Using the Wii Balance Board™ as a Low-Cost VR Interaction Device

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Figure 1: *VR scenarios using the Wii Balance Board™. From left to right: Our analysis environment to study incoming signals, 3D rotation in a desktop visualisation application, navigating a map in an personal VR station, controlling animation speed on a projection screen.*

Abstract

We demonstrate the use of the Wii Balance Board™ as a low-cost virtual reality input device. We provide an overview of obtaining and working with the sensor input. By processing the sensor values from the balance board, we are able to use it for both discrete and continuous input, which can be used to drive a variety of VR interaction metaphors. Using continuous input, the balance board is well suited for interactions requiring two simultaneous degrees of freedom and up to three total degrees of freedom, such as navigation or rotation. The discrete input is suitable for control input, such as mode switching or object selection.

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Keywords: Virtual Reality, input devices, balance board

1 Introduction

In this paper, we demonstrate the use of the Nintendo® Wii Balance Board™ as a virtual reality (VR) input device. By processing the changing sensor input values from the board's four pressure sensors, we are able to use it for both discrete and continuous input. Using continuous input, the balance board is well suited for interactions requiring two simultaneous degrees of freedom and up to three total degrees of freedom, such as navigation or rotation. The discrete input is suitable for control input, such as mode switching or object selection.

As an input device, the balance board is applicable in a variety of scenarios. While standing on the board to control first-person travel comes quickly to mind, we also explore other scenarios and interaction techniques, including using balance board while seated. See Figure 1. In many of these scenarios, the user's hands are already occupied with a primary task, such as object selection. Transferring secondary tasks, such as travel, to the feet avoids mode-switching and possibly improves the application's usability.

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2 Related Work

Body-centered or torso-directed steering techniques enable natural proprioception and kinesthetic senses for first-person navigation, see [Kruijff 2006] for an overview. The Virtual Motion Controller (VMC) [Wells et al. 1996] consists of a large curved platform with four pressure sensors and appears most similar to the balance board. The user steps from the center of the device onto the rim to indicate direction, while the curve shape provides feedback to the user. [Beckhaus et al. 2005] compares a *dance mat* and a swiveling stool prototype, the *ChairIO*. Their informal user study suggests that users perceive navigation with both devices as intuitive. However, in complex navigation tasks, the cognitive load of the stepping motions is reported to be higher than the leaning on the stool. As the Wii Balance Board™ is production quality and only requires leaning instead of stepping, it has good potential for practical use in first-person, egocentric navigation task in VR. For our VR applications, we are also interested in the use of the balance board when sitting down with the feet resting on the board, similar to pedal control, for hands-free control of object rotation.

3 Processing Balance Board Data

The balance board input device is a sturdy plastic panel that rests on four feet, which each contain a pressure sensor. The pressure values measured by the board are communicated to a host computer via Bluetooth™.

The four pressure sensors give the balance board four degrees of freedom. In practice, however, the balance board is an *isometric* input device, and one cannot accurately control the individual degrees of freedom separately. During normal use, the balance board supports the user's weight, and the user cannot increase the pressure on one sensor without also decreasing the pressure on other sensors.

We use the cross-platform WiiUse library[1] to handle communication with the balance board. We integrated this with VRPN [Taylor et al. 2001] to retrieve the sensor values in our applications. We poll the sensor values in a separate thread so that we can apply the necessary filtering on the sensor input at a rate that is independent of the application frame rate. Our applications are built on our in-house, *OpenSceneGraph*[2]-based VR toolkit *VRmeer*.

We calibrate the balance board by mapping the average sensor values over a period of time to 0.5. We use this mapping to map and clamp sensor values to the range $[0, 1]$. During calibration, we use a threshold to determine whether the user is sitting or standing. To

[1] http://www.wiiuse.net/
[2] http://www.openscenegrapph.org/

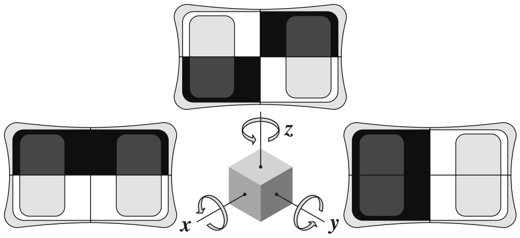

Figure 2: *Shifting weight to the black quadrants causes a positive rotation around the illustrated axis.*

produce usable data, we smooth the sensor values and derive a number of other values. We combine sensor values and negated sensor values to derive 1D axis positions. We snap positions close to 0 to 0 and rescale the remaining range to $[-1, 1]$. In some scenarios, these are then further (logarithmically) re-scaled. We also threshold the sensor values to generate discrete on/off values.

