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Rotate and Lean: Does Leaning towards the Target Direction Improve Virtual Reality Navigation?

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Motivation

Standard locomotion interfaces for Virtual Reality (VR), such as joystick or mouse/key-board can lead to disorientation or motion sickness. This motivates the need for development of alternative embodied locomotion interfaces.

Research Questions

This study investigates whether physical rotation and leaning-based translational motion cueing can help to reduce motion sickness and disorientation and improve the user experience and usability in terms of:

- motion sickness
- sensation of self-motion (Vection)
- spatial presence
- intuitiveness
- precise control
- ease of use
- overall usability

Methods and Materials

Technology: HTC Vive Head-Mounted Display

Study Design: Within-Subject, mixed methods

Conditions: Joystick vs. 3 more embodied interfaces

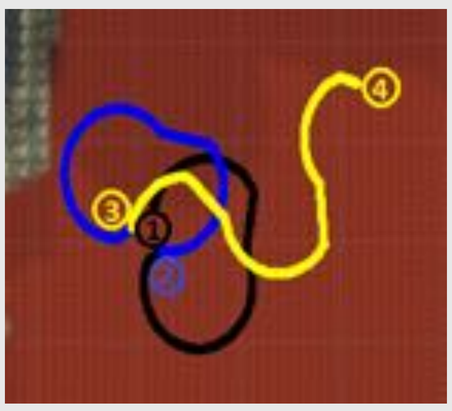
Participants: 14 student volunteers (age: 21.4)

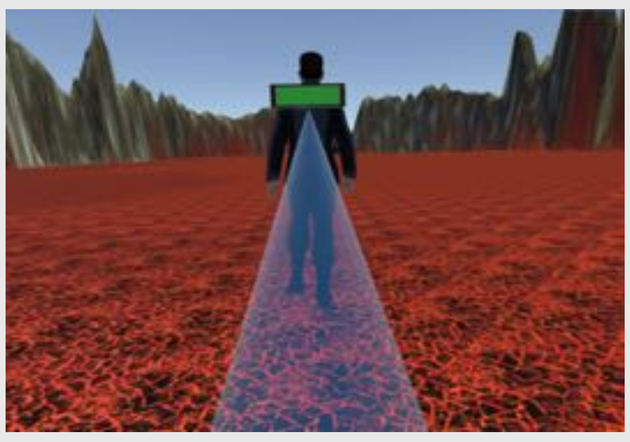
Task: Following avatar along unpredictable curvilinear path (see below Figure)

Behavioral Measures: Distance/angular error

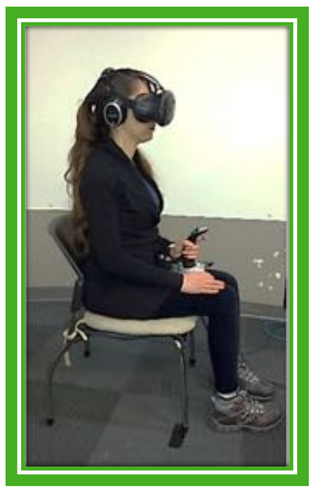
Introspective Measures: Post-trial questionnaire to assess 15 aspects of user experience using visual analog scale (0-100%).

Qualitative Measures: Post-experiment open interview





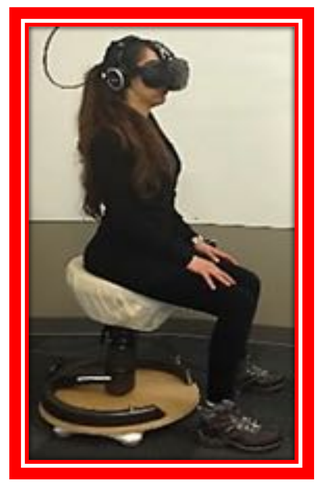
Interfaces



Joystick
Familiar joystick used as the gold standard interface for the control condition.

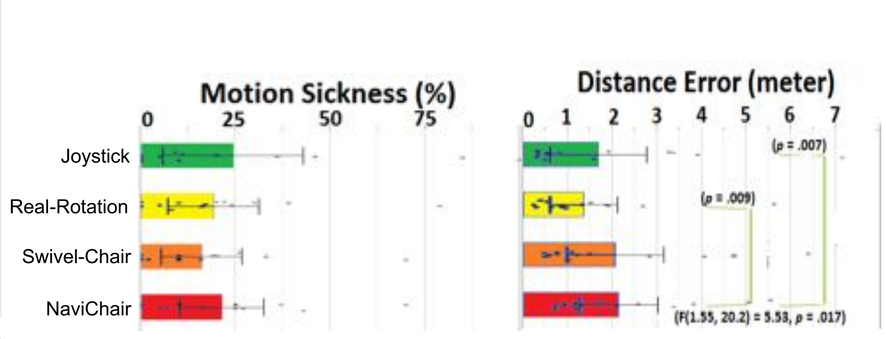
Real-Rotation
An HTC Vive controller attached to the backseat of a regular office swivel chair. User rotates physically to control their simulated rotation, and uses a joystick for forward/backward and sideways translation.

