Interaction Techniques for Laymen in Immersive Virtual Reality

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ABSTRACT
Virtual Reality is increasingly gaining space in the consumer market, and other uses for this technology - besides the mainstream gamer target - are starting to appear as exciting solutions for old problems. However, the average user for non-traditional virtual reality applications still faces difficulties getting adjusted to the most trivial of interactions. We present some of the most relevant problems we encountered by observing laymen during their first experiences with virtual reality headsets, as well as a series of navigation tests each designed to solve a different subset of such problems. Within this work we have no ambition of proposing a definitive solution in this area that still has much to grow, we offer a better perspective over the problem and point out the best directions to follow in the search for the best immersive interaction heuristics for laymen.

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virtual reality; 3D user interaction; immersive systems; Oculus Rift; cybersickness;

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H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION
Virtual Reality (VR) has been around for a long time, recently however it has received a considerable amount of attention given the popularity of new consumer affordable devices in the market (e.g. Oculus Rift). The main target of such products, computer gamers, are already used to the idea of 3D virtual environments as well and interacting with them. Given the motivation to play such games, and the amount of time often spent on them, it is not difficult to imagine such users adapting to this new technology. But VR has potential to be applied to so much more than entertainment, and reach a much broader audience than just gamers.

Not all potential users of new VR applications are accustomed to interacting with virtual environments, and neither are willing to spend time getting familiarized with such technology. On the contrary, chances are that an average interaction shouldn't take more than a few minutes, and an unpleasant experience would likely backfire on the goal in question. This work is precisely focused on how to offer the best experience possible to a laymen interacting with a VR headset device inside a virtual environment for the first time.

One exciting use case of VR is for real-estate sales. The experience of being able to look and walk around a house that hasn't yet been built in reality is promising. Being such an important and expensive purchase, any simulation that is able to offer relevant comforting feedback to the buyer is likely to be found useful in the sales process.

PROBLEMS
To firstly identify the existing problems, a quick and dirty [5] user test was applied to a small group of laymen (i.e. users that have little to no experience with games or other kinds of virtual environments). The setup was the following: a Oculus Rift headset was worn by the user, while standing-up, that found himself inside a two-story house. A guide with control over the application would ask the user to choose the direction he/she wished to explore by looking at it, and the guide would activate the movement in the chosen direction (figure 1).

Figure 1. The setup for testing the navigation with Oculus Rift with a guide handling the navigation

The main issues brought up were the following:

- **Translation without user movement:** The fact that the user would see himself moving without actually walking caused cybersickness [6] in most tests, and this problem would aggravate during vertical movements (e.g. stairs).
- **Imprisoned feeling:** All users without exception once accustomed to the virtual environment would feel the urge of walking instead of being navigated by the guide. The mandatory cable connections - one for receiving the scene render, the other for returning the headset orientation - due to optimal latency not yet being achievable through wireless data-transfer, broke the immersive feeling and freedom of the experience.
- **Lack of an avatar:** Looking down and seeing an empty space brought up negative feedback from testers, that reasonably informed that such experience only distanced them from a sensation of reality.
- **Lack of haptic feedback:** Leaning towards a wall, or occasionally walking through scene objects also broke the immersion sensation from users.
- **Lack of control:** The users that brought up that they felt uncomfortable with not being able to navigate themselves were given the opportunity to do so. However, being laymen, they were also not comfortable and experienced difficulties with the control interfaces available: a mouse and keyboard, or a console joypad.

EVALUATED METHODS

Being an open problem, different methods with specific improvements as well as limitations were proposed to mitigate some of the problems mentioned above. Due to the fact that none of the methods of this nature had been previously attempted by the authors, once again a quick and dirty approach was used dispensing formalism with the goal of obtaining a more direct and broad feedback. The methods implemented and tested were:

- **Teleport:** Given that translation was a major problem during user testing, the first chosen approach was a straightforward no-translation solution. The user would select the location he/she would wish to teleport through a menu by looking downwards (figure 2), and the selection was made by looking at the same option for a minimum duration threshold. Despite not being able to navigate freely, the user had no limitations to examine the environment around him.

  The teleport method was very low cost, not demanding any sensor or controller. It succeeded in eliminating dizziness and vertigo, however the complaints around feeling stuck and the lack of an avatar were always present. Cable tangling was also an issue. It proved to be a cheap, easy to develop, and useful approach, but still far from a definite solution.

- **Kinect:** The main goal of using motion capture was to allow navigation through gestures and solve the avatar problem, while also making head-tracking (not available in the first Oculus Rift devkit) possible. The user would be able to see him/herself as a virtual avatar performing the navigation gestures, and would also gain visual feedback from translating his/her head sideways. Such gestures would be inspired in a previous work made for caves [2].

