Silver Surfer: A System to Compare Isometric and Elastic Board Interfaces for Locomotion in VR

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ABSTRACT

In this poster, we present the design and the implementation of a surfboard travel interface inspired by the "Silver Surfer" cartoons and movies. The board interface works in either tilt mode or balance mode, creating an interesting comparison of isometric and elastic devices for rate control and position control travel in virtual environments. We also demonstrate the setup of a complete virtual reality system aimed to evaluate the usability of this travel interface in a future study.

KEYWORDS: 3D user interface, travel, tilt board, balance board, virtual surfing.

INDEX TERMS: I.3.6 [Computer Graphics]: Methodology and Techniques — Interaction techniques; I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism — Virtual reality.

1 INTRODUCTION

Travel in virtual environments (VE) has been a difficult problem since the beginning of virtual reality (VR), basically due to the difficulty of designing an intuitive, effective, and precise interface which can map the user's finite movements in the real world to a potentially infinite virtual world while maintaining as much presence as possible. Based on real world skateboarding, snowboard, and surfing, VR researchers and arcade game platform designers have implemented various board interfaces which enable the users to surf a VE intuitively and effectively, such as the PEMRAM motion base and the Hawaii Surf Simulator. Because it is hard for people to yaw a board when standing on it, most board interfaces only support two degrees of freedom (DOF), namely pitch and roll. And they limit the virtual movement to be on a surface (e.g., the ground) due to the 3-DOF requirement of complete 3D travel. This is sometimes not a sufficient solution because for many VR applications, such as virtual 3D modeling, virtual data visualization and virtual tourism, being able to travel along the Z axis is indispensable. Not willing to occupy the user's hands as they were designed to fulfill wayfinding tasks, Valkov [3] programmed a special foot gesture tracked by the Wii Fit balance board to extend his board-surfing metaphor to 3-DOF. It allows the user to travel in 3D completely by using her lower body alone, but is not very intuitive or effective, and is prone to undesired inputs. In the system we propose, we choose to add the third DOF to the user's arm, which is independent with the lower body movements, and is more intuitive based on the "Silver Surfer" cartoons and movies.

In [5], Zhai reported a user study designed to compare a hand-held elastic device and a hand-held isometric device for 6-DOF manipulation by rate control. Results showed that the former has some superiority over the latter, but this advantage vanishes after 20 minutes of practice. We are interested in a similar study, but applied to surfboard-type travel interfaces, with a tilt board being the elastic device and a balance board being the isometric device, and to control the yaw of the virtual board by either position control or rate control. The purpose of this poster is to introduce the implementation of our "Silver Surfer" system designed to facilitate this study in the future.

2 HARDWARE SETUP

General 3D space navigation consists of 6-DOF in two categories: pitch, roll, and yaw for orientation control and translations along the X, Y, and Z axes for location control. The "Silver Surfer" in the movie can pitch, roll, and yaw his surfboard and use his "super charge" ability to speed up and move forward, giving him control of 4-DOF locomotion by which he can travel to any location in the 3D world.

Because in essence 3DOF are sufficient to completely travel in 3D and according to Vidal & Amorim [4], roll (rotation along the forward direction) is against the human natural balance system and may lead to severe sickness and loss of orientation, we disabled rolling of the virtual board in our design. The left part of Figure 1 illustrates the 3-DOF we plan to implement.

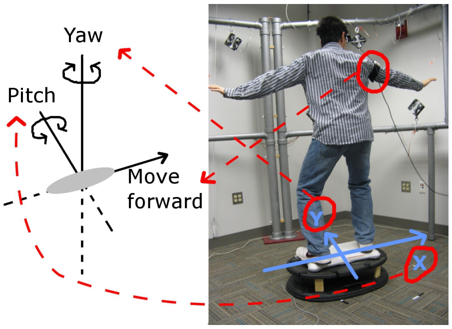

Figure 1. Implementation of 3-DOF travel

The first DOF, the control of the travel speed along the forward direction, is implemented by mounting a B-Pack Compact Wireless Accelerometer (Model WAA-001) on one of the user's arms, as indicated in Figure 1. The accelerometer senses the tilt of the arm as it is lifted or lowered and feeds data to the system in real time to control the travel speed.

The board interface shown in Figure 1 supports control of the other 2-DOF, namely, the pitch and yaw of the virtual board. It is made by mounting a Nintendo® Wii Fit Balance Board on top of

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a Reebok® Core Board. The balance board is a sturdy plastic panel that rests on four feet [2], each containing a pressure sensor whose output values can be synthesized to obtain the gravity center of the user, which consists of X and Y components corresponding to the pitch and yaw control we need to realize the interface. The tilt board is a fitness board which tilts in four directions. The springs in it resist tilt to re-center the top surface parallel to the ground, making it an elastic interface. Its pitch and roll values are sensed by another B-Pack accelerometer mounted below its top surface and are mapped to the pitch and yaw of the virtual board, respectively. The combined board interface is able to work in either balance mode or tilt mode. For the former, we put four pieces of wood on each corner below the tilt board so that the surface the balance board rests on is supported and fixed, and the data from it being used to control the virtual board, as shown in Figure 1. For the latter, we take off the wood pieces so that leaning on the balance board will tilt the board, and the B-Pack sensor data below it is used to control the virtual board. This special board combination design is to guarantee an unbiased comparison between the tilt board and the balance board, as each board used independently would have a different height.

