A New Navigation Method in Virtual Environment

(2D Map-Based Navigation in 3D Virtual Environment)

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Abstract

This paper puts emphasis on navigation in virtual environment, which is one of the major interfaces for the interactivity between human and virtual environment in virtual reality circumstances and worlds. It proposes a new navigation method: 2D Map-Based Navigation, which prevents user's spatial lost in 3D Virtual Environments and provides a very simple, natural and user-centered navigation method in virtual environment. The 2D Map-Based Navigation is composed of three major processes, Constant Velocity Navigation, Collision Detection and Avoidance, and Path Adjustment. The 2D Map-Based Navigation can reduce user's difficulties and improve user's sense of presence and reality in the virtual environments. The experiment study proved that the 2D Map-Based Navigation is a very natural, straightforward and useful navigation interface in the virtual environment.

1. Introduction

This paper puts emphasis on the navigation method in the virtual environment, which is one of the major interfaces for the interactivity between human and virtual environment in VR circumstances and worlds. It proposes a new navigation method: 2D Map-Based Navigation, which prevents user's spatial lost in 3D VE and provides a simple and natural navigation method in virtual environments, closer to how we walk or move in the real world. It can then improve the Presence and Immersion, the final goal for Virtual Reality. The 2D Map-Based Navigation is composed of three major processes. When a user select a point on the 2D map then the relative target position on the 3D VE is estimated. And then the first process, Constant Velocity Navigation (CVN) supports continuous and automatic constant travel and navigation service until the user arrives at the selected location, even without any additional input from the user. The second process is the Collision Detection and Avoidance (CDA), and the last process is Path Adjustment

2. 2D Map-Based Navigation

An important feature of virtual reality is Navigation, the facility for the user to move through a virtual environment in a natural and easily controlled manner. Natural locomotion methods can contribute to a sense of presence, which is cited by some researchers as a defining attribute of VR. The illusion of presence can be lost through unnatural experiences during travel in VE. This can be caused by poor interactive metaphors or by experiences, which do not agree with the user's everyday understanding of the real world.

When a user travels in 3D VE, sometimes the user cannot easily figure out the user's location in 3D virtual environment, and we name this as "spatial lost". The spatial lost is one of the major problems in virtual reality system. In order to reduce spatial lost, the Virtual Reality service developers consider the user's spatial awareness. In most of the existing Virtual Reality systems, if the user wants continuous travel or navigation, then the user has to input each moving event continuously with a mouse or keyboard. It is not an easy job for a typical VR user to control the navigation in 3D VE by mouse, keyboard or other input devices; especially when the user is not familiar with VR or computer environment. And when a user travels in 3D VE, spatial lost can happen because it is not easy to recognize his/her location in 3D Virtual Environments without any additional information.

The 2D Map-Based Navigation provides a natural navigation method in virtual environments, closer to how we walk or move in the real world. It can then improve the Presence and Immersion, the final goal for Virtual Reality. The 2D Map-Based Navigation provides three major processes. Constant Velocity Navigation (CVN), Collision Detection and Avoidance (CDA), and Path Adjustment

2.1 Constant Velocity Navigation (CVN)

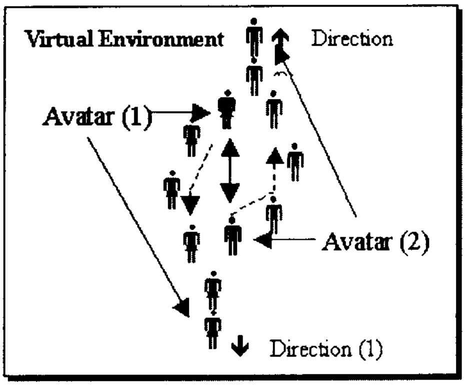
The CVN supports constant and continuous travel as if the user is continuously giving moving events with various input devices. If the CVN is serviced, it gives hand-free navigation. Hence, the user can handle other tasks as well, such as chatting, reading, or talking on the telephone, while traveling and navigating in the virtual environment, without any additional inputs for the moves in the VE.

In order to support CVN, we change the user's viewpoint by modifying the position variable in the viewpoint node in the VRML world file. At first, we calculate the angle (azimuth) between the target location and the user's current location, using the JavaScript Math.atan function with the location values of the user (X_o, Z_o) and the target (X, Z). (Angle (θ) = $\tan^{-1}((Z - Z_o) / (X - X_o))$).