  Our effort in combining the VR headset with a Kinect proved to be unsatisfying. Firstly, even an user already comfortable with the device would have trouble maintaining a correct alignment with the Kinect camera, causing increasingly capture precision problems during the interaction. Secondly, despite the avatar feedback appearing to be coherent when seen in the third person, when immersed most users felt a uncomfortable sensation due to the lack of coherence with their known body movements and the visual feedback, i.e. the precision tolerance for the feedback from the avatar proved to be much lower in the 1st person point of view than in the 3rd person, causing a fall into the uncanny valley (figure 3) [7]. Lastly, vertigo and dizziness still remained.

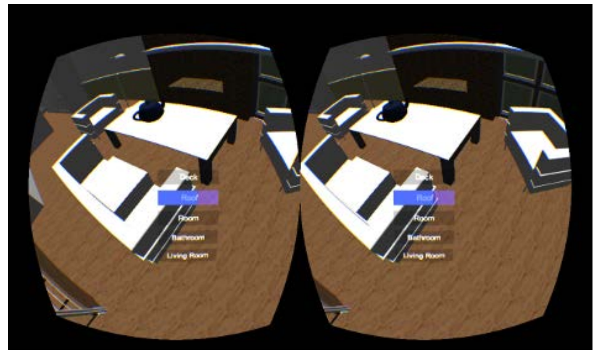

Figure 2. Virtual teleport menu during interaction

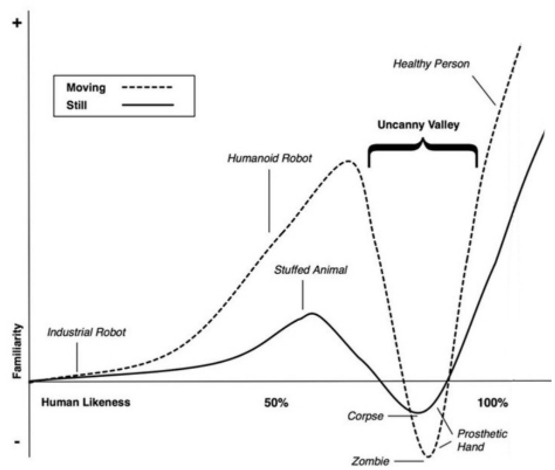

Figure 3. Uncanny Valley

- **Vehicle:** Delegating the translation responsibility to another object is a visual hack that can convince the user that translation may be occurring naturally despite the lack of feedback from ones own body. It is also very convenient in this scenario since: it would justify siting down (avoiding vertigo [9]); would not demand physical space for movement; and would avoid cable tangling problems since the user orientation would be fixated. Vehicle usage also opens a diversity of possibilities of controllers (e.g. steering wheel) to be used, and at the same time offers a solution to the avatar problem since the only movements made (manipulating the controller) can easily be transformed into visual feedback. In our case, we presented the user with a floating chair with a joystick controller for navigation (figure 4).

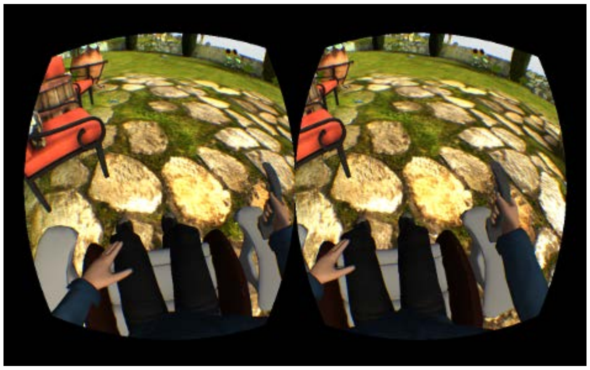

Figure 4. User seeing his own avatar during the vehicle navigation

By far this method offered the best results in our testing process. Vertigo and dizziness were significantly reduced (in some cases non existent), the controller oriented navigation - despite not being as fluid as walking - accomplished the goal of making the user feel immersed in the virtual scenario, and no wire limitations emerged at any time. Curiously, despite trying to reach a solution for laymen, this approach also appealed positively to more experienced users and proved promising for more complex interactions such as games. The con involving this method is that vehicle usage is not fitting for small or crowded environments (e.g. small apartments or densely furnished rooms) since navigation is significantly limited, causing sometimes a trapped sensation.

An issue that came up during testing that is worth mentioning was discomfort when using stairs, specifically the irregular (bumpy) movement caused by each step. Since the whole avatar would shake, most users would understandably feel vertigo and even nausea. Fortunately this problem can be solved with a simple solution: using a ramp collider over the stairs geometry [3].

