Walking the "New World": Optimizing the way we navigate VR

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Introduction

How does the development of advanced Virtual Reality immersion techniques influence the future of fully immersive Deep-Dive Virtual Reality?

Virtual Reality (VR) stands as a beacon of opportunity not only in the entertainment and gaming sectors, but also in education, healthcare, and professional training. As virtual reality evolves, a pressing challenge is the enhancement of immersion: intuitive, natural movement is a key component to improve the immersion of users (Lee 2017). Redirected walking (RDW), which subtly changes the trajectory of one's direction to fit expansive virtual spaces within physical space constraints, is an emerging solution (Razzaque 2001, Razzaque 2005). RDW is a natural walking technique that allows users to traverse a virtual space indefinitely while being within the constraints of a finite real-world space. Slight curvatures in the user's path caused by distortions the world, imperceptible to those who would not expect it, effectively "redirect" the movements of the user (Qi 2016). These induced curves to natural walking with RDW exploit the poor sense of direction humans tend to have, especially when visual information from the real world is inhibited by a VR headset (Razzaque 2005). The redirection feels natural similar to how an optical illusion operates, and unless we understand how it works precisely, we perceive what is presented to us (Razzaque 2005). There have been attempts at significantly reducing this fatigue, known as VR sickness (Lee 2017), immensely improving the way we immerse ourselves with RDW. Additionally, humans are highly adaptable, and it has been seen by VR experts that perceptual detection of curved walking paths increases as humans are exposed to increased curvature, allowing for more aggressive RDW techniques (Bolling 2019).

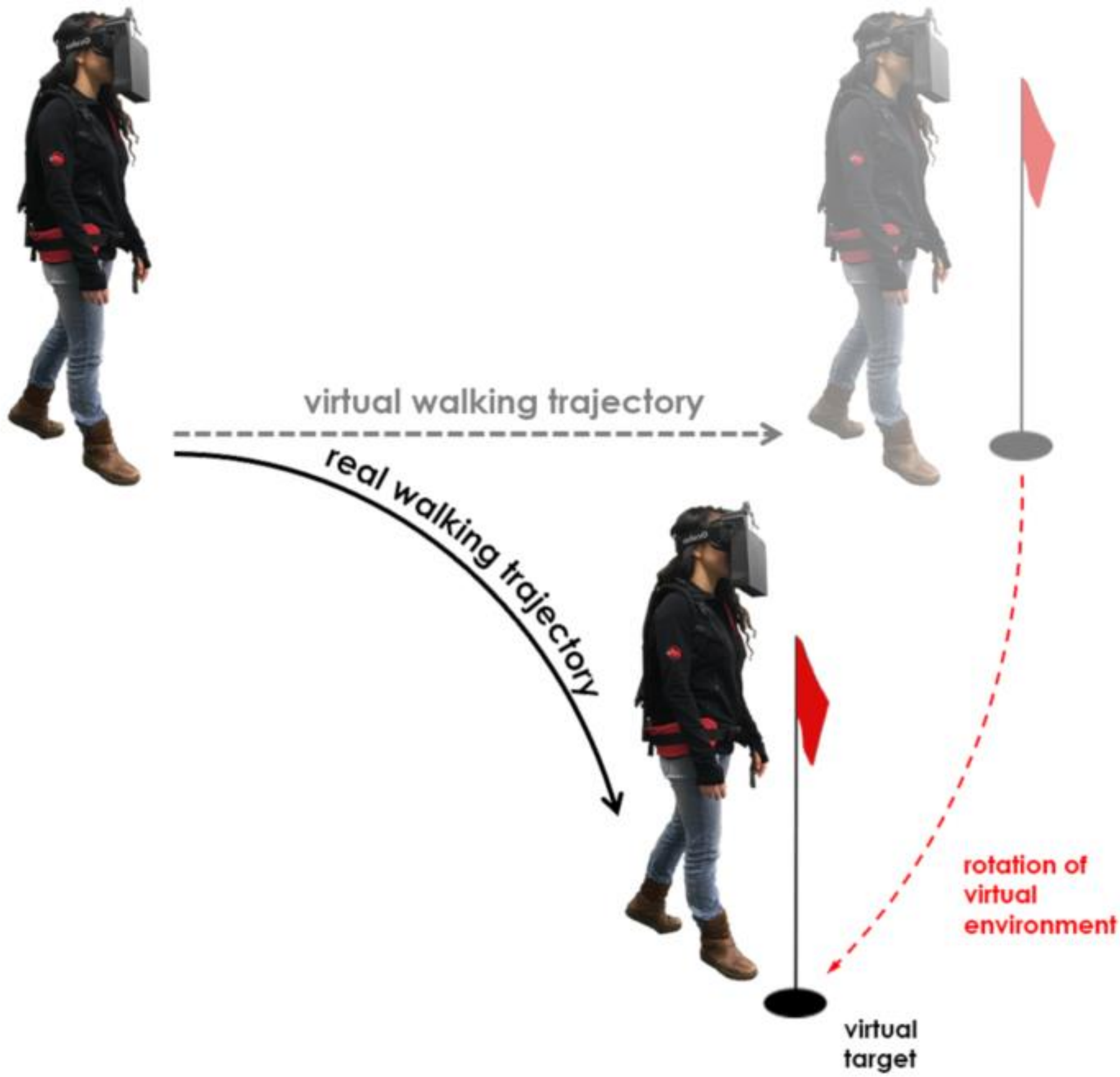

Figure 1: How typical redirected walking works **(**Rothacher 2018)

The two main challenges that RDW faces are improving immersion and avoiding the redirection of users into unforeseen areas. Attempts have been made to optimize RDW in many ways that will be detailed in the Technical Project section, but primarily the research shown will focus on improving immersion using redirection when the user blinks.

