LITERATURE REVIEW III

Name : Shwetambara Narayan Patil

UML ID : 01666303

E-mail : ShwetambaraNarayan_Patil@student.uml.edu

Date : 04/18/2018

PRIMARY PAPER :

The Implementation and Validation of a Virtual Environment for Training Powered Wheelchair Manoeuvres

@ARTICLE{7917262,
author={N. W. John and S. R. Pop and T. W. Day and P. D. Ritsos and C. J. Headleand},
journal={IEEE Transactions on Visualization and Computer Graphics},
title={The Implementation and Validation of a Virtual Environment for Training Powered Wheelchair Manoeuvres},
year={2018},
volume={24},
number={5},
pages={1867-1878},
keywords={Monitoring;Navigation;Tools;Training;Virtual environments;Visualization;Wheelchairs;Virtual reality;simulation;virtual environment;wheelchair navigation},
doi={10.1109/TVCG.2017.2700273},
ISSN={1077-2626},
month={May},}

SECONDARY PAPER :

Development of a wheelchair simulator for children with multiple disabilities

@INPROCEEDINGS{7155405,
author={N. Rodriguez},
booktitle={2015 3rd IEEE VR International Workshop on Virtual and Augmented Assistive Technology (VAAT)},
title={Development of a wheelchair simulator for children with multiple disabilities},
year={2015},
volume={},

number={},
pages={19-21},
keywords={handicapped aids;patient rehabilitation;patient treatment;virtual reality;wheelchairs;children;multiple disability;rehabilitation;therapy field;virtual reality;wheelchair simulator;Games;Pediatrics;Prototypes;Solid modeling;Virtual environments;Wheelchairs;augmented and alternative communication;disability;interaction devices;learning;multiple disabilities;simulator;virtual reality;wheelchair},
doi={10.1109/VAAT.2015.7155405},
ISSN={},
month={March},}

Summary

The primary paper here addresses the issue of driving the powered wheelchairs around. Learning the necessary driving skills can be a tough task, particularly for individuals with severe, or multiple motor limitations. There are many challenges in the process such as the need to improve a person’s spatial awareness, reaction times, familiarization with and general confidence in the wheelchairs operation. Although modern buildings increasingly accommodate people with disabilities, there are still many areas where wheelchair access is still an issue and rely on learning to control the device. However, there is no common standard for wheelchairs and each company has it’s own protocol.

There have been attempts to use virtual reality (VR) to help train wheelchair users, but price and technology limitations have been a barrier for economic feasibility. However, affordable, high fidelity interfaces for VR such as the Oculus Rift head mounted display are now becoming readily available. The authors have hypothesized a game that utilizes affordable modern interface technologies can provide a safe environment in which a new user of a powered wheelchair can quickly learn how to operate it, and navigate it through different scenarios. The paper focusses on the design and implementation of a VR training environment that exploits the new generation of HMDs. Although aimed at a specific user domain lessons learned will be relevant to other training applications.

The paper takes reference from the secondary paper which sheds light on the development of a wheelchair simulator designed to allow children with multiple disabilities to familiarize themselves with the wheelchair, aged between 13 and 16 years. This simulator will prepare children to wheelchair driving based on motor and cognitive aspects. As multiple disabilities is a serious handicap associating motor impairment and severe mental retardation. In addition, the handling of the vehicle is not intuitive and requires practice, especially for patients with severe motor dysfunction preventing them from using conventional devices such as the joystick. A simulator may help find which devices are suitable for the individual and teach him how to use it without taking any risk.

In this paper, the target users have extreme difficulties in communication; the level of verbal expression and even body language is very low. But studies and experiences in educational centers, show that children are able to express themselves and learn when you provide the right tools. The simulation tool has four independent wheels, allowing simulating the behaviour of the wheels of various models of real wheelchairs. Authors set the correspondence between the different movements of the wheels and the values of the joystick in order to better reproduce in the simulator the real behavior of the wheelchair.

