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Velocity-dependent curvature gain and avatar use for Redirected Walking

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Abstract

We investigated in a study whether humans' sensitivity to curved walking is affected by their walking velocity. Amongst other techniques, redirecting users of an immersive virtual environment on a curved path is part of the so-called 'Redirected Walking'. We conducted an experiment in which 12 participants walked specific curvatures at given speeds in a VR. We found that people are significantly less sensitive to walking on a curve when walking slower. Moreover, we assume the possibility of using avatars to support redirection algorithms as it was shown by Llobera et al. ([LSRS10]) that proxemics holds true for avatars in virtual environments, too. In this work, we depict three possible applications of how avatars could be used to achieve a better redirection.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual Reality

1. Introduction

In order to make use of a virtual world of greater extents than the existing tracked area, an existing technique called 'Redirected Walking' (RDW, [RKW01] [RSS*02]) can be used ([SBRH08]). The main principle of RDW is to alter different components of human locomotion, namely rotation ([ECT*08]) and translation ([IRA07] and [WNM*06]), in order to redirect the user's trajectory to avoid collisions with walls or obstacles ([SBJ*10]). Furthermore, it was shown that people are less sensitive towards rotational discrepancies between the real and virtual world, so they can be redirected by suited reorientation techniques ([WNR*07] and [PWF08]). Part of the redirection is done by introducing real curvature to virtual straights.

Whereas related work ([SBRH08]) provided quantitative data of detection thresholds of the added curvature, the influence of walking speed on curvature sensitivity has not been investigated. We conducted an experiment, in which we made our participants walk on different curved trajectories at three different walking speeds. The experiment is described in detail in the following section.
In section 3, we describe the possibility to distract ([PWF08]) and redirect people by the use of avatars. As it was shown that proxemics also holds true in virtual environments ([LSRS10]), we suggest there could be an influence of avatars on the user's real-world walking trajectory.

2. The influence of walking speed on curvature sensitivity

To determine whether the sensitivity towards curved walking is influenced by walking speed, we conducted a psychophysical experiment with 11 participants ([NSB*10]). It was the participants' task to follow a floating sphere. By this, we had them walk on specifically curved paths at given speeds. We tested 5 different curvatures (0.05 .. 0.005), each to the left and to the right. The experiment conditions were made up by the walking velocities, which were 0.75, 1.00 and 1.25 m/s. We randomized the walking duration between 6 and 7 s to prevent conditioning. We randomized the conditions and repeated them in reversed order. So per condition, we ran 2x100 test runs. The experiment took place in the TrackingLab of the Cyberneum (http://www.cyberneum.de).

After having walked a test run, the participants had to judge whether they had walked on a left-hand or right-hand curve. We determined the ratio of a response of having walked on a left-handed curve and fitted a psychometric

function to this ratio. We determined the point of subjective equality (PSE) and the detection threshold based on this curve (see figure 1).

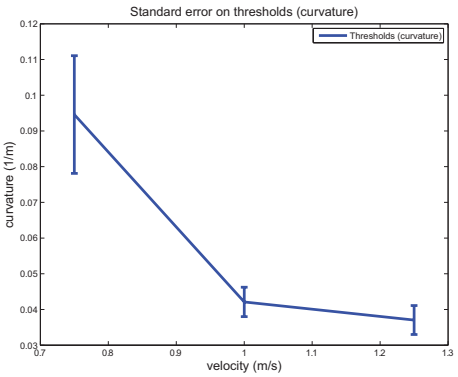

Figure 1: *Detection thresholds for curved walking*

The results show that people are less sensitive to walking on a curve when they are walking slower. Within the tested values, we found detection thresholds of approx. 0.100 m^{-1} (which equals a radius of 10.0 m) for 0.75 m. For a walking speed of 1.25 m/s, we found a value of approx. 0.036 m^{-1}, which represents a radius of 27.7 m.

3. Using avatars to improve redirection

Previously, [LSRS10] found out that proxemics also holds true in virtual reality. Based on these findings, we suggest the possibility to use avatars to support underlying RDW techniques by initiating additional movement of the user. This movement could be triggered by curiosity (turning towards interesting avatars) or collision-avoiding behaviour (turning away from the avatar, walking a slight detour). So as a passive method, we propose to implement an avatar to appear from the side and walk across the straight walking direction of the user. As an active method, avatars could be used to approach the user by e.g. waving or talking to him. We could

Figure 2: *Screenshot of avatar walking in Virtual Tübingen (http://virtual.tuebingen.mpg.de)*

also use avatars to slow down the user, since we have determined that people are less sensitive to curvature redirection when walking slower. This could be done either by filling up the space with people or by having an avatar walking in front of the user.

To investigate the influence of avatars and evaluate the dynamic curvature gain, we implemented a virtual scene with two types of avatars. One avatar was constantly walking in front of the user and diminished its leading distance as the user's velocity increased. The second avatar was walking into the scene from the side of the viewing frustum, intersecting the straight walking trajectory of the user. Further experiments are needed to evaluate the effeciveness of these avatars.

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