Interfacing Cultural Heritage

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Abstract
In this paper we describe briefly intuitive physical interface called "Virtual Balance", present recent modifications and give the most impressive example of its use for navigation in and exploration of reconstructed models of ancient cities. One can imagine that example as a fly on a magic carpet in the ancient cities.

1. Introduction

Virtual Reality applications allowing exploration of large architectural models (e.g. reconstructed model of ancient towns) need intuitive input and output devices which involve the full body scale and used without special description.

The authors' main interest is to develop systems that focus on the linking of real and virtual environments and the users sense of presence. This aim is also reflected in earlier works: *The Spatial Navigator*[1] uses a treadmill where the viewer walks through a virtual castle. *The Responsive Workbench*[2] has put the conventional dialogue concepts for human-computer communication into a user-oriented shape. Virtual objects and tools are projected stereoscopically on a real workbench as a virtual design environment. The computer art installations *Rigid Waves*[3], a mirror based on image processing and *Liquid Views*[3], a water surface based on a touch screen stride new ways in human-computer communication, where the interface is tangible to support the users perceptional process.

In this paper we describe our recent improvements and investigations of the interface called Virtual Balance (VB)[4].This interface is realized as a platform that reacts on the body movements of the user which is staying on it. The position of the user in the virtual world is updated in accordance with the data from that platform. For user's immersion to the virtual environment the wall screen is used.

2. Physical principles, underlying ideas

The interface VB is based on man-machine interaction by movements of the human body on a platform. The platform consists of two circular plates (disks) with three weight sensors arranged in triangular form between these disks. 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 F_1, F_2, F_3 against a contradirectional force vector F_g (i.e. the weight of the object). It is quite obvious that the point on the upper disk 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 on the Figure 2.

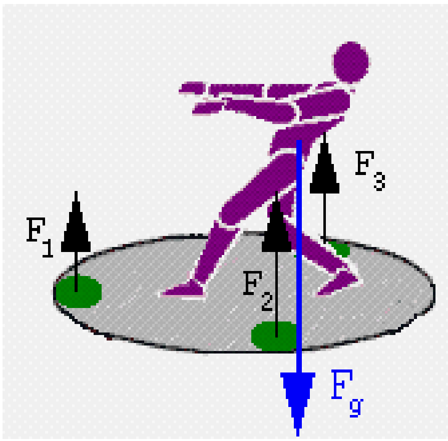

Figure 1: *The physical principles of the VB.*

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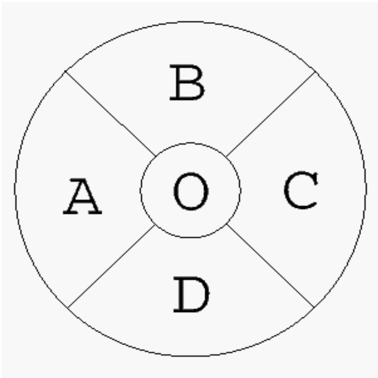

Figure 2: *Mapping of data from the VB.*

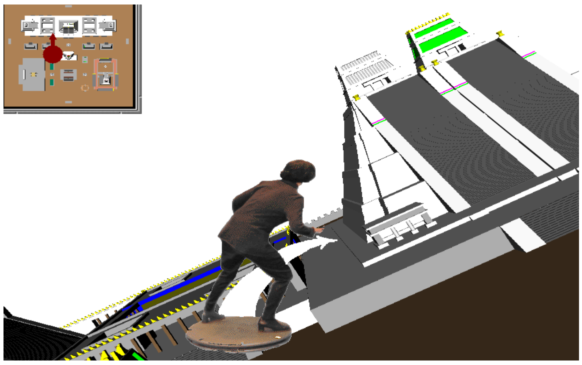

Figure 3: *Making a turn with the VB. The top view of the model of Aztec city is shown on the left top corner.*

3. Implementation

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 separate signals the barycenter coordinates of the user's body on the platform (the location of the point on the disk to which the user's weight is applied) are calculated and sent to the SGI's 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 sensors. From these data the current position, speed and orientation of the user's viewpoint are calculated in accordance with the chosen mode of navigation.