- **Tracking:** Here we try to reach the holy grail, real-world navigation as translation input. The user position information is obtained from a tracking system using infra-red sensors and transmitted through Wi-Fi, requiring the user to wear not only the VR headset as well as a infra-red markers. Since the movement should occur freely, we placed a notebook running the VR application as well as a battery for the Oculus Rift in a backpack worn by the user. A limitation imposed by our available resources is physical space, the area covered by the tracking has only approximately $22m^2$ (figure 5). To avoid only allowing the user a limited amount of space for navigation, a speed multiplier approach was also included in the test, allowing the user to walk more with less physical space available. Since the rotation and orientation feedback from the headset itself are already excellent, these were maintained and such information from the tracking system was ignored, only the user position was used in this interaction.

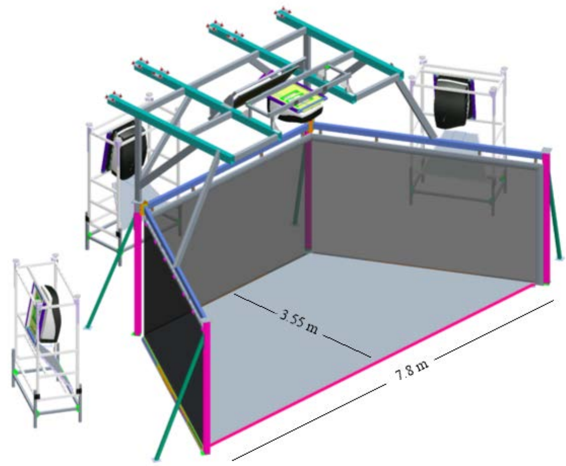

Figure 5. Navigation area inside cave.

Since we were working with an already existent tracking equipment used in an immersive CAVE setup, the available infra-red markers were already coupled with stereoscopic glasses, which had to be placed overlapping the VR headset (figure 6).

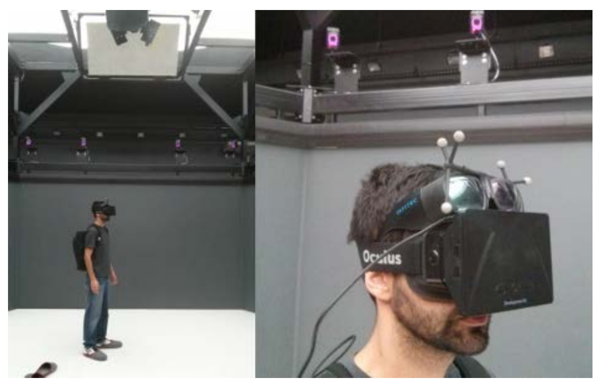

Figure 6. Tracking in a cave.

The natural movement sensation was successfully achieved, however users that interacted with the speed multiplier felt strong dizziness and at some cases the headset had to be removed prematurely, and users that interacted without the multiplier complained about the lack of space for navigation. Our physical limitations proved to be more problematic than expected, however in the opinion of the authors in a 1:1 scale of the environment this type of interaction is promising. A common question is "If there already is a 1:1 representation of the environment, why VR?", and the answer can be the active interaction with such environment. Moving furniture, painting walls, and altering the light sources are a few

Problems/Methods	Teleport	Kinect	Vehicle	Tracking
Translation	✓	✗	✓	✓
Imprisonment	✗	✗	✓	✓
No Avatar	✗	!*	✓	✗
No Haptic Feedback	✗	✗	✓	!**
No Control	✓	✓	✓	✓

Table 1. High-level overview of the results achieved: methods and solved problems comparison table. * Despite displaying an avatar, the disparity between the users actual movements caused a fall in the uncanny valley. ** Could be obtained in an actual 1:1 scenario.

examples. However, 1:1 is not the only solution, as there have been other recent approaches made in dealing with limited space solutions [4, 1, 8]. New tech involving spatial tracking (e.g. project Tango from Google) is also a strong candidate of offering a more viable solution for this problem.

CONCLUSION

Despite not being able to come close to a one-size-fits-all solution, the tested methods provided a clearer direction to follow on future tests - as well as approaches that should be avoided (table 1), something that was not obvious given this new technology.

Now with this basic know-how we intend to advance on the most successful strategy (the vehicle) investing more on formal testing, fine tuning and also a more elaborate setup. Haptic and audio feedback (e.g. shaking chair and joystick, and motor sound effects) are intuitive improvements to make, and better hardware (e.g. appropriate chair and joystick) will definitely improve the experience.

It is important to state that despite each method imposing its own limitation, such limitations are not necessarily deal-breakers, and each type of interaction can benefit from them when well defined and applied.

Since we are dealing with the problem of bringing a completely new type of immersive interaction to most users, there is still no consensus on which are the best practices to be followed, and which approaches should be avoided. Many tests still need to be performed so that we can obtain guidelines and/or heuristics for the development of applications using this technology. This work is a contribution in this direction, shedding some light on some issues within this context.

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