Exploring Gamification for Understanding Learning Behaviors

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Tertiary students are often treated as mature learners leading to the development of learning traits taking a backseat in most tertiary institutions. The development of learning traits is a lifelong activity that has not been given enough attention to. This paper investigates the experiential responses of several common gamification mechanics in the context of a online self-learning platform for building learning traits.

CCS Concepts: • **Human-centered computing → Human computer interaction (HCI)**; *Haptic devices*; User studies.

Additional Key Words and Phrases: Virtual Reality, Walking-In-Place, Locomotion, Immersion

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1 INTRODUCTION

A straightforward implementation for VR locomotion is controller-based locomotion, but suffers from the shortcoming of inducing intense cybersickness. Controller-based locomotion allows virtual navigation via directional pads/sticks and/or buttons with video game-style controllers. Although this works for traditional desktop or handheld game experiences, it is almost unusable in VR settings due to excessive cybersickness [8]. The most cited theory to explain such cybersickness occurrences is the visual-vestibular conflict [11] which can be reasonably applied here as there is a strong mismatch between visual stimuli (virtual movement) and real life motion (being stationary with controllers).

Virtual teleportation is a popular locomotion method in commercial VR titles although it may not be suitable for VR applications that require naturalistic locomotion. Teleportation has been shown to reduce cybersickness when compared to controller-based locomotion [4] and is a prominent locomotion method even in recent VR game titles by major publishers, e.g., Valve Corporation's *Half-life: Alyx* [2]. However, the notion of teleportation itself is entirely fictional and may not fit in virtual experiences that prioritize naturalistic locomotion, e.g., in a commuting simulation.

Commercially, several mechanical hardware solutions exist for VR locomotion but currently exists in obstrusive form factors and requires costly add-on hardware. Stationary VR "treadmills" (e.g., KAT VR [17], Virtuix Omni [15] and Cyberith Virtualizer [5]) inhibits accessibility by requiring users to purchase expensive and bulky hardware, and have questionable usability in which they require users to wear custom shoe covers to enable sliding of their feet on a slippery surface whilst suspended by a harness. This seemingly obtrusive form of interaction had the community sometimes referring to such VR hardware as "slidemills" instead [9]. Actual belt-driven treadmills exist but mostly appear to be in constant development phase and not made available to the general public [1, 6, 13].

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Motivated by the lack of viable usable and accessible solutions for naturalistic VR locomotion, this paper aims to inform the implementation of such locomotion methods by comparing various low-cost and easy-to-setup walking-in-place implementation approaches. To establish the scope of the study chosen in this paper, a review of the state of research in VR locomotion methods is presented next.

2 REVIEW OF VR LOCOMOTION METHODS

2.1 Walking-in-place

Walking-in-place [14] is popular method that has been somewhat explored in prior research.

Prior work has compared the locomotion performances of users for Arm Swing and Leg Lift methods [18] and found that Leg Lift produced the best spatial awareness and distance estimation performances. However they did not evaluate experiential constructs like presence and cybersickness.

Arm Swing is a common implementation approach for WIP. For example, Myo arm [10] uses a wearable EMG Myo armband to detect arm swinging and found that

Other than walking-in-place, other methods like custom mechanical shoes [16], custom locomotion chairs and ... have been explored. However, these methods are in their infancy and the ease to recreate the hardware setup limits the accessibility to the common consumer.

This paper hence aims to limit the scope of investigation to locomotion methods that only rely hardware components that are easily accessible to a VR consumer, namely, consumer-grade HMDs (e.g., HTC Vive Pro) itself and consumer-grade tracking devices (e.g., the Vive Tracker add-ons).

3 METHOD

A user test comparing 4 locomotion methods, namely arm swinging, leg lifting, head bobbing and a combination of arm swinging and leg lifting was conducted by the team. We evaluated the presence, flow state and simulation sickness levels of these methods in a within-subjects methodology with randomized sequence to maintain a counter balanced result.

3.1 Implementation

4 different locomotion method were implemented and compared for the feasibility of walking in infinite space. They are the following: Arm-Swing, Head-Bob, Leg-Lift and a combination of Arm-Swing and Leg-Lift.

3.1.1 Arm-Swing. The algorithm is based on Arm Swing Paper [12] by Yun Suen Pai and Kai Kunze. However, the algorithm on correcting the direction is modified from correcting direction based on previous direction outputs into increasing the number of direction inputs in-order to correct output. This is done due to the lack of clarity on smoothing or correcting of the output in the Arm Swing Paper and to retain good quality for the direction output without the limitation of moving for a while first.

For the VR arm swing locomotion, no additional input is needed except for the velocity from each controller and the facing direction given from the headset. Do note that the facing direction do not directly affect the direction that the user is moving toward in the virtual environment but it is used to determine the forward and backward direction of the user arm swing which will be further explained below.

The brief concept of the algorithm is to use each hand velocity and determine if a swing motion of forward or backward occur for that hand. The swing motion data is then passed to a controller that determines if the user is to move in the virtual environment.

For the magnitude test is to check the velocity of hand against a set amount to remove noise input caused by a slight motion of the hand.

The direction test is to determine if the current hand swing is forward or backward. The determining factor is to use the velocity vector from the hand to project onto the facing direction vector to evaluate the hand velocity vector is aligning(forward) or against (backward) the facing direction. The projection method is done by using dot product of the hand velocity vector with the facing vector.

Forward:

$$Vhand \cdot Vfacing >= 0$$

Backward:

$$Vhand \cdot Vfacing < 0$$

The error count serves as the purpose to make sure that any false input or noise does not affect the input set.

To determine that an actual swing has occurred, the algorithm uses an input set to ensure that the user is swinging his hand as well as to gain a set of velocity that can be used for averaging to get a better quality velocity data. However, the amount of input needed to determine as a swing motion is based on testing with two factors in mind which are how natural the walk in the natural environment and the quality of velocity data.

Using the velocity data, it is then used to calculate the walking direction in the Virtual Environment.

The hand manager has two processes which are to have a breather time to take in both hand data and register them as a swing motion to serve as a receiver and generate the walking direction in the virtual environment.

The calculation of the walking direction is done by :

$$WalkDirection = N(Vforward) - N(Vbackward)$$

where N() is normalized function

The speed of the user is walking is based on the average magnitude from both hand velocity and apply onto min-max function with a set multiply amount.

3.1.2 Head-Bob. The algorithm used is based on the paper [7] by Juyoung Lee, Sang Chul Ahn and Jae-In Hwang. Step recognition is performed through the tracking of the position and orientation of the HMD. Each step is then translated into virtual velocity which is used to move the user in VR.

In the paper, calibration was done before hand to determine the range of a step to prevent unintentional movement. To further ensure that the range is always following the user's head, the range calculation and calibration was done before each step recognition phase in the implementation of the HeadBob algorithm.

3.1.3 Leg-Lift. The algorithm used is based on the paper [3] by Jeff Feasel, Mary C. Whitton and Jeremy D. Wendt. Using trackers attached to the user's legs, the heel position is used to obtain the vertical velocity by performing a numeric differentiation on the vertical component. The absolute value of the vertical velocity, which will be discarded if it is to huge or too small, is then passed through a Butterworth Filter with a cutoff frequency of 5Hz. Lastly, a fixed value is subtracted from the result of the Butterworth filter to reduce on virtual locomotion drift. This results in a virtual locomotion speed that we apply it in virtual reality.

3.2 Combination of Arm-Swing and Leg-Lift

3.3 Participants

3.4 Procedure

4 RESULTS

5 DISCUSSION

5.1 Insights for implementing WIP for VR locomotion

6 CONCLUSION

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