We classify the angle(θ:360 ^{0}) into 4 sections, and then continuously add to or subtract from the user's current position value in viewpoint node, depending on the angle. For instance, if the angle is - 0.39249(- 22.5 ^{0}) then it conveys the plus sin(22.5) value to the X-axis value, the minus cos(22.5) value to the Z-axis value; in the user's current position variable in viewpoint node.

2.2 Collision Detection / Avoidance (CDA)

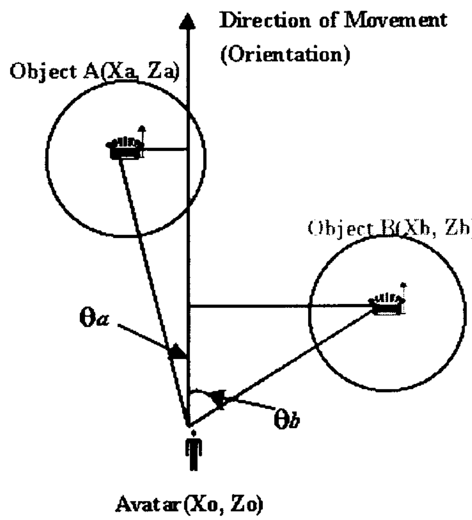
The CDA process first catches and recognizes a collision situation with virtual objects or with other users' avatars in the virtual environment. If the user's avatar runs against a virtual object then it generates a collision detection event, therefore the CDA has to systematically catch or receive this collision detection event, using virtual object's location data. It also generates a collision detection event when the two different avatars approach each other. To detect collision situation, the CDA uses the avatar's data information in the system, such as their ID, location, scale data, and so on. After the Collision Detection, this process starts the next step: Collision Avoidance. This step assumes that the user's avatar will by-pass objects and other avatars systematically and naturally until the avatar is moved to a distant location, which will prevent colliding with the object or the other users' avatar (see Figure 1).



[Figure 1: CDA and Path Adjustment]

The CDA process predefines the angle between the user and other avatar or the virtual objects based on the user's orientation (Direction of movement) (see Figure 2). The angle between the user and an object A (a) is calculated by the JavaScript Math.atan function with the location values of the user (Xo, Zo) and the object A (Xa, Za).

This Collision Detection process considers only the virtual objects, located in the focus area: less than 20 meters from the user's location. If a virtual object is in the focus area and the sin(è) value is smaller than Repulsive Force Field (RFF)(1.5 times of the object scale value), then the user's avatar and the object make a collision situation. In the Figure 4, the object A is in a collision situation because the sin(è) value is smaller than the radius of the circle A (RFF-a). However, the object B is not in a collision situation, for the sin(è) value is bigger than the RFF-b.



[Figure 2: Collision Detection]

If the collision detection occurs, the process starts the next step, Collision Avoidance. The goal of this step is to make this process seem more natural and more similar to the real life situation when we come across an object or other people on the street. Moreover, we try to make this avoidance path look like an ellipse based on the scale value of the virtual object and avatar. The ellipse route is much more similar to a real life situation, so it makes the avatar's behavior smoother and more natural.

The direction of avoidance is dependent on both the sin(è) value and the user's orientation value. When the user's orientation value is in between + 0.0 (+ 0 o) and + 4.70988 (+ 270 o) and the sin(è) value is smaller than the user's orientation value, then we can assume that the object is on the right side of the user's locomotion way. Therefore, the left way collision avoidance is performed for this case. At this step, it generates the right- or left- and forward-movements, which makes the avoidance path look like an ellipse. The system also counts the number of generations for right- or left- and forward-movements for the next process, Path Adjustment.

