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Countering User Deviation During Redirected Walking

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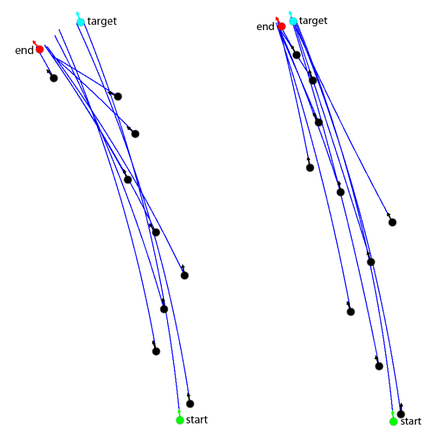
1 Introduction

Redirected Walking is technique that leverages human perception characteristics to allow locomotion in virtual environments larger than the tracking area. Among the many redirection techniques, some strictly depend on the user's current position and orientation, while more recent algorithms also depend on the user's predicted behavior. This prediction serves as an input to a computationally expensive search to determine an optimal path. The search output is formulated as a series of gains to be applied at different stages along the path. An example prediction could be if a user is walking down a corridor, a natural prediction would be that the user will walk along a straight line down the corridor, and she will choose one of the possible directions with equal probability. In practice, deviations from the expected virtual path are inevitable, and as a result, the real world path traversed will differ from the original prediction. These deviations can not only force the search to select a less optimal path in the next iteration, but also in cases cause the users to go off bounds, requiring resets, causing a jarring experience for the user. We propose a method to account for these deviations by modifying the redirection gains per update frame, aiming to keep the user on the intended predicted physical path.



(a) Static Gains (b) Dynamic Gains

Figure 1: *The path traversed by simulated user in the real world while walking towards a virtual world waypoint. The predicted path is shown at various points along the path. In Figure 1(a) with static gains, the user ends up farther away and with greater angular deviation from the target configuration compared to the case of dynamic gains in 1(b).*

2 Approach

The core idea of our approach is reframing the problem such that the search output is formulated as a series of *configurations* (position and orientation pairs), expressing the user's state at each part of the predicted path. We then mathematically solve the problem, "Given the user's current position and orientation, assuming the user will walk along the predicted virtual path, what gains should be applied for the user to reach the next planned configuration?" By providing a closed form solution to the problem, it can efficiently be recalculated every update frame. Theoretically, if no deviation is committed, the calculated gain would be constant every frame, and the approach would effectively function as the normal fixed-gains setup.

The more the user deviates, potentially the stronger the gains need to be in order guarantee the user reaches the desired configuration. To prevent gains from being noticed, we clamp each gain to its detection threshold as determined in the literature. In such cases, reaching the exact configuration is not guaranteed, but a best effort is made while remaining undetected.

3 Discussion and Future Work

We have shown via simulation that with minimal computational overhead, user deviations can be reduced by 47% in positional and 8% in angular deviations. The question remains though if rapidly changing the gains can be noticeable or straining on the user. [Zhang and Kuhl 2013] proved that dynamic changes in rotational gains are not noticeable by for users. Furthermore, in various redirection methods, gains are designed to change instantly along the user's path, and these sudden changes have not been reported to be noticed by users.

Two modifications can easily applied to improve this work. First, if it is desirable to avoid drastic gain changes, the algorithm can be easily modified by applying an exponential moving average to provide a more gradual change in gains. Also, from [Neth et al. 2011], noticeability thresholds for each gain can be calculated based on the user's observed speed, reducing the clamping effect, and effectively allowing better deviation countering.

With active deviation countering, offline path planning can now be more practical since the introduced error will be prevented from accumulating. More importantly, users can have a more natural exploratory behavior and no longer need to be restricted to walking rigidly on the intended path for a successful redirected walking experience.

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