
Moving on the Virtual Balance^{TM}

Intuitive interface environment: The Virtual Balance^{TM}

1. Objectives

Traditional WIMP interfaces are related to word processing tasks. Virtual environments require for new interface paradigms and techniques. The goal is to create an input device for free body interaction by using principles of navigation the human is familiar, such as movement in space. The device should be based on mental principles of movement and gravity and should extend these natural human features for navigation and orientation in virtual environments. Furthermore this interface has to be intuitive to be used by a large number of untrained people without any description or explanation. Therefore the development of the interface is focused on usibiltiy for a single user application, such as exploring large virtual architectural databases in a cultural context looking for didactic principles in a museum. The first part of the Virtual Balance is realized as a platform reacting on the body movement of a user staying on it. The position of the user in the virtual environment is updated in accordance with the data from this platform. The navigation is visualized on a large screen infront of the user who feels immersed based on the realtime relation of body movement and visual perception.

2. Conceptual Principles of the Virtual Balance

Conceptual background is always necessary in interface design. The Virtual Balance is based on several ideas everybody is familiar with. In fairy tales the „magic carpet“ is a vehicle for unencumbered traveling over landscapes. In the greek myths Hermes the messenger is able to fly around the world connecting people with information. Both examples indicate human dreams of the ability to fly stored in a collective conciousness of mankind. The wish to fly is about seeing the world from distance, to extend the narrow view of one‘s individual world, to create a different relation to the world. As these are manifested stories on basic wishes of extending the human body they can serve as cultural touchstones for everybody. Therefore interfaces based on issues of cultural history can be defined as intuitive ready to be used without any description.

3. Physical Principles of VB

In order to inhabit Mixed Reality spaces we introduce intuitive interfaces for input and unemcumbered navigation in virtual environments. The interface Virtual Balance is based on man-machine interaction by movements of the human body on a platform. This platform consists of two circular discs containing three weight sensors arranged in a triangular form between these discs. The sensors receive changes of weight distribution on the upper disc and transmit them to an analysis unit, which in turn controls the position and orientation of the user's viewpoint in the virtual environment. The number of the sensors and their location are derived from the well known fact that any plane is stabilized by three force vectors F1, F2, F3 against a contradirectional force vector Fg (i.e the weight of the object). It is quite obvious that the point on the upper disc to which user's weight is applied at the given moment can be unambiguously calculated from three numbers from the sensors, as it is shown in Figure 1.

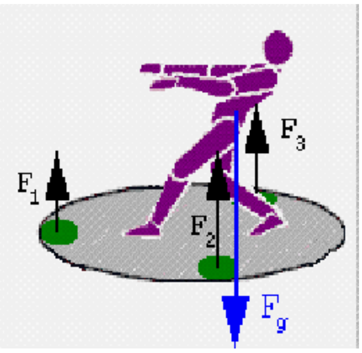

Fig.1. The physical principles of the VB

The Virtual Balance requires the use of the whole body. Minimal weightshift on the platform enables navigation. Thus, depending on the actor's shifting of weight or minor movements the viewpoint of the virtual scene is rendered in real time. Similar to the panorama of the 19^{th} century, with the illusion of motion, a dramaturgical narration is created. Using interactive digital media replaces the static perspective into a dynamic view.

4. Implementation of VB

We use a personal computer as an intermediate stage between input signal measurement (weight sensors) and SGI's graphics workstation.The signal from the weight sensors are sampled via three I/O ports. From these seperate signals the barycenter coordinates of the user's body on the platform (the location of the point on the disc to which the user's weight is applied) are calculated and sent to the graphics workstation over a fourth I/O channel for rendering of the new scene. The data sent from the PC to the graphics workstation as input for scene rendering consist of two coordinates for the barycenter on the navigation platform and total weight measured by three sensor. From these data the current position, speed and orientation of the user's viewpoint are calculated in accordance with the chosen mode of navigation.

5. Navigation principles

With the Virtual Balance the ground below the user's feet becomes an interactive surface and the body's perceptual sensitivity coupled with body balance becomes a control environment. Weight shift, i.e. change of position of the reference point can be induced just by changing the body's balance without changing the position of the feet. This procedure can be seen as some kind of ‚gesture recognition, if ‚gesture' is not only defined by the hands, but rather by the complete body. Certain gestures (i.e. body positions) can be related to certain pre-defined actions at the basic Virtual Balance calibration model. Weight shift is transformed into movement in a Virtual Environment in an intuitive way. Shifts to the right or left change the direction accordingly, while shifts to the front or back lower or raise the tip of the virtual flying device, thus changing the height by inducing a tendency to sink or rise, respectively. In virtual environments simulating the real world, most detailed objects are located near the ground, while in a position high up the sky you would rather want to get an overview. Therefore, speed on the Virtual balance is controlled by the height related to the model scene. Rising above the ground means also increasing speed. In completely artificial environments, where details are equally distributed in all three dimensions , another navigation strategy might be required.

To help the user to navigate through a large or even infinite model that is spread over a rather large area we introduced the top view as a visual interface showing the user's current position in the virtual environment as well as the current orientation of the user's viewpoint. (Figure 3). We use the as top view the 2D image created beforehand to save computational resources. Depending on the available computational recources one can use a virtual mirror to give the user a notion of the entire environment surrounding him. However one should use the virtual mirror with care since the use of it assumes recalculation of all normals of the virtual environment, resulting in a very low frame rate.

