Prospectus

Delivering Effective Physical Therapy Remotely via a Wearable Sleeve and Mobile
Application
(Technical Topic)

The Gamification of Physical Therapy via a Mobile Application
The Implications
(STS Topic)

By

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Introduction

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 sleeve that tracks, analyzes, and shares data over Bluetooth. Along with the motion capture sleeve, 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 mobile application is focusing on gamifying the process of physical therapy.

My goal, and what I'm researching, is how 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 so far 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. My objective is to understand what are the best

practices and principles to get people to care about preventive medicine and comply with physical therapy demands. Furthermore, understand what has been successful and not successful in the past in terms of the gamification of personalized medicine, in order to make the best possible product.

Technical Topic

The overall objective for our project is to revolutionize physical therapy via remote technologies and gamification. With telehealth becoming more popular, 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 during the pandemic, especially those in rural areas or those unable to physically go to a clinic (Lee et al., 2018).

Our capstone group is developing motion capture sleeves with autonomous data collection and analysis for integration into physical training and therapy applications. The deliverable is a data focused wireless motion capture sleeve combined with both mobile and web applications that tracks user motion while ensuring their compliance to prescribed or set exercise routines. The motion capture component will consist of 9-axis inertial motion units and a Bluetooth Low Energy chip that will send quaternion coordinate data to a phone or central server utilizing the Bluetooth beaconing method, where the peripheral sensors are the

beacon and the phone or central server is the scanner. For our project to be

successful, it relies on the system working as a whole. The system as a whole,

named BravePT, can be seen in Figure 1.

Figure 1

System Architecture of BravePT Platform
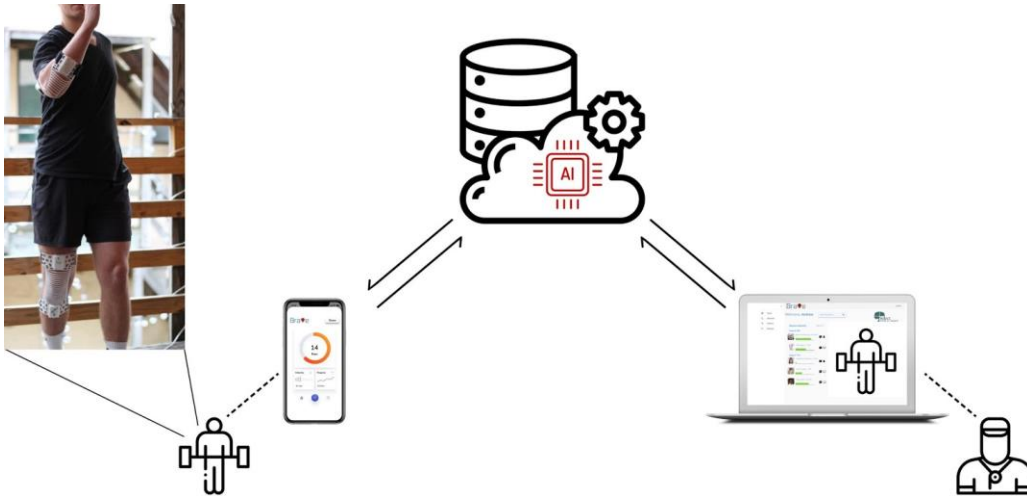
Note. Diagram made by our capstone project, Brave Virtual Worlds, to describe the

platform for our project.

     With patients already 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. Thus, the project's motion capture sleeve provides the convenience of enabling complaint at-home therapy routines with quantitative data collection to ensure recovery. This eliminates the need to sacrifice time by receiving professional care anywhere, anytime.

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). This can be mitigated through the accurate data reporting using the group's motion capture sleeve.

STS Topic

As previously mentioned, getting people engaged in physical therapy and at-home exercises has been an issue. With our mobile application, we want to gamify the experience, in order to make users more engaged in physical therapy and their in-home exercises. Computer games and personalized health share the ability to place the individual in the center of the action, by providing challenges and engaging the player (Blobel et al., 2012). By gamifying the experience, a plethora

of data is also collected, which can offer a new opportunity for individuals to understand more about their bodies, minds, and daily lives (Wallenburg & Bal, 2018). While there are upsides of gamification, how it has been carried out, and what has been done with the data collected, have been called into question. The wealth of data produced by gamification exists, the challenge is to find ways to analyze it (Blobel et al., 2012). The documentation of data produced, and how the data is presented to the user is crucial for the success of a gamified application. I want to be the most capable developer of this product because of the quality and engagement of the game, the extensive documentation of data, and making the mobile application user-friendly.

While in theory, gamification applications seem like the future of personalized medicine, there's 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).

