New Interaction Paradigms in Virtual Environments

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Abstract—The way of interacting between user and environment is one of the main characteristics that increases the sense of presence inside a virtual world. However, interaction could be the weak point of virtual environments based application. In this paper we present a very brief taxonomy of 3D interaction for virtual environments and discuss why interaction is, in our opinion, a key element in the new developments of virtual reality technology.

I. INTRODUCTION

The development and evaluation of new interaction paradigms within virtual environments (VEs) has become a topic of special interest for the Virtual Reality (VR) scientific community. Some initiatives have appeared in Europe addressing this issue. Some good examples are INTUITION and ENACTIVE Networks of Excellence, where scientific and industrial communities in VR work together. More efforts should be done in order to strengthen the links among researchers coming from various knowledge areas, as Engineering, Psychology, Design, etc.

II. TAXONOMY OF INTERACTION

Interaction is a key concept of VR because it allows the manipulation of virtual objects and navigation through the VE [1]. Manipulation and navigation provide the user with interactivity in the VE avoiding the sense of being inside of a passive environment.

This implies that user inputs are responded to by corresponding actions of the computer. These events increase our sense of presence. In VEs, the aim is to avoid using the keyboard and mouse and allow the user to interact with the VE in a more intuitive and natural way. This way must have a less cognitive load for the user, that is to say, the process must be transparent. Moreover, a common characteristic for all ways of interaction is that they must mitigate the user fatigue and to minimise the cognitive load during the virtual experience.

Interaction depends on how the user interface is designed [2]. Some interaction interfaces are not natural for the untrained user. Fortunately, humans can be trained and adapted to new ways of interacting with their environment. In fact, some strange interfaces have been integrated into the culture, making them seem natural (for example, the car interface). However, this requires taking into account human factors psychology and human-computer interaction if we want to achieve a usable design.

A useful strategy is the use of multimodality. Multimodal information (e.g., haptic, visual and auditory) in object manipulation often improves user’s performance and increases the degree of realism and the sense of presence [3].

There are two main ways of interacting with a virtual world: manipulation and navigation, although we consider some other secondary ways of interaction.

- **Manipulation**

  It allows the user to modify the VE and the objects inside it. Manipulation consists of two tasks: selection and action (the latter is also called directly manipulation) [1][4][5]. The selection task allows the user choosing one or more virtual objects and the action task sets the position and/or orientation of the selected virtual object.

- **Navigation**

  It is defined as the control of the user’s viewpoint motion in the three-dimensional environment and it allows the user to travel through the virtual world and explore it [6]. In most cases, navigation is not an end unto itself; rather, it is simply used to move the user into a position where he can perform some other, more important task. Because of this, the navigation technique should be easy to use and cognitively simple. Moreover, the mechanism of navigation would be more transparent. Navigation has two separate components: travel and wayfinding [1]. Travel is the act of moving through a space. Wayfinding is the knowledge of where you are and where (and when) you are going.

- **Other ways of interaction**

  Other ways of interaction are related with certain concepts, as communication and control system.
Communication permits to communicate with other users or with virtual agents inside of the same VE [7]. Other authors use the concept control system [1] or metacommands [7] to indicate commands that are used by the users to provide to the system information regarding to applications control.

A. Manipulation

There are several manipulation methods [8][9][10]. In three are listed: direct user control, physical control and virtual control, and [7] adds a fourth one, the agent control. 

- In direct user control the user interacts with objects in the VE just as the user would perform it in the real world.
- Physical control uses a real world apparatus which allows a haptic feedback (buttons, switches, joysticks, trackballs, steering wheel and foot pedals, etc).
- Virtual control only exists in the virtual world and, therefore, it requires a physical input to work. Its advantage is that allows the reduction of the number of physical devices (e.g., the mouse is a physical device used to control many virtual inputs). Besides, its appearance, location and visibility are entirely at discretion of the application designer [12].
- Finally, agent control allows the user to