Working with a small group of children, authors managed to get ways to improve and offer a tool used by children with multiple disabilities. The system can however, only be tested with children in an advanced state of development.

The authors of primary paper studied the previous work based on two factors :

- The importance of VR as a training tool

  They state a survey by Slater and Sanchez-Vives which states that new affordable systems will facilitate not only the reach to final consumers but also to more developers and research groups, resulting in a much wider range of applications and generation of content for VR that will emerge in the near future. They also came across many examples where VR has been used to train the motor skills required to carry out specific medical and surgical procedures.

- Prior work on wheelchair simulators

  The previous studies provided some evidence that VR training can be effective and increase the motivation of the users. However, it was evident that the models of wheelchair behaviour needed to be improved as the visual interface and the integration of feedback was not explained.

Based on the previous work, authors identified the need for three main areas of development:

1) Environments that actively train speed modulation and wheelchair control in complex spaces, particularly crowded areas.

2) Interfaces which allow for natural interaction and accessibility to physical interfaces such as switches, door handles, swipe card mechanisms, etc.

3) Force-feedback, allowing the user to feel the virtual environment through the wheelchair.

While some force-feedback has been shown to be effective in wheelchair simulation, it is an area which has received relatively little attention. The authors addressed the first two of these areas in this paper for implementation of Wheelchair-VR. Wheelchair-VR was designed and tested with subject matter experts from four different regional Wheelchair Centres.

Authors restricted the simulation to Class 2 wheelchairs, which can only be used on the pavement if outside and are limited to traveling at 4 mph. The wheelchair was based on two units : The control unit and the drive system. For training purpose, the trainee is given a first person view of the scene from the perspective of sitting in the virtual wheelchair model. If the trainee looks down, they will see virtual legs in the position where their real legs would be. The following scenarios were taken into consideration:

- Navigating through a simple maze, requiring the user to make several turns, open doors, and maneuver through doorways.
- A goal orientated scenario consisting of navigating through a room filled with floating red and blue balls. The trainee has to collect all of the blue balls by driving in to them. Collisions with the red balls must be avoided.
- Traverse a room that contains a random number of human size capsules that move around the room. This represents driving the wheelchair through a crowded room.
- Navigate through a track made up of kerbstones as quickly as possible, avoiding collisions with a kerbstone.
- A room full of ramps that must be ascended and descended. Time taken is recorded.

The validation study was performed to determine if the VR simulator had any effect on learning the driving skills needed to safely operate a real powered wheelchair. Thirty three able-bodied volunteers participated in the validation study. They were all screened at the beginning of the study to ensure that they could demonstrate a good reaction time. The participants were randomly divided into three groups of eleven: a Control group who would receive no training; a ‘HMD’ group who would receive training using the immersive Wheelchair-VR application; and a ‘Desktop’ group who also used Wheelchair-VR but just with a desktop monitor and not the HMD.

The authors carried out one-way analysis of variance (ANOVA) on the overall timings from the first run of the obstacle course to confirm that there were no significant differences between the three groups. The initial prediction was that most participants in the validation study would likely improve between the first and second run of the obstacle course, just from the experience of having completed the course once before. However, the overall improvement with the HMD group was far better than both the Control and Desktop groups, and showing significance at the 5 percent level for some of the particular manoeuvres. There is less evidence that any group did significantly better in learning how to manouevre through a physical doorway, which seemed to be the most challenging task, despite the fact the physical doorway was designed for wheelchair access and could be opened automatically. Authors attribute this to VR training systems being predominately non-contact.

The authors created and demonstrated the utility of a costeffective virtual environment for powered wheelchair training, built from commercial off-the-shelf components. A serious game (virtual environment) utilising the Oculus Rift HMD can provide a safe environment in which a new user of a powered wheelchair can quickly learn driving skills. They want to improve in future to reduce the occurrence of cybersickness. Once the cybersickness problem has been alleviated, they plan to perform a second validation study with volunteers who are actual wheelchair users.