Immersive physical therapy experiences in virtual reality: how computer science can help in socially-distant times

Virtual reality (VR) is a practical and effective approach to facilitate physical therapy sessions during the COVID-19 pandemic as it eliminates COVID-19 transmission risk, reduces chances of injury (compared to video physical therapy), and provides individualized experiences for patients.

A team of researchers from the University of North Carolina at Chapel Hill's Computer Graphics and Virtual Reality research group conducted an investigation about virtual reality and image reconstruction for healthcare applications. They constructed an immersive exercise program in VR through the use of a two-fold 3D image reconstruction pipeline: first reconstructing the static background, then the human exercise animations, and finally combining the two components to form the interactive VR experience. The researchers used advanced software released in 2019 or later in developing the program.

Ritika Tejwani, the primary author, said "COVID-19 has restricted access to in-person health-care services and among those affected are patients requiring physical therapy. Furthermore, several physical therapy patients are those who have underlying conditions or are of old-age, making them more susceptible to COVID-19. Our research demonstrates that virtual reality is an effective approach to facilitate physician-patient communication and interaction without the risk of COVID-19 transmission."

The reconstruction of the static background used photogrammetry software to build spatial point clouds. The human model and exercise animations were reconstructed with a depth sensor, skeletal tracking software, and a rigging process in which the skeletal movements were applied to the physical therapist model. These two components were combined to form the VR experience in a headset, where the patient can successfully walk around and see the trainer in 3D, use functions such as play/pause and slow down, and see real-time annotations giving instructions for each exercise.

Feedback was also incorporated into the program. Using an algorithm known as dynamic time warping, the program compares the trainer and patient's exercise performance regardless of the time difference. It outputs a mathematically calculated accuracy score between 0-100% based on the patient's form, technique, and speed.

The authors found that the four features of the VR program: 3D space, real-time annotations, user interface, and feedback - make VR an effective approach to facilitate remote physical therapy sessions as the program eliminates COVID-19 transmission risk, reduces chances of injury, and provides individualized experiences for patients.

The researchers also found that feedback was very important to the effectiveness of the virtual learning experience. As Dr. Michael Lewek, a physical therapy and researcher, explained, "Feedback should be

given after the patient completes the exercise; continual feedback (feedback during the exercise) distracts the user and causes them to overuse or underuse certain muscles, which could cause injuries if repeated." This project could be further improved by analyzing the accuracy of the dynamic time warping score and the impact of the feedback on user performance.

Limitations of the design and functionality of the program include visual quality and tracking accuracy. The visual quality is restricted by the technology used, which is not advanced enough for patients to be able to see high-clarity muscle movement details. As a result, patients could be misguided on proper form for exercise and may be at a higher risk of injuries. Furthermore, the technology is not advanced enough for exercises in which one limb goes in front of the other. In such exercises, the Kinect v2 skeleton tracking becomes disjointed and is unable to accurately reconstruct the movements, thus restricting the use of complex exercises and those that involve lying on the ground. Further research could be conducted to find cost-effective yet higher-quality skeletal tracking methods.

In the future, this project could be advanced by creating a real-time experience, where the input data is processed and feedback is available almost immediately for a more realistic and efficient patient and physical therapist interaction. Future research could also incorporate data from wearable fitness devices to better track patients' form and thus provide more accurate feedback.

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1. Research article:

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