4 Interaction and Applications

We will discuss some of the interaction metaphors and applications we have implemented for the balance board. Figure 1 shows some of these. All of our test cases work using the balance board both while sitting and standing.

3D Rotation Control: The Wii Balance Board™ can also be used as rotational input device. This is useful in exocentric VR applications, where the user rotates a particular object of interest, e.g. a data volume being visualized or the entire virtual world, while keeping his or her hands free for other interactions.

To use the balance board as a rotational input device, we extract three rotational signals from the four sensors. Figure 2 illustrates the sensor combinations we use to control rotation around the x, y, and z axes. To compute the rotational signal for an individual axis, we sum the sensor values for positive rotation and then subtract the sensor values for negative rotation. To give the user both fine control over the rotations and the ability to make quick rotations, we apply a logarithmic scaling to the rotational signal.

We found the rotation was intuitive to control, but there are two things to be aware of. First, when seated, rotations y axis require significantly more effort than rotations around the x and z axes. Scaling the input signals up reduces but does not eliminate the problem. Second, when standing, rapidly shifting one's body weight is difficult, which can lead to difficulties in stopping objects once they are in the desired orientation. Increasing the range of values used for fine-grained control of the rotations helps alleviate this problem.

Navigation Control: The three individual axes can also be used to control up to three degrees of freedom in egocentric or first-person viewpoint control for navigation. By standing on the board, leaning forwards or backwards can control velocity or "drive" in a forward or backward direction. Leaning sideways controls strafing left or right, while pressing on the toes and heel of opposing feet (similar to rotating around the z axis) initiates turning. In an exocentric or third-person viewpoint, the leaning controls can be used for translating or panning the virtual world. An example of navigating a city model is shown in Figure 1.

We found that the transitions between forward motions and rotations can be made very intuitively and result in smooth movements through the environment. A transition from forward motion to sideways strafing or panning was found to be generally slower, as it requires a larger shift of balance. Similar to the the rotation experiments, careful adjusting of the threshold and scaling of the signals is required to get good overall control. When a simplified flying metaphor does not suffice, one can combine the balance board with other input devices to control more DOFs (e.g. upward motion, roll and pitch).

Abstract Control: A third area where the balance board can be used in VR is for controlling application specific tasks. Providing sufficient control over the environment in an intuitive and uncluttered way is a common design challenge, often complicated by limited or a lack of suitable input devices available to the user. By remapping some common control tasks requiring 1 DOF to the user's feet, the balance board can help simplify the virtual environment while giving the user more control. This effectively "decouples" these control tasks from the environment, i.e. the user no longer has to directly interact with the virtual environment itself to exert control over it.

For these control tasks, we use can use either the discrete on/off values for the panels or the 1D axes we compute. The on/off values can be used to enable or disable various modes or tools within the virtual environment. Two examples we implemented that use the 1D axes are controlling time in a time-dependent visualization (Figure 1, right) and zooming in and out on an object of interest. In our tests, we found that using the balance board for such control inputs worked well. The decoupled nature of the interaction is especially helpful for controlling time since it is easy to stop and rewind to an interesting event in the data. Two disadvantages to using the balance board in this way are that unintended movements are also registered as control inputs and the board can only be used to control one or two parameters simultaneously.

5 Conclusions and Discussion

We demonstrated using the Wii Balance Board™ as an VR input device. We described our software pipeline and the processing we perform on the raw sensor values. We also presented some design considerations when using the board for 3D interaction techniques. The important caveats are that not all degrees of freedom can be controlled with the same ease and ceasing input is not instantaneous due to the delay in the user shifting his or her weight.

Based on our experiences and input from colleagues, we found the balance board to be effective and easy to use. We were particularly impressed by using the board as an extra input device while seated. The ease of use suggests that the balance board could easily be used in a wide variety of applications, even outside of VR.

Videos, further information on getting started with the balance board, and our source code are available at:
http://visualization.tudelft.nl/Projects/WiiBalanceBoard.

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