2020). Current in-home exercise programs do not engage patients effectively as well as don't provide proper communication channels with physical therapists (Nelson et al., 2020). Without a solution, patients will continue to go without the care they deserve, especially those in rural areas or those unable to physically go to a clinic (Lee et al., 2018).

Finally, health insurance companies spend unnecessary costs per year for patients with a physical injury who undergo long term drug use, chronic pain, or reinjury. These can all have a high likelihood of being avoided if patients undergo physical therapy as stated anecdotally and in literature by PTs and surgeons. For example, in a APTQI report from 2017, beneficiaries who receive therapy within the first 15 days, compared to 45-90 days after being diagnosed, are observed to have downstream costs that are ~ 27% lower on average (Athletico, 2020). However, insurance companies, Medicare, and physical therapists are missing the quantitative measurements and reports needed to justify such claims and treatments are effective. Additionally, Medicare has become the most susceptible government mandated program in the United States to lose money due to fraudulent claims, with over $60 billion lost to waste in 2017 (Eaton, 2018).

Advances in Physical Therapy and Gamification

With motion capture tools now becoming more widely available, the uses for them have also expanded. Motion capture is now being used more often in physical therapy recovery plans to help patients recover more rapidly. This technology has been utilized to improve movement quality, increase lower limb loading, improve

adherence to weight-bearing restrictions, and beneficially alter gait mechanics (Owens et al., 2020). The motion capture technology also helps patients visualize their movements, and become more aware about the exercises they complete. This technology also provides plenty of data from the movement of a patient. Research has shown that displaying graphical summaries of movement, such as bar charts for range of motion, provide patients with simple targets to achieve during rehabilitation exercises (Owens et al., 2020). With these advancements from motion capture technology, patients are now more aware about their recovery process, and it also helps them become more motivated to complete their prescribed recovery.

With motion capture technology providing advancements in physical therapy, it also provides the patients and therapists with a lot of data. While this data can be displayed in charts and graphs, it could also be used to track time spent exercising, track the number of exercises completed, and the correctness of each exercise along with tips to help the patient improve. This is where a gamified app could combine the progress made with the motion capture technology, along with better user engagement, to provide greater incentives for patients to complete at-home exercises. Gamifying the experience will challenge patients, set goals, and create user interactions which promote other areas of health, both social and cognitive (Blobel et al., 2012). This process works because it provides motivation and incentives to complete exercises in a more fun and rewarding way.

Along with the motion capture data, the game itself will also create useful data that will be displayed to the user in a more fun and engaging way. By gamifying the experience, a plethora of data is also collected, which can offer a new

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opportunity for individuals to understand more about their bodies, minds, and daily lives (Wallenburg & Bal, 2018). If the data by the game is analyzed correctly, it will be tremendously powerful. Also, the data the game generates will also be used as part of the diagnostic systems, and the game will form an integral part of most treatment plans (Blobel et al., 2012). A gamified platform would provide the patient with more incentives to complete their prescribed course of physical therapy, and it would give therapists more resources and knowledge to help patients recover quicker and more effectively.

While there are many upsides to using a gamified application for physical therapy, there is a lot of concerns that currently surround the topic. First, the user must buy into the game that's in the mobile application in order to ensure accurate patient statistics. If not, performance management cannot be standardized by gamification, as actors move towards a certain target defined by benchmarks, because the goals are either adapted, ignored, or changed (Wallenburg & Bal, 2018). Second, the data collected by the game and application has to have meaning and be displayed in a way the therapist and patient can understand. Without thinking about the documentation or infrastructure, the data itself is surprisingly weak, and cannot ensure accountability on its own (Hoeyer & Bødker, 2020). The documentation of data produced, and how the data is presented to the user is crucial for the success of a gamified application.

In order for gamification to be successful, there has to be unanimous trust in the system between patients and therapists. In order to do this, the problems of data accuracy, presentation, and application infrastructure must be addressed. One method that helps solve these issues is using adaptive gamification. Adaptative

gamification is an approach that targets a single user instead of a one-size fits all approach, it has been tested with positive feedback and increased user usage (Böckle et al., 2018). By targeting a specific user, the process feels more tailored towards them, and the user adapts to the approach instead of trying to ignore or change it. With the user bought into the process, this helps therapists believe in the results, which creates a more trustworthy system. The data in adaptive gamification is also displayed in a way that's geared toward user's short-term goals and over-all end goals, and adapts their goals based on their progression or regression (Böckle et al., 2018). This provides a framework that displays the data in a useful and informative way based on a single user and provides infrastructure for documentation.