As RDW and other VR immersion techniques advance, we may see the development of Deep-Dive Virtual Reality (DDVR) — a new space, independent of what we observe as our current physical reality that may completely revolutionize the cultural of our existences, but may also convolute the distinction between true reality and artificial reality. Thus, we must take into account societal and cultural implications that stem from the fabrication of such a reality.

Technical Project

How can we optimize current Redirected Walking thresholds in combinations with blinks to produce the most immersive Virtual Reality experience?

In order to develop a RDW that effectively redirects the user in their scene, there are three main algorithms that will be looked further into within my research: steer-to-center, curvature gains, translation gains (Azmandian 2015; Hodgson 2023).

Steer-to-center (S2C) is the most important of the three algorithms, ensuring the user does not veer outside their defined VR play space. This is crucial to avoid crashing into physical real-world walls or objects while moving in a virtual space, which may be injurious to the user. Ideally, S2C works best for one dimensional movement in a circular shape, where a 40m x 40m VR play space was found to be most optimal (Steinicke 2010), but one should have a play space of minimally 6m x 6m to be considered “viable” for RDW (Azmandian 2015). To achieve greater than 95% effectiveness, we need a tracking space of at least 22 m x 22 m when using steer to center and translation gains (Azmandian 2015).

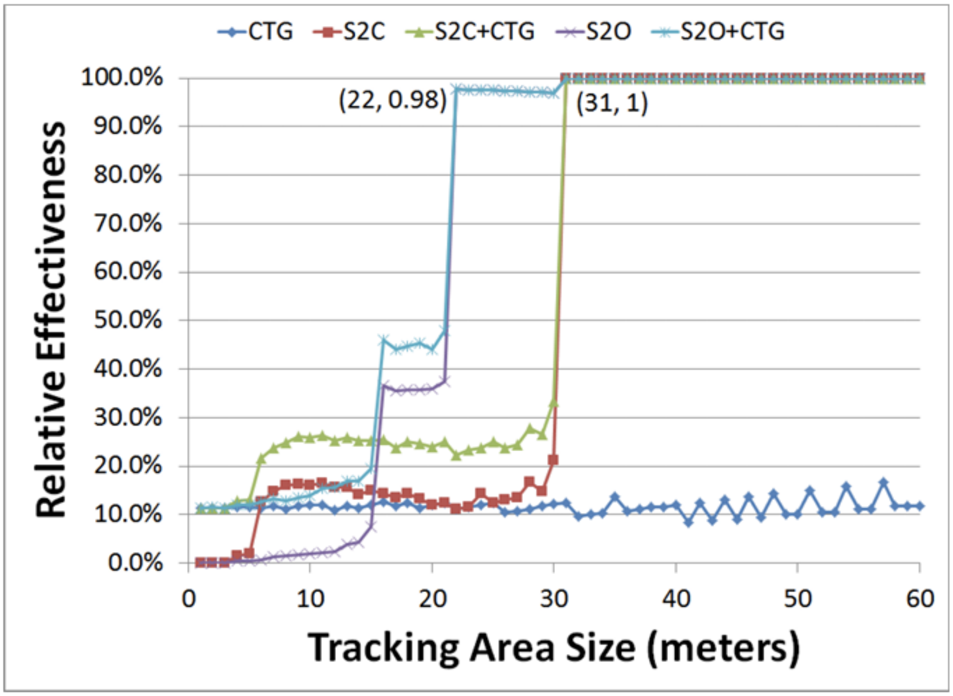

Figure 2: Effectiveness of RDW algorithms with various tracking areas (Azmandian 2015).

A more localized of S2C, known as steer-to-orbit (S2O) has the same functionality more applicable to polygon-like spaces that is more useful for avoiding obstacles in a particular region of the play space (Williams 2021, Azmandian 2015).

Curvature gains to the user ensure the same goals as S2C, but are they are more effective at creating two-dimensional movement. Rather than drawing a bijection between a circular real-world path with a one-dimensional linear virtual path, each curve can effectively correspond with a two-dimensional linear virtual path, and thus provide more variable movement (Grechkin 2016, Bolling 2018). Additionally, S2C can work in smaller play areas more effectively than S2O (Azmandian 2015). It is important to note that a series of curvature gains that form a circle make up a typical S2C algorithm: S2C and curvature gains have a similar basis.

Translation gains, given the analogy to “seven league boots” in European folklore, adjust the distance the user covers when stepping forward. This adjusted measure for movement is done for two main reasons: it allows for a larger coverage of distance, enabling quick, seamless navigation in a VR scene, but mainly for the purposes of redirection, it prevents the user from straying away from the VR play area — it does so by negatively scaling translation as the user gets close to the edges of the VR tracking area (Kim 2022, Azmandian 2015). By doing so, it encourages the user to subtly change their trajectory and thus redirect away from the wall or obstacle.

To simplify redirected walking procedures and introduce difference redirected walking thresholds, algorithms, and techniques, we have seen the development of various redirected walking toolkits — redirected toolkit, made in 2016, was (Azmandian 2016). OpenRDW, another toolkit that was development to support more redirected walking algorithm as well as multi-person interactions, will be used for this research due to the fact it is more recently maintained and supports greater features (Li 2021).

Optimizing the main infinite walking algorithms as they would be difficult due to the large contributions that have already been made by highly experienced individuals in the field. The best course of innovation would be to introduce a new method of redirected walking or combine an existing form of redirection with a new form of redirection.

One newer form of redirection that has been seen is redirection with blinks. Rather than experiencing a redirection factor while walking, individuals will have their scene redirected after blinking their eyes (Nguyen 2018, Davis 2022) There have been some attempts to use eye movements as a means to redirect users in the scene. For example, blinks (Suma 2011, Nguyen 2018) and saccadic eye movement (Davis 2022) have been utilized to redirect VR scenes for special redirected walking. However, little has been done to combine these techniques with contemporary redirected walking. The technical project will attempt to combine a small redirection factor in blink redirection with the following contemporary algorithms with also a small redirection factor: S2C, S2O, curvature gains, and translation gains. Since the main issue that redirection in small scenes faces is the fact that users have such large redirection factors to avoid hitting walls (thus losing immersion), displacing some of this redirection factor into blinks may be an effective way to lower redirection factor while preserving immersion.

STS Project Details

How does the development of Deep-Dive Virtual Reality raise societal concerns, and how could we use DDVR effectively without comprising our own reality?

Due to the significant increases of immersion caused by redirected walking, one repercussion we may see is the development of Deep-Dive Virtual Reality (DDVR).

DDVR has not seen technical research due to its lack of production the task, as well as the human brain it attempts to altercate, is immensely complex. In order to realize such a development, further research into Brain-Computer Interface technology (BCI) as well as specific inhibitory and excitatory neuron interactions within the brain need to be analyzed to produce sufficient altercation to the brain to effectively change human perception.

The development of DDVR presents a range of societal concerns that stem from its potential to alter human perception. With more sophisticated DDVR systems that develop as a result of redirected walking, the line between actual reality and artificial reality blurs. With such thin lines between real and fake, this raises a psychological concern about the impact of prolonged DDVR exposure, which may lead to dissociations of the real world for a DDVR environment, especially if DDVR continues to feature similar attractions that VR does such as new modes of transportation like flying and teleportation, as well as the altercation of time that the real-world would never feature.

On the contrary, the push for more immersive VR techniques like redirected walking could be lifesaving for medical and emergency training when applied with ethical concerns. Medical practitioners could use DDVR to simulate complex medical cases and thus improve for real world operations. Police force can use DDVR as a way to train to ensure they properly handle criminals at a scale that is appropriate to the crime, and soldiers can use it as combat training to reduce casualties.

Moreover, DDVR may cultural and economic ramifications as a result of the further development of immersive VR and RDW include a boom in the entertainment and gaming industries, as well as more usage of a virtual world. Social distancing during the early years of the COVID-19 outbreak gave life to increased forms of work at home and virtual learning. Similarly, with an influx of immersive development, we may see a large shift in culture towards large usage of virtual environments, similar to the dissociation mentioned earlier.

Conclusion

The trajectory of RDW techniques and the integration with nuanced mechanisms such as blink-based redirection stands as the front of VR innovation as a mode of movement. Continuing to realize improvements to the immersive nature of VR could unlock a future with DDVR for better or worse — the implications of DDVR support the learning in life-threatening medical and combat cases but may lead to dissociation from this world. Along with the current increase in loneliness globally, dissociation could be the biggest threat to true reality and may lead to the adoption of an artificial reality. Thus, it is crucial we navigate these concerns carefully with a balanced approach, fostering the benefits while safeguarding against the detrimental. Ethical regulations, such as time spent in DDVR or ability to exit DDVR be universal, must be crafted and adhered to in order to enforce protections against potential malicious practices and preserve the fabric of the current reality we cherish.

As researchers, developers, and consumers, it is our responsibility to keep the transition from VR to DDVR as safe as possible. Though, we are unsure if a full migration to DDVR may be more beneficial to society than staying in our current reality, it is important to preserve what we have in order to make that call in the future. The advancement of RDW and VR into DDVR are not only technological milestones, but are pivotal points to the human experience. We must tread this path with foresight and consideration, ensuring that as we dive deeper into virtuality, we do not cease to value the physical world and our human connections that to this day, sustain it.

Word Count:

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