The Modification and Development of a Simulator for Powered Mobility for Children

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***Abstract*—This poster describes the process of developing and modifying of the McGill Immersive Wheelchair Simulator (MiWe) for children with physical disabilities (MiWe-C). The simulator enables children to practice driving skills in a controlled environment. Data from the validation process for children who are proficient drivers are presented.**

Keywords—powered mobility, simulator, children with physical disabilities

I. Introduction

Independent mobility is a major milestone in a child's development. Through it a child develops motor, sensory, cognitive and spatial skills [1]. When independent mobility is limited, assistive devices may be provided including crutches, manual or powered wheelchairs. Learning how to use the devices entails practice, with some devices requiring more practice than others. Learning powered mobility for some children can be difficult, therefore practice is essential [2]. However, not all children have access to powered wheelchairs for intense practice and their ability to reach a proficient level of driving is thus hindered. Simulators have been found to be a viable practice option for adults, enabling them to master specific skills, and to practice in a controlled environment, without the need for constant supervision [3]. For children, simulators appear to be an alternative practice option where long term practice is needed or powered chairs are not available.

II. Methods and Results - Powered Mobility Simulator

A. Identifying a Powered Mobility Simulator

Three simulators were used to illustrate training of navigation skills within a virtual environment to a focus group. The first was the EnvironSim simulator [4] developed to assess executive functions in a shopping mall without specific applications for practicing powered mobility. The second was the Star Kart [5], an animated simulator for practicing powered mobility and the third was the McGill Immersive Wheelchair Simulator (MiWe) that was designed, validated and researched for adults [6,7] but not for children. All developers were contacted to determine if the affordances of these simulators were appropriate for training powered mobility of children with physical disabilities.

B. Focus Group Participants and Protocol

A group of ten powered mobility experts (pediatric occupational and physical therapists, powered mobility vendors and a simulator developer) with more than 20 years of experience each, took part in a two-hour focus group. Following an explanation of the goals, a short overview of the research objectives was presented and three different virtual simulators were shown. The participants were then asked to generate a list of key elements needed in powered mobility training environments, what data should be recorded during training, and how it should be presented to participants. The recommendations were divided into different areas: (1) general characteristics of a simulator, (2) how a powered wheelchair should be rendered in the virtual environment, (3) key data outcomes and (4) essential elements of powered mobility (e.g. acceleration) that need to be incorporated into the simulator.

C. Recommendations

All participants agreed that the simulator needed to be realistic with a life-like appearance (eliminating the Star Kart), to have ambient background sounds, to provide auditory feedback of collisions, to randomize the levels of difficulty during practice, to display avatars that walk or sit during the simulation and to be viewed from a first person perspective. These recommendations were compiled and then evaluated in terms of their feasibility and cost/benefit trade-offs given the constraints of the target population and research goals. The MiWe simulator best met the recommendations and was selected to serve as the base platform for a child-appropriate version.

D. Modification of MiWe simulator for children (MiWe-C)

Illogika (www.illogika.com), the MiWe developer participated in a series of discussion sessions in which designs for adaptation of the six original MiWe tasks were compiled. These included the addition of children avatars to enhance virtual presence, randomization of task levels, rendition of a local pediatric rehabilitation hospital's physical features, and inclusion of an automatic activation button for doors and elevators. A Hebrew language interface was also added as were two hospital routes for evaluation purposes. Navigation of the two routes incorporated skills needed to drive a powered wheelchair (e.g. controlling all directions, driving through doorways, and stopping when obstacles encountered

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and at a predefined locations). These design features were compatible with the Powered Mobility Program (PMP) [8], well accepted evaluation outcome measure.

Certain recommended modifications were not implemented due to limitations in the interface and the ability to program the joystick parameters. For example, the focus group recommended that the wheelchair avatar reflect different wheelchair configurations but this could not be readily coded. Another example was the simulator's joystick interface, which in contrast to regular powered wheelchairs, could be used in one speed only. Furthermore, the range of acceleration and deceleration values were limited.

The simulator was developed over a period of 12 months and included 32 versions until the final prototype which is currently being tested.

III. METHODS AND RESULTS - VALIDATION OF SIMULATOR FOR CHILDREN

A. Participants

Thirty children aged 5-18 years, with a physical disability (Cerebral Palsy, Spinal Cord Lesion, Neuro Muscular Conditions) are participating in the study. All children used a joystick to drive their own powered wheelchair which was provided to them by the Ministry of Health after their recognition as a proficient driver. They had at least three months of driving experience at the time of testing. Children who use ability switches or a scanning device to drive their powered wheelchair were excluded. The study took place in ALYN Hospital, Jerusalem Israel and was approved by its Research Ethics Committee. Informed written consent was obtained from all parents and participants.

B. Instruments

The participants used their personal wheelchairs and access devices while being assessed. A laptop computer with a hybrid joystick was used to assess navigation via the MiWe-C. Two different virtual routes were developed, replicating two physical routes within the hospital. The children drove one of two routes in their powered wheelchair and using the simulator. Their driving skills were assessed using the PMP [8], an outcome measure including up to 34 tasks and the Assessment for Learning Powered Mobility (ALP) [9] that assesses the user's emotional, intellectual and behavior elements of power mobility

C. Procedure

A demographic questionnaire was completed by a parent prior to commencement of the study and consent forms were signed. Data were collected during a single 60-minute evaluation where children drove their powered wheelchair through one of the hospital routes and then drove the same route via the MiWe-C simulator (order was counterbalanced). The children were evaluated using the PMP and the ALP. The PMP was performed twice, once for the powered wheelchair and once for the simulator whereas, the ALP was performed once at end of session, based on performance in both conditions.

D. Statistical analysis

All data were analyzed using non-parametric statistics in SPSS version 25 (SPSS, Inc., Chicago, Illinois). The Wilcoxon Signed-rank test will be used to compare differences in the PMP scores between the two conditions (driving a powered wheelchair and the MiWe-C simulator).

E. Results

To date, data from 12 participants have been collected. Their mean (SD) age was 14.9 years (3.0) and their mean (SD) driving experience was 3.7 years (2.0). The mean (SD) ALP score was 7.75/8.0 (.34). The mean (SD) powered wheelchair and simulator PMP scores were 4.94/5.0 (.15) and 4.91/5.0 (.12), respectively. These high scores demonstrate that the participants were extremely proficient in both powered wheelchair driving and in navigating the simulated tasks, with no significant differences between them ($Z=1.47$, $p=.14$).

CONCLUSIONS

A simulator for children to practice powered mobility in a controlled environment was designed to provide an alternative practice option for children who need to become proficient powered wheelchair drivers. Initial findings demonstrate good validity. These results substantiate its use in an ongoing study comparing the effectiveness of proficiency training via a simulator. Authors and Affiliations

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