4. Mapping of data from the VB

To navigate through large architectural models like the models of ancient cities (see Applications) the user must be provided with the opportunity to change the position of the viewpoint in the 3D space, to change its orientation on the horizontal plane, to move with different speed to see more or less details of the virtual world. At the same time when choosing the appropriate mapping one should consider the following facts:

1)The Virtual Balance provides only two independent streams of data(coordinates in the disk's plane)

2)Untrained user must not undertake special complex actions to change the parameters of the motion in the virtual world.

In our current implementation the data from the VB are mapped in the way described below and depicted on the Figure 4.

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. This is neutral area.

When the user's weight is applied to the 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 of 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 vector of the speed 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 the large architectural models and simulates well known mechanical effect which motobikers and skiers experience when trying to fit on the high speed to a turn with rather small radius. They have to lean very close to the ground to displace the center of gravity closer to the center of the turning. This action decreases the force of friction from the ground and prevents the person from the breakdown.

Figure 4 illustrates these principles. When the user's weight is located in the area B or D (Figure 4) 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). In addition, the orientation of the user's viewpoint turns around the axis parallel to the hor-

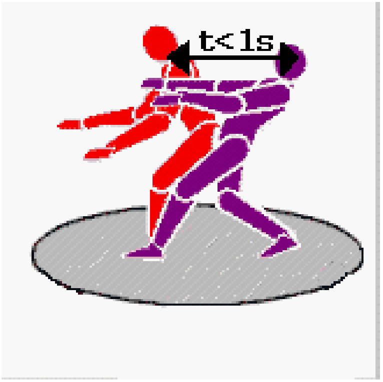

Figure 4: *The change of mode of the VB through predefined actions of the user on the VB's platform.*

izontal plane and perpendicular to the vector of the speed of the motion in the virtual environment. The angle of the turning is increased linearly with the distance from the user's weight to the center of the disk. This feature simulates the following effect. When the user is on the back side of the disk, the forward part of the virtual platform on which the user flies in the virtual environment is going up, and the height is being increased. In the same manner when the user is on the forward part of the VB's disk the forward part of the virtual platform is going down and the height is being decreased.

The data provided by the VB are not enough to change the speed of motion in the virtual environment in the same intuitive manner. We propose two solutions to this problem.

1) The speed depends on the height of the user's viewpoint in the virtual environment. In the large architectural models all information is located on the ground. So it makes sense to move with relatively small speed on the ground to see the model in details and to fly with a larger speed in some height from the ground where the opportunity to see more details is not important.

2) The change of the mode of the mapping of data from the VB through some predefined actions of the user on the VB's platform. One can use the areas B and D on the disk not only for increasing and decreasing the height of the user's viewpoint in the virtual environment but also for increasing or decreasing the speed of motion. We implemented the following way of the change of the mode of the mapping of data 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 small predefined value, otherwise the change of the mode does not occur (Figure 4).

Until the user's weight is located in the area B the speed of the motion in the virtual environment 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 the mapping of data returns to its usual state when areas B and D are used for changing the height. In the same manner the user can decrease the speed of the motion in the virtual environment.

However testing of this feature with different people showed that such actions can not be considered as intuitive and some time is required for adaptation to this functionality.

We use the first mentioned method of changing of the speed of motion in the virtual world in our public demos when our visitors navigate through large architectural models (see the next section).

We also plan to use additional devices (electric field sensors) for changing the speed in an intuitive way through free user hand gestures.

5. 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 (100 a.o.t) created from archaeological data by joint work of architects, civil engineers, archaeologists 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. To help the user to navigate through a large model that is spread over a rather large area we introduced the top view with a cursor showing the current user's position in the virtual environment as well as the current orientation of the user's viewpoint (Figure 4). We use as the top view the 2D image created beforehand to save computational resources. Depending on the available computational resources one can use in our framework 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 small frame rate.

6. Future work

As a future step we plan to realize collaborative exploration of the cultural heritage models. It is supposed that two users on the Virtual Balances located distantly explore the model jointly. The question of the appropriate user's representation arises here. The output of the video camera capturing each of the users can be used for the such representation. One need to use image segmentation techniques to extract the image of each user from the static background. As a result each user will see on his/her screen natural and expressive bodily movements of the other user steering the VB. The communication between the users is realized via natural gestures and speech.

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