6. Mapping of data from the VB

To navigate through large architectural models the user must be provided with the opportunity to change the position of the viewpoint in 3D space, to change its orientation on the horizontal plane, to move with different speed to see more or less details of the virtual environment. At the same time when choosing the appropriate mapping one should consider the following facts:
The VB provides only two independent streams of data (coordinates on the disk plane). Untrained users must not undertake special complex actions to change the parameters of the motion in the virtual environment. In our current implementation the data from the VB are mapped in the way described below and depicted on the Figure2.

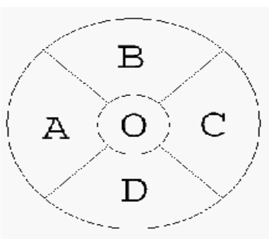

Fig.2. Mapping of data from the VB

For the simplicity we will call the position of the point on the VB's upper disk to which the user's weight is applied 'the position of user's weight'. If the user's weight is applied to the central area O, no parameters of the user's viewpoint are changed. If the user's weight is applied to the central area A or C correspondingly to the left and to the right from the central area the user's viewpoint turns in the virtual environment with angular velocity increasing linearly with the distance from the position of the user's weight on the disk to the center on the disk. So with the given speed of the motion in the virtual environment the user's weight has to be closer to the left or to the right border of the VB's disk to fit to a turn with smaller radius in accordance with the well-known formula from mechanics $\vec{v} = [\vec{\omega}, \vec{r}]$
In addition the user's viewpoint rotates around the speed vector in the virtual environment on an angle increasing linearly with the distance from the user's weight to the center of VB 's disk. These functionalities provide more immersion for the motion in large architectural models and simulates well known mechanical effect which motorbikers and skiers experience when trying to fit on the high speed to a turn with a rather small radius. They have to lean very close to the ground to displace the center of gravity closer to the center of turning. This action decreases force of friction from the ground and prevents the person from breakdown. Figure 3 illustrates this principles.

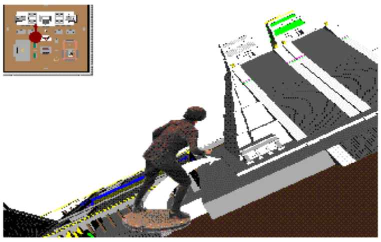

Fig.3. Making a turn with the VB. The top view of the model is shown on top left corner

When the user's weight is located in the area B or D (Figure2) before or behind the central area of the disk the user changes the height of his viewpoint in the virtual environment: decreasing (area B) or increasing it (area D).

The data provided by the VB are not sufficient to change the speed of motion in the virtual environment in the same intuitive manner. In addition to the approach in which the speed of motion depends on the height as explained earlier, we propose the other solution to this problem. The user can change the mode of mapping of data from the VB through some predefined actions on the VB's platform. One can use the areas B and D on the disk not only for increasing and decreasing the height but also for increasing or decreasing the speed of motion. We implemented the following way of change of the mode of data mapping from the VB. If the user wants to increase the speed of motion he goes back on the platform (so his weight is located in the area D) and immediately goes forward (his weight now is located in the area B). The time between these two events must not be greater than 1 second or another predefined value, otherwise the change of mode does not occur (Figure 4).

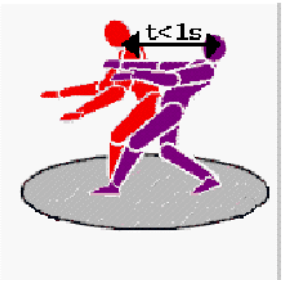

Fig.4. The change of mode on the VB through predefined actions of the user on the VB 's platform

Until the user's weight is located in the area B the speed of the motion is being increased depending on the distance from the user's weight on the VB's platform to the center of the disk. Once the user's weight leaves the area B, the mode of mapping the data returns to the usual state when areas B and D are used for changing the height. In the same manner the user can decrease the speed of motion in the virtual environment. However, testing of this feature with different people showed that such modes of interaction can not be considered as intuitive and some time is required for adaption to this functionality. Therefore we use the first method of changing the speed of motion in our public demonstrations when visitors navigate through virtual environments.

7. Applications

Our numerous tests with different users show that the interface VB is well suited for investigation of large architectural models, like reconstructed models of ancient cities. We use the model of the roman village Colonia Ulpia Traiana (100a.o.t) created from archeological data by joint work of architects, civil engineers, archeologists and computer scientists. Body navigation determines height and speed. Depending on the navigator's distance from the virtual objects, different levels of detail (LOD) are activated. The public trials to evaluate the usability, functionality and acceptance of the VB interface system had been demonstrated at the Telepolis exhibition in Luxemburg and at the Cebit for a mass audience of about 2000 untrained users. The evaluation results had been used to improve the system during the process of development.

8. Conclusion

The VB is a body centered re-/action device with computer connected sensors to navigate and interact in a virtual environment . It is thus a responsive environment that can be placed in the context of VR interfaces based on the human body and on innovative communication concepts. The VB is a durable, robust and water resistant system which registers slightest changes in body balance and transforms them into stable performance. The VB is drift free and sensitive working in high accuracy (+/-1%). Its flexible and mobile use, safe and easy handling for children and adults, its possible therapetic use as well as its use for dancers and actors in virtual studio, TV settings or theatrical environments make it very attractive. We can think of artistic installations presented inside and outside public places like museums, art galleries, in front of a bank or inside a shopping mall. The VB can also be used outdoor, e.g. for window shopping in e-commerce application in front of a shopping window. Advantages of the VB are free hands for other tasks, such as using additional interfaces, e.g. a palm top device. Navigation requires no effort to support the immersion of the user in the virtual environment.

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Application:
The *Virtual Balance*^{TM} is currently used in the context of virtual museum navigation. Interfacing an old roman village the visitors are able to explore the ancient urbanism of Xanten.

References: (add from Montpellier paper)

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