Integrating Virtual Reality and Motion Capture in Unity 3D for the Training of Children with Cerebral Palsy

Xiaoxu Ji
Department of Biomedical, Industrial and Systems Engineering
Gannon University
Erie, PA 16541, USA
ji001@ gannon.edu

Kristen Snarski
Department of Physical Therapy
Gannon University
Erie, PA 16541, USA
snarski001@gannon.edu

Arnon Ashkenazi, Ethan Swierski and Davide Piovesan, *Member, IEEE*
Department of Biomedical, Industrial and Systems Engineering
Gannon University
Erie, PA 16541, USA
ashkenaz001@ gannon.edu, swierski001@ gannon.edu, piovesan001@gannon.edu

Abstract

This study has successfully created a virtual reality training environment for wheelchair users aimed to serve children with severe cerebral palsy and cognitive impairments. The proposed system integrates motion tracking with virtual reality technologies in real time for rehabilitation purposes. The system aims at improving the trainee motor functions allowing the caregivers to directly interact with the child using visual cues. The live motion trajectory recorded from caregivers could provide a strong interaction with patients to enhance their engagement, comfort, and enjoyment of training. The proposed system can potentially help improve the lives of dozens of children who suffer from the effects of cerebral palsy in a safe, cost-effective, and entertaining environment.

Cerebral palsy (CP) is one of most common diagnosed childhood motor function disabilities in United States. It affects a person's movement and coordination of muscles to maintain balance. Though many treatments do exist on the market, they can be expensive and time-consuming activities which are often beyond the means of many families. There is often the problem of limited space available for practicing the control of assistive devices in a safe manner. Virtual reality (VR) technology has gained attentions as an intervention to improve motor function for the children with CP. It can provide end-users the feel that they are engaged with their surroundings with far more realistic conditions than a training program which involves only screen-based action. Meanwhile, the level of task difficulty can be easily modified to effectively improve their motor function, based on the real-time feedback from task performance. In 2022, the report from Birth Injury Help Center indicated that a large percentage of children with CP have some level of hearing impairment. It directly leads to their speech and language problems, which greatly results in their difficulties to follow instructions and may result in training ineffectiveness. Accordingly, motion tracking technology can be used to incorporate visual cues from the therapist within VR sessions when interacting with individuals affected by CP. Unity 3D software was used to create the VR environment in this study. Considering that the users will be children with CP, the training "game" was produced to simulate a moving wheelchair in an urban environment. The different therapy training levels are provided by changing the driving speed of the wheelchair and the number of obstacles in the VR environment. The individual can control the wheelchair by only steering left or right. Additionally, Xsens MVN system was used to capture the full-body movement of one volunteer, which was selected as the caregiver's action for patients to follow. Given the unique compatible feature of Xsens and Unity 3D,

the live motion of the caregiver recorded by Xsens was successfully projected into the VR environment to effectively provide real-time instruction/command and obtain a reaction from children with CP. Our study has successfully created a VR motor function training environment. This is the first time in which motion tracking technology is used within VR for the training purpose of children with CP. This technique solves the limited space issue for mobility training avoiding the risk for the trainee of getting physically injured in the realistic circumstances, by not being able to control a powered wheelchair. It also adds a layer of connection between the caregiver (therapist or parent) to directly interact the trainee within the VR environment. This is specifically important for children who have hearing impairment or cognitive deficit. The caregiver can directly interact with the child indicating the direction to go and providing a familiar human interaction. The combination of VR and motion tracking technologies makes for a comfortable training environment with the interaction between patients and caregivers that can greatly improve the confidence of the child.

Keywords
Cerebral palsy, Virtual Reality, Rehabilitation, Unity 3D and Xsens MVN

Biographies
Xiaoxu Ji is an Assistant Professor in the Department of Biomedical, Industrial and Systems Engineering at Gannon University. He received his Ph.D. in Kinesiology (2011-2015) from the University of Western Ontario, Canada. Dr. Ji's main research interests include the application of motion tracking technology in Ergonomics; the application of robotics to reduce the risk of whole-body vibration transmitted to heavy machinery operators; and the application of Artificial Intelligence (Neural Network) algorithm in modeling design.

Kristen Snarski is an Assistant Professor in Physical Therapy Program at Gannon University. She received her Ph.D. in Pediatric Science in 2018 from the Rocky Mountain University of Health Professions. Dr. Snarski is also a Physical Therapist at Barber National Institute, Erie, PA.

Arnon Ashkenazi graduated from Gannon University in 2021 with degrees in Biomedical engineering. Currently, he is employed at Guardant Health.

Ethan Swierski is a senior undergraduate student with Biomedical engineering major and Mathematics minor at Gannon University. His research experiences include CAD modeling, FEA, prototyping, biomimetic robotics, and Virtual Reality.

Davide Piovesan is a Professor and Chair in the Department of Biomedical, Industrial and Systems Engineering at Gannon University. He received his M.S.M.E in 2003 and Ph.D. in Mechanical Measurement for Engineering in 2007 at the University of Padova, Italy. Davide's main research interest is to gain insights on the role of biomechanics in the neural control of movements, with applications to rehabilitation engineering. He is also Interested in Assistive devices and Additive manufacturing. He is the founder of the Special Process and Additive Manufacturing (SPAM) laboratory at Gannon University.