2.3 Path Adjustment

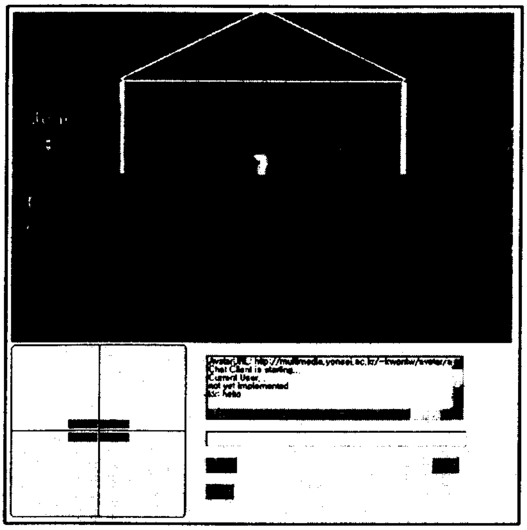
The goal of this final process is to guarantee that the avatar keeps his original travel/navigation direction and path. This process is an original path-oriented process which depends on the original path of the user's avatar. In the previous process, the system keeps the data of avatar's original position and counts the number of generated right- or left- and forward-movement inputs during the Collision Avoidance process. If the Collision Detection process does not receive any more collision detection events, then the 2D Map-Based Navigation starts the Path Adjustment process. This process uses the counted number of the right- or left- and forward-movements, which was saved at the second step in the previous process. In this process, it generates the left- or right- and the forward-moving events to make the adjusting path follow an ellipse (see Figure 1). And the left- or right-moving events offset the generated counts of the right- or left-moving events in the previous Collision Avoidance step.

3. Results and Disccusions.

We developed a template Multi-user 3D Virtual Reality system with JAVA and the commercial CosmoPlayer browser. We created a virtual world; it has the boundary of 500 * 500 and the building of 160 * 60 with a cross shape corridor in the center. Moreover, it is composed of 250 virtual objects including 12 objects inside the building (see Figure 3).

Twenty-six people took part in the experimental study; they came from five different laboratories within the Computer Science Dept. and the Mechanical Engineering Dept.. in Yonsei University. Among them, three participants came from the Mechanical Engineering Dept.. All of the participants were graduate school students: 19 in Master's programs and 7 in their Doctoral programs. In addition, eight participants (5 from Master's programs and 3 from Doctoral programs) were researching in the same field, Virtual Reality.

In the post-experiment questionnaire, five questions were asked in total. Three questions



[Figure 3: MBN Multi-user 3D VR System]

covered the following three aspects of navigation: general movement - how simple or complicated it was to move around; placement - how difficult it was in getting from one place to another; and how "natural" the movement was. And the last two questions covered the effects of the research and the application area for the navigational interface.

For general movement, the attendees gave points in between 6.0 and 10.0 (Mean: 8.057, S.D: 1.098). The reason they gave the points was that it does not require additional input for navigation. And for placement question, the attendees gave points in between 6.0 and 10.0 (Mean: 8.269, S.D: 0.897), too. The reason was that it also did not require additional input and it simultaneously supported both the typical mouse- and keyboard-based navigation interface and this research's MBN navigation interface. For the question concerning the naturalness and unnaturalness, the results showed that attendees have rated the interface from 7.0 to 10.0 (Mean: 8.788, S.D: 1.050); it was much higher than we have expected. The major reason they gave the points was that it supports automatic collision detection and avoidance with virtual object and avatar. Overall, most of the attendees voted for the interface to be effective and convenient means of Navigation in VE's. The reasons they presented for the results were the user-friendliness (easy to use), supporting of parallel job, and so on of the interface.

4. Conclusion and Future Works

The 2D Map-Based Navigation composed of those three major processes mentioned above, implements the navigation metaphor by providing more user-centered and natural navigation methods in interactive virtual environments. It also gives more useful and effective navigation services to the user by solving unrealistic navigation situations. 2D Map-Based Navigation can improve the user's virtual Presence and Immersion, which is the ultimate goal of virtual reality.

One of the effects we expect to gain from the research is an improvement in Spatial Awareness in the VE. The 2D Map-Based Navigation will enhance navigation performance in VE and improve spatial awareness by displaying the user's location information on the 2D map. And the user can decide navigation direction and destination in 3D VE, by selecting a relative position on the 2D map.

The second effect will be a reduction in user's fatigue and a support for parallel works.

The third effect is an improvement in Presence and Reality in the VR. Because the 2D Map-Based Navigation tries to service a much simpler user-centered navigation method similar to the real life and to eliminate the unrealistic conditions and difficulties in some of the existing VR service systems, it will be an appropriate and convenient service tool.

From the experiment study, we got very encouraging results in the general navigation in VE, the natural navigation, and the navigation interface for the user in VE. For our future research, we will work toward in developing more natural collision-detection technique and a more natural and smoother S.P(system processor) in avoiding or bypassing virtual objects and avatars. We will also continue a further research on the effective interfaces between virtual avatars that can improve the virtual Presence and Immersiveness of VEs.

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