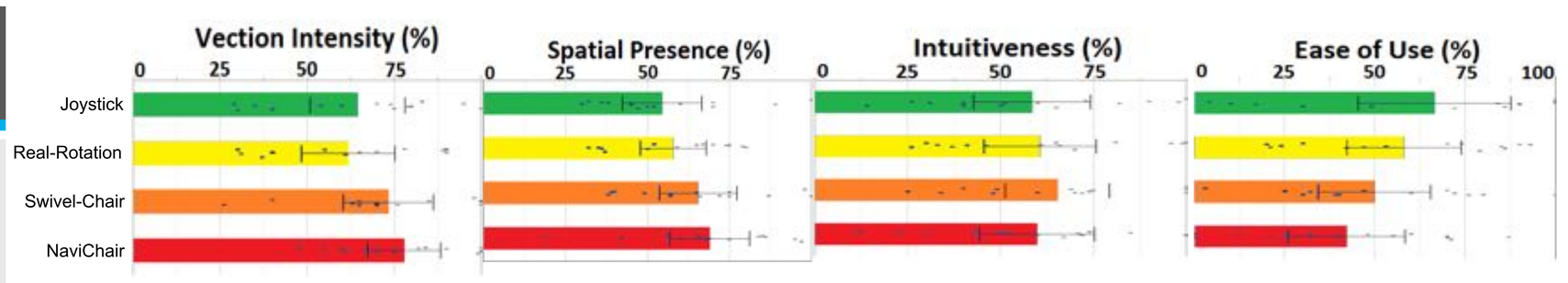
Swivel-Chair
Similar to Real-Rotation, but users controls forward/ backward translation by leaning the chair backrest forward/backward, while sideways upper torso movements control sideway locomotion.

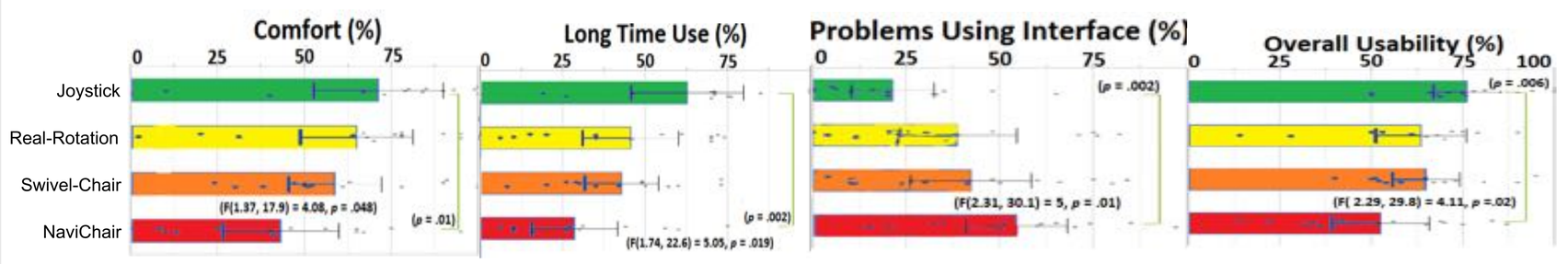


NaviChair
User sits on a seat/stand stool (Swopper™) mounted on top of a Wii Balance board force plate, and controls forward/ backward and sideways translation by shifting their weight toward the corresponding direction.

Quantitative Results







Qualitative Results

Joystick: 2 participants enjoyed the Joystick over the other interfaces. However, five participants mentioned that joystick locomotion was not natural, and two of them reported that they rotated their neck instead of rotating the joystick.

Real-Rotation: 5 participants enjoyed Real-Rotation more than the other interfaces. However, four participants mentioned that it was difficult to control two different interfaces (i.e., chair for rotation and joystick for translation) simultaneously.

Swivel-Chair: 5 participants enjoyed Swivel-Chair more than the other interfaces. However, five participants mentioned that it was difficult to decelerate by leaning backwards.

NaviChair: 2 participants enjoyed NaviChair more than the other interfaces. However, eight participants mentioned that it was hard for them to control it accurately. Two participants reported that it was too loose and jumpy and three participants indicated that the NaviChair was too high for them.

Conclusion

Swivel-Chair seems promising, because it showed no significant differences with the joystick, which means that its usability is approaching or even matching that of a well-used interface such as joystick.

Moreover, the Swivel-Chair showed a trend towards reduced motion sickness and higher sensation of self-motion, spatial presence, and intuitiveness than both the joystick and Real-Rotation.

However, Swivel-Chair had slightly higher distance error and usability problems, and lower ease of use, comfort, long time use and overall lower usability than the joy-stick.

NaviChair showed higher distance error and usability problems and lower comfort, long time use and overall usability than the joystick.

In sum, combining physical rotation with leaning-based translation for VR locomotion is a viable direction for development of better VR interfaces, but some usability aspects need to be improved.

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