Redirected Scene Rotation for Immersive Movie Experiences

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ABSTRACT

Virtual reality (VR) allows for immersive and natural viewing experiences; however, these often expect users to be standing and able to physically turn and move easily. Seated VR applications, specifically immersive 360 degree movies, must be appropriately designed to facilitate user comfort and prevent sickness. Our research explores a scene rotation-based method for redirecting a viewer's gaze and its effectiveness given three parameter adjustments: rotation delay, rotation speed, and angle threshold. The technique may be useful in the development of future immersive movie or VR experiences. From the research, we expect to discover which parameters prove most effective at redirecting a viewer's gaze in an immersive movie experience. We present preliminary developments and an informal usability evaluation to collect participant feedback about preference, comfort, and sickness.

Index Terms: Human-centered computing—Visualization—Visualization techniques—Virtual reality;

1 INTRODUCTION

Virtual reality (VR) systems bring a range of benefits for experiencing 3D simulated worlds [3]. The use of advanced display and interaction features allows users to experience detailed, engaging, and interactive narratives for entertainment. Recently, many commercial VR experiences have been presented as forms of immersive stories or movies that bring new opportunities for story telling through a highly interactive medium. For such applications, interactive view control is assumed as a requirement to be considered a VR experience, especially since head-tracking capabilities are supported as core "immersive" elements for head-worn systems such as the Google Daydream, Oculus Rift, or HTC Vive.

However, while many designers often assume the use of VR where users stand and are free to physically turn without constraints, this excludes many commonly desired usage settings where the user is seated [6], such as use of VR while relaxing on the couch or passing the time in a plane during a flight. For such situations, it may be uncomfortable to have the head physically turned for much time. To address this problem, we study the use of redirected scene rotation techniques to allow the viewer's gaze to gradually redirect towards the straight-ahead physical direction during immersive movie experiences. We employ a method similar to *washout filters* used for motion simulators, which can be used to gradually "pull the position of the simulator back to its neutral position" over time [4]. By rotating back to the neutral orientation, it is able to simulate a greater range of motion than would be physically comfortable in seated VR (or more than would be physically possible in the case of motion simulation). These washout filters aim to reorient the user without the user noticing the motion through their visual or vestibular senses [4].

In this research, we explore the use of washout filters as a form of *redirection* that can be applied to VR experiences where limited physical turning is possible. We aim to study variations of the washout method with different degrees of rotation delay, rotation speed, and angle threshold applied to reorient the physical head orientation while users watch immersive movies. We conduct user studies focusing on user comfort, sickness, and overall preference. We present preliminary design and tests as we continue to refine the technique and study its feasibility for immersive movies.

2 REDIRECTION FOR IMMERSIVE MOVIES

An important aspect to consider when developing any VR technique is motion sickness, which has proven challenging when developing motion-based VR experiences [1]. One promising technique for overcoming some of the limitations with VR is *redirection*. Many researchers have studied the use of redirection techniques for gradually adjusting viewer gaze in interactive VR experiences (e.g., [2, 5, 7]). While *redirected walking* techniques primarily deal with redirecting and reorienting a user that is physically moving or walking through space to navigate [5], researchers have also explored gradual redirection in stationary experiences. For example, Sargunam et al. [6] presented a *guided rotation* technique for seated VR that is applied dynamically as the user virtually travels through the 3D world; however, this technique had limitations for free navigation in 3D spaces due to the need for slow view adjustments. In our research, we focus on experiences in which the user has head-tracked view control but does not have interactive control of translational movement. In particular, we study a variation of redirection applied to viewing immersive movies.

This technique may be effective for immersive narrative or cinematic experiences that have a central focal point in the experience—that is, a direction where the designer or director expects the user to look for the majority of time. For such applications, even if this focal point moves in such a way that requires scene rotation to follow the target, the viewer will often have limited need to freely look around for an extended amount of time. As a result, the focal point can more easily be kept in alignment with the physical forward direction to reduce physical discomfort associated with extreme or awkward head or body rotations during seated viewing.

3 TECHNIQUE OVERVIEW

Our redirected scene rotation technique uses an approach similar to that found in motion simulator washout filters but for VR movies with head-worn displays. After the user rotates their head to an extreme enough angle and remains for a given amount of time, the technique starts to slowly rotate the virtual scene to bring his or her head back to the neutral physical position while maintaining their focus on the same point of interest. The technique accomplishes this by slowly rotating the entire scene of the immersive movie, causing the user's focus to be shifted to directly in front of them; this essentially allows the focal point of the immersive movie to always be placed toward the front of the user's body so that it can be viewed

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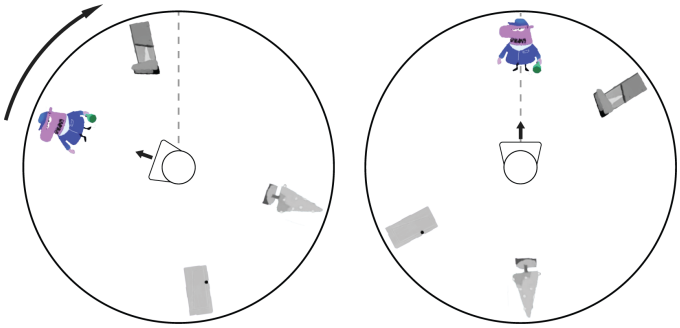

Figure 1: The redirected scene rotation adjusts the virtual viewing orientation while the user follows the focal point (in this case, the colorful purple and blue character).