With those thoughts in mind about the shortcomings of gamification, there also a lot of aspects that work. The main issue right now with physical therapy is there's not a great incentive to complete your in-home exercises. Gamifying the

experience challenges patients, sets goals, and creates 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. As already discussed, data by itself is weak, but gamifying the process does produce valuable data, and if analyzed correctly is a tremendous benefit to using gamification. The data the game generates will be used as part of the diagnostic systems, and the game will form an integral part of most treatment plans (Blobel et al., 2012).

Moving forward, the final key aspect of gamification is 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.

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 form the best possible product, some form of adaptive gamification should 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 should 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 needs 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.

Next Steps

As I continue to work on the mobile application, the next step is to take these thoughts into consideration as I design the gamification portion of the application. Specifically, focus on making a high-quality gaming experience, and extensive documentation and infrastructure for the data collected. Once that has been accomplished start looking at adaptive gamification, and how I can tailor the results towards individual users to increase interest and involvement. Finally, doing real life tests along the way, acquiring user feedback, and making the user interface as friendly as possible as I strive towards the best possible application to revolutionize physical therapy.

References

Athletico Physical Therapy. (2020) Physical Therapy for Back Pain - Spine Therapy - Low Back Pain Rehabilitation. (n.d.). Retrieved November 04, 2020, from https://www.athletico.com/services/specialized-services/spine-specialty-program/

Böckle, M., Micheel, I., Bick, M., & Novak, J. (2018). A Design Framework for Adaptive Gamification Applications. 10. https://scholarspace.manoa.hawaii.edu/bitstream/10125/50038/paper0151.pdf

Blobel, B., Pharow, P., & Sousa, F. (2012). pHealth 2012: Proceedings of the 9th International Conference on Wearable Micro and Nano Technologies for Personalized Health. IOS Press, 1, 85-96, https://books.google.com/books?hl=en&lr=&id=cqwQfyrD-oYC&oi=fnd&pg=PA85&dq=gamification+of+personalized+medicine&ots=xNL-OFjYm6&sig=rlKp7gFHdQAxwIVMLIJO55D7o7I#v=onepage&q=gamification%20of%20personalized%20medicine&f=false

Coppola, S. M., & Collins, S. M. (2009). "Is physical therapy more beneficial than unsupervised home exercise in treatment of post surgical knee disorders? A systematic review," The Knee, 16(3), 171–175, doi:10.1016/j.knee.2008.09.001.

Eaton, J. (2018, March 30). Medicare Fraud, Medical Identity Theft And Scams. Retrieved November 04, 2020, from https://www.aarp.org/money/scams-fraud/info-2018/medicare-scams-fraud-identity-theft.html

Grant, J. A., Mohtadi, N. G., Maitland, M. E., & Zernicke, R. F. (2005). Comparison of Home versus Physical Therapy-Supervised Rehabilitation Programs after Anterior Cruciate Ligament Reconstruction. The American Journal of Sports Medicine, 33(9), 1288-1297. doi:10.1177/0363546504273051

Hensley, C. P., Millican, D., Hamilton, N., Yang, A., Lee, J., & Chang, A. H. (2020). Video-Based Motion Analysis Use: A National Survey of Orthopedic Physical Therapists. Physical Therapy, 100(10), 1759–1770.

Hoeyer, K., & Bødker, M. (2020). Weak Data: The Social Biography of a
        Measurement Instrument and How It Failed to Ensure Accountability in Home
        Care. Medical Anthropology Quarterly, 34(3), 420-437.
        https://anthrosource.onlinelibrary.wiley.com/doi/10.1111/maq.12602

Klepps, R. (2019, October 04). 7 Facts About Physical Therapy You Can't Ignore.
        Retrieved November 04, 2020, from https://www.webpt.com/blog/post/7-
        thought-provoking-facts-about-physical-therapy-you-cant-ignore/

Lee, A. C., Davenport, T. E., & Randall, K. (2018, October 1). Telehealth Physical
        Therapy in Musculoskeletal Practice. Journal of Orthopaedic & Sports Physical
        Therapy, 48(10), 736 - 739.

Nelson, M., Bourke, M., Crossley, K., & Russell, T. (2020). Telerehabilitation is non-
        inferior to usual care following total hip replacement — a randomized
        controlled non-inferiority trial. Physiotherapy, 107, 19–27.
        https://doi.org/10.1016/j.physio.2019.06.006

Tuncer, A. B., Ergun, N., Tuncer, A. H., & Karahan, S. (2013). Effectiveness of
        manual therapy and home physical therapy in patients with
        temporomandibular disorders: A randomized controlled trial. Journal of
        bodywork and movement therapies, 17(3), 302–308.
        https://doi.org/10.1016/j.jbmt.2012.10.006

Wallenburg, I., & Bal, R. (2018). The gaming healthcare practitioner: How practices
        of datafication and gamification reconfigure care. Heath Informatics Journal,
        25(3), 549-557.
        https://journals.sagepub.com/doi/full/10.1177/1460458218796608