Applying Gamification to Physical Therapy

Competition Within the Physical Therapy Space

For a long time, especially before the COVID-19 pandemic, the most common form of physical therapy was in person. Patients would meet with their therapist weekly, perform monitored exercises, and get real time feedback. With in-person sessions, patients would usually get a high quality of care, as the patient has the therapist's attention. These sessions also are very cost efficient, and there is easy connectivity between the patient and the therapist. With new technology arriving in the space, and in the height of the pandemic, physical therapy has moved away from in-person sessions. This has led to new forms of telehealth, the greater use of motion capture applications, and even some gamified applications to meet the demand for patients and therapists.

Starting with telehealth platforms, the very first issue that needed to be solved when adapting to at-home physical therapy was communication. The platform that took off for many, not just therapists, was Zoom. Zoom offered an easy way for patients and therapists to teleconference, and also allowed therapists to have a high patient volume as they could meet with many different patients using the same platform. Other solutions started to become more popular as well, one of them being TelePT solutions. TelePT solved more than just communication barriers, as it provided software to help schedule patient visits, and also a platform for patients and therapists to teleconference (TelePT, 2021). Another solution that also became popular was MedBridge, as they offered mobile apps for patients and therapists to communicate, they have a library of home exercise programs, and outcomes and reports to track patients exercises (MedBridge, 2021). Along with these platforms, there are also many others that offer some way of telecommunication, along with different features to help patients and therapists.

With advances in telehealth, there also have been many emerging products in the motion capture space. One example of a company leading the charge in developing motion capture products is Xsens. Xsens is a leading innovator in 3D motion tracking technology and products. Their sensor fusion technologies enable a seamless interaction between the physical and the digital world in consumer electronics devices and professional applications such as motion capture, motion analysis, healthcare, sports and industrial applications (XSENS, 2021). Another example is Noitom, a company focused on motion capture and virtual reality. By creating innovative, affordable and accessible products, Noitom is able to deliver motion capture not only to the film, gaming and animation fields, but can also

extend their versatile technology into the realms of education, medicine and science (Noitom, 2021). Finally, another example of a company developing a motion capture accessible is Vicon. Vicon offers advanced, customizable, end-to-end motion capture solution, covering the entire pipeline, without relying on third party software; while also providing true flexibility through integration plugins for other platforms (Vicon, 2021).

With there being many different applications for a motion capture system, lets dive into some products that use motion capture that are aimed specifically at recovery. A company taking a more aggressive approach and using a full body exoskeleton to track movement and aid with recovery is EksoHealth. Their product, EksoNR, is a lower extremity exoskeleton that supports upright posture and teaches the wearer how to walk again and regain their natural gait. With postural trunk support as well as support at the knee, hip, and ankle, this device amplifies ambulation ability and allows for extended therapy sessions without fatigue (Carlan, 2020). A company taking an opposite approach to the same problem is EuMotus. Instead of using a full body exoskeleton, or even motion capture nodes, their system requires no wearables. Their product BodyWatch is the first-ever completely portable and markerless motion capture and analysis system that automatically evaluates functional body motion in 3D, in order to help patients recover (EuMotus, 2021).

For a lot of these companies and products involved in the motion capture and recovery spaces, they either have a physical product, or a software platform but not both. These two companies have combined their motion capture system with a software platform aimed for rehabilitation and recovery. The first of which being

Notch, with their mission being to improve the human capacity to visualize, understand, and to better perform movement. Notch is a platform that helps channel knowledge about human movement accumulated in healthcare, sports and art into new mass-market products (Notch, 2021). The second company, and our products biggest competitor, is MioTherapy. MioTherapy is a digital healthcare company dedicated to bringing physical therapy to the 21st century, leveraging innovations in technology to offer a patient-centered and data-driven solution for clinical rehabilitation. Along with their motion capture technology, they also have a gamified application that provides visual and audio feedback in real-time for exercise guidance and progress updates (MioTherapy, 2021). With many different products out there for motion capture recovery, and a very similar product in MioTherapy, it is going to be very import that our product stands out from the competition.