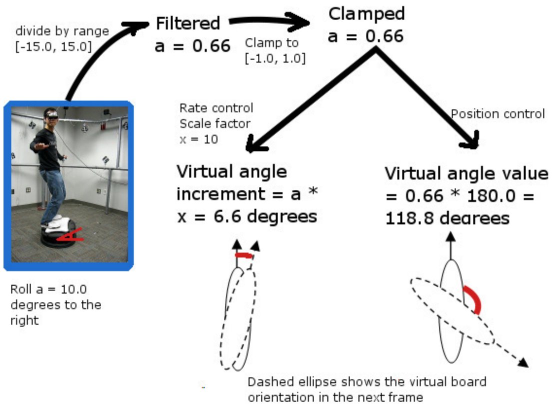

Figure 2. Board data processing

Based on Zhai's research [5], we apply the concept of rate control and position control to the yaw of the virtual board. In rate control, the data from the real board (clamped to [-1.0, 1.0]) are mapped to the velocity of the yaw ([-max speed, max speed]). In position control, it is mapped directly to the angle value ([-180.0, 180.0]). Figure 2 illustrates the data processing in these two conditions, with the board working in tilt mode. The range values used to divide the raw data from the board are obtained from a calibration procedure required for every user before any trial, differed by their individual height, weight, and skill of balance. The pitch mapping is always by position control because in the rate-control pitch scenario, the user would pitch the board continuously and reach a value larger than 90 degrees or smaller than -90 degrees. In both cases, her avatar and viewpoint would be upside down while she is still standing normally. According to Vidal & Amorim [4], this can greatly confuse the user.

For the system's output, we use an eMagin z800 Head-Mounted Display (HMD) to give the user visual and auditory feedback. The user's head movement is tracked by the gyroscope in the HMD to control her view in the VE. Because the travel direction is solely and completely controlled by the board interface, the user is able to look in one direction while moving in another. In a public demonstration of our system, we observed that this setup confused the users at the beginning of their immersion, but helped to achieve better VE cognition when they got used to it because the orientation of their views are not restricted by the travel interface.

Bowman, Koller, & Hodges [1] categorized travel interfaces into gaze-directed interfaces, pointing-directed interfaces, and torso-directed interfaces. The surfboard interface falls to a fourth category, namely device-directed interfaces, because the virtual board, whether pitched or yawed or kept still by the real board, always moves towards the front side of it, which is also the front side of the real board from the user's perspective.

In addition, we use our TactaCage system to simulate wind. This system was designed for an immersed user to stand in the middle, and have her body tracked, as well as allow fans mounted around the perimeter to provide wind feedback under computer control. Seven muffin fans mounted in front of the user are used in the current system. The speeds of the fans are directly mapped from the speed of movement, which is controlled by the arm-mounted accelerometer, and the direction of rotation.

3 VIRTUAL ENVIRONMENT

Figure 3 shows the VE we developed by the Unity3D Game Engine. It consists of nine terrain tiles that repeat in eight geographical directions based on the current location of the "Silver Surfer" avatar, forming an infinite virtual world. The avatar stands on a silver board whose direction is controlled by the board interface, either in tilt mode or balance mode. The goal is to find and collect targets floating in the sky by flying through them.

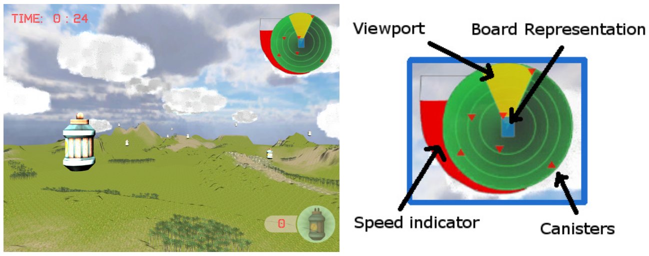

Figure 3. The virtual environment

To decrease the demands of wayfinding and focus the comparison mainly on travel, we overlay a north-up radar in the top right corner of the user's view, which is zoomed in and showed Figure 3. It helps the user to locate the targets near her and to differentiate her gaze direction from her moving direction.

REFERENCES

[1] D. A. Bowman, D. Koller and L. F. Hodges. Travel in Immersive Virtual Environments: An Evaluation of Viewpoint Motion Control Techniques. *Proceedings of Virtual Reality Annual International Symposium '97*, pages 45–52, Albuquerque, NM, 1997.

[2] G. de Haan, E. J. Griffith, and F. H. Post. Using the Wii Balance Board as a Low-Cost VR Interaction Device. *Proceedings of the 2008 ACM symposium on virtual reality software and technology*, pages 289–290, New York, NY, USA, 2008.

[3] D. Valkov, F. Steinicke, G. Bruder and K. H. Hinrichs. Traveling in 3D Virtual Environments with Foot Gestures and a Multi-Touch enabled WIM. *Proceedings of Virtual Reality International Conference (VRIC 2010)*, pages 171–180. 2010.

[4] M. Vidal, M. Amorim, and A. Berthoz. Navigating in a Virtual Three-dimensional Maze: How do Egocentric and Allocentric Reference Frames Interact? *Cognitive Brain Research 19*, pages 244–258. 2004.

[5] S. Zhai. Investigation of Feel for 6DOF Inputs: Isometric and Elastic Rate Control for Manipulation in 3D Environments. *Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting'93*, pages 323–327. Seattle, Washington, USA. 1993.