Training Powered Wheelchair Manoeuvres in Virtual Reality

THOMAS W DAY, CHRISTOPHER J HEADLEAND, PANAGIOTIS D RITSOS, SERBAN R POP, NIGEL W JOHN
UNIVERSITY OF CHESTER, BANGOR UNIVERSITY
Motivation

2016 has seen the release of multiple cost effective Head Mounted Displays
- Oculus Rift, HTC Vive, Gear VR

Possible medical applications that can benefit from a HMD?
- Full immersion
- Head tracking so you can look around the virtual environment
- Interaction with joystick or other intuitive peripheral
  - E.g. Leap Motion for hand tracking

One possibility is training powered wheelchair manoeuvres in a safe environment
Wheelchair-Rift Hardware

Oculus Rift DK2

Microsoft Xbox One Controller for a convenient joystick
  - A joystick adapter has been 3D printed to resemble the joystick on an actual powered wheelchair

Standard “Gaming” Desktop PC or Laptop
Wheelchair-Rift Software

Unity 3D
- Cross platform games engine with advanced physics and rendering
- Offers built-in VR support for most head mounted display
  - E.g. Oculus Rift, HTC Vive
  - Plugins Available for different input devices.
Wheelchair Physics

Real Wheelchairs
- Two wheel drive, free motion of front pivoting front caster wheels
- Direction changes are made by variable speeds on each individual powered wheel

Hand-operated joysticks with proportional control are now the *de facto* interface for most wheelchair users

Virtual Wheelchair
- Two models were developed for the purposes of this simulator
  - A physics based model
  - A non-physics based model
- The latter was chosen because of its adaptability to different chair specifications
- The virtual wheelchair was limited to a max speed of 5 mph, as per the regulations on indoor powered wheelchair usage.
Training Environment

Any desired training environment can be modelled

For our prototype, we designed a virtual building with a different challenge on each level:
- Collecting objects by driving up to them
- Avoiding static and moving obstacles
- A maze of doorways

Metrics such as time taken and obstacles hit can be recorded by the software
Simulator in Use
Does it work?

No standard method of training or assessment.
- Four different PMG Centres were visited
- All used different methods of training and assessment

Some examples of good practice identified

Our first validation study using able bodied participants was recently completed...
Validation Study

A validation study was carried out using 33 able bodied participants
  ◦ Age range 20-55, Male and Female

All participants navigated an obstacle course in a real chair to establish their driving competence at the beginning of the study.
  ◦ A Spectra XTR2 powered wheelchair was loaned to us by Invacare.

The participants were then randomly divided into three groups of eleven:
  ◦ Desktop - trained with the simulator using a standard desktop monitor
  ◦ VR - trained with the simulator using an Virtual Reality Head Mounted Display
  ◦ Control Group - no training given, they just read a guide to using an electric wheelchair safely

All participants repeated the obstacle course after the training period
Validation Study – Reaction Times

Reaction times were accessed for each participant using a mobile reaction time app.

Each participant did the reaction test 3 times and the average reaction time was calculated.

All reaction times were within an acceptable range and no-one was excluded from the study.

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<thead>
<tr>
<th>Response Test</th>
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Validation Study – Obstacle Course

The obstacle course for the Spectra consisted of 4 sections

- Doorway
- Arches
- Slalom
- Reverse Parking

The time taken to traverse each section, together with the number of cones hit was recorded.
Slalom and Reverse Parking Tasks
Validation Study - Results

Results from the validation showed greater improvement (i.e. less time taken to successfully navigate the obstacle course) for those who used the oculus.
Validation Study - Results
Overall Improvement per Group

![Graph showing overall improvement percentages for Control, Desktop, and Oculus groups](image-url)
Cyber-sickness

The feeling of motion sickness when in virtual reality using a head mounted display.

Each participant in the VR group filled out a SSQ (Simulator Sickness Questionnaire) before and after training.

Most of the participants did feel some effects of cyber-sickness.

Caused by a neuro conflict, for example, seeing motion but not feeling it.
# Validation Study - Feedback

<table>
<thead>
<tr>
<th>DESKTOP</th>
<th>VIRTUAL REALITY</th>
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<tbody>
<tr>
<td>Training without worry of hitting real object</td>
<td>Realistic Feeling / Control</td>
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<td>Simulator felt like a computer game</td>
<td>Sense of spatial awareness</td>
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<tr>
<td>Unable to look around</td>
<td>Nausea / Cyber-sickness after period of use</td>
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<td>Lack of depth or perspective</td>
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Future Work

Improved hardware
- New Oculus Rift, Wheelchair Joystick
- Haptic Feedback
- Hand Tracking

Augmented Reality Training
- Use a real powered wheelchair but with virtual objects to manoeuvre around
- Possible use of the HTC Vive or Microsoft Hololens

Planning to apply for EU funding
- Let me know if you are interested in partnering with us
Questions

Visit our web site for more information on this and other medical simulations projects

- http://medical-graphics.org
Acknowledgements

Invacare Ltd
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The participants that took part in the validation study