Differentiation from the Competition

With a lot of different companies in the telehealth space, motion capture industry, and gamified recovery, it is important that our product stands out in three different categories. Starting with regular telehealth platforms, they offer a way of patients and therapists to communicate effectively, schedule appointments, and maximize time patients spend with their therapists. Some solutions offer scheduling, and a database of exercises, but no way to communicate effectively through the platform. Other solutions offer an efficient way to teleconference but no way to schedule appointments efficiently, or have no database of exercises. That is where out product stands out. With a mobile application as the patient portal and a web application for therapists, patients and therapists can teleconference and direct

message each other using the platform. The web platform also has a calendar feature for therapists to easily access appointments, create and reschedule an appointment, or cancel appointments. The platform also contains a database of exercises that therapists can load into their patient's mobile application from their web portal. As described, our product takes into account what other platforms offer and combine them into one, creating a streamlined application for communication, scheduling, and data management.

In the motion capture space, there are many different competitors that we have to take into account. In terms of competitors that we need to be worried about are ones with lightweight motion capture hardware that are used to collect data. Suits that require assistance to put on, or require other technology in order to use, we have an advantage on because our motion capture suit can be put on by almost any patient, and is ideal for at-home use. In terms of the technology that we use for our motion capture suit, it rivals our competitors, as we use a motion capture component that consists of 9-axis inertial motion units and a Bluetooth Low Energy chip that sends quaternion coordinate data to a phone or central server. One aspect of the system we do need to scale down on is the size of each motion capture node to order to match our competitors. The one factor we can beat our competitors on is price. Since we created the design for the system, and have a manufacturer for our design, we can control how much we sell the platform for, and undercut our price competitors if need be.

The main selling point of our product is that it is a complete platform, from the motion capture suit, to the mobile application and web portal, it solves the problems of connectivity while providing real-time feedback. On top of being a

complete platform, the mobile application is gamified in order to encourage, challenge, and engage patients in their exercises and recovery course. Unfortunately, there is a competitor, MioTherapy, doing a project that is very similar. The main difference between MioTherapy and our product is our machine learning algorithms. Our product is actively learning and improving to help provide patients with the most accurate, real-time feedback available. On top of that, our product provides better patient-therapist connectivity, which our biggest competitor lacks. Finally, using adaptative gamification, the game will be tailored more towards user specific short-term goals, along with a user-friendly interface that actively engages patients and is easy to use. The data that is presented to the user through the game, or through graphs or charts, will also be well documented in order to make sure patients and therapists understand the knowledge that is being presented to them.

Conclusion

With at-home physical therapy becoming more of the norm, and motion capture technology rapidly evolving, the need for a complete solution has become apparent. In order for our product to be successful though we will have to accomplish two major tasks. The first is creating a game using adaptative gamification, along with a user interface that is streamlined and easy to use. The second is to differentiate from our competitors in a way where we standout in the saturated motion capture and telehealth markets. Tackling gamification will not be an easy task. While it's clear that there are benefits to gamification, how the game is implemented within the application and how users and therapists interact with

the game will decide the success or failure of the method. The main points of failure include lack of participation within the game by the user, which leads to lack of trust in the process by the therapist, and issues with how data is used and displayed. In order to create the best possible product, some form of adaptive gamification will be used in order to engage the user on a more personal level, along with a method of presenting personalized data. Along with adaptive gamification, extensive documentation will be provided on what the data collected means in terms of success or not, and how that translates into the game. Finally, the game within the app will have to be robust in the sense the user cannot easily make up false data, or be able to easily cheat, in order to provide trust between patients and therapists.

After successfully creating an app with a game as described, we will be ahead of the competition in terms of user engagement in our mobile application. Now, we will have to go against rival competitors in the telehealth and motion capture industries. We can do so because we have a product that fixes the greatest number of problems at the least cost. Our competitors are fragmented within the distinction of a physical device, motion capture companies, versus a software platform, telehealth products, causing a gap that our product can fill. With an all-around system from the motion capture suit, the therapist web portal, and the patient mobile application, we solve issues with communication, provide accurate real-time feedback that is always learning with artificial intelligence, and promote user engagement with a complete game and friendly user interface. Finally, we are able to control the price of our product. By designing and producing our own motion

capture system and software, we will set a price that is reasonable and affordable,

in order to get our product into the hands of patients and clinics everywhere.

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