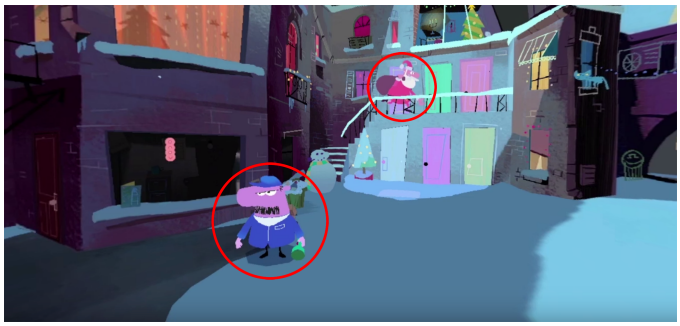

Figure 2: Still frame from *360 Google Spotlight Story: Special Delivery* (single frame used under fair use for research and demonstration purposes). The focal point of the story follows two main characters (circled in red). Since the viewer is expected to turn to follow these two characters together in 360-degree rotation, the redirection technique can assist in rotation to neutralize the need for physical turning.

in a comfortable position. Figure 1 shows an example of how the process works and how the scene is rotated to shift the focal point.

To reduce any visual-vestibular discrepancies as much as possible, a smooth curve with flat tangents at the endpoints is used to interpolate the rotation of the scene; this ensures a constant acceleration. Given the angle of the user's gaze, a corresponding scene rotation is calculated that will rotate the scene to such a position that the user's head returns to a neutral position. The scene then rotates from the initial angle to the calculated angle following a smooth Bézier curve to transition the orientation to the intended rotation.

We developed a working implementation of the redirected scene rotation technique in a custom video movie player using the Unity game engine. For the implementation, immersive movies are displayed on a sphere that surrounds the user and scripts were created to implement the technique. The movie player tracks where a user has been looking and for how long; if the user has looked at an extreme enough angle (*angle threshold*) for a long enough time (we call this time the *rotation delay*), then the scene rotation is triggered. The appropriate scene rotation angle is calculated and the scene then rotates at a specified *rotation speed* (which can be parameterized according to preference or requirements for a specific video). This *scene rotation* rotates the scene in the direction of the desired physical rotation, which in turn encourages the user to physically turn with the scene to return to the neutral viewing orientation.

4 Preliminary Evaluation

We conducted a preliminary evaluation of the technique for three immersive movies from 360 Google Spotlight Story: *Rain or Shine*, *Special Delivery*, and *Buggy Night*. These are all short, good-natured digitally animated narrative videos that last between approximately 3 and 5.5 minutes. For example, *Rain or Shine* is about an unlucky girl whose sunglasses cause a rain cloud to form above her, bringing a constant torrential downpour. *Special Delivery* is about a grumpy animated character attempting to catch Santa Claus (Figure 2 shows an example still frame from this movie). *Buggy Night* is about a group of small bugs attempting to escape being eaten by a frog.

So far, we conducted informal qualitative user studies with five participants to test the technique, collect feedback, and learn about what parameters appear to be most influential on the user experience. In each trial, the user viewed one or two of the immersive movies one to three times with different parameters during each viewing. We observed participants during each trial and then asked questions about their experience—particularly comfort, nausea, ease of use, and overall preference. From these preliminary trials, we have determined that the primary parameters influencing user experience are rotation delay, rotation speed, and angle threshold. Interestingly, we encountered one difference in preference for rotation speed during these preliminary trials. Most participants preferred a slower rotation speed because it felt more cinematic and fluid, while the faster speed felt too jarring or made the user dizzy. One user, however, preferred the faster rotation speed because it allowed him to quickly turn his head to his desired point of interest and rotate the scene correspondingly. Further study is needed to determine which parameters prove most effective and are most preferred.

5 Conclusion and Future Work

Our preliminary evaluation has shown promising results for the use of redirected scene rotation for immersive video viewing. The technique allowed users to view the tested immersive movies without having to rotate their chair or body or having to maintain their head at an extreme angle for extended periods of time. The preliminary evaluation also revealed that slower rotation speeds helped reduce user discomfort (e.g., dizziness or nausea) and distraction. The one preference for a faster rotation speed revealed that there may be specific use cases where a faster rotation speed is more effective (perhaps for fast-moving immersive movies or gaming). We will proceed with further, more formalized user studies to observe which parameter settings in the technique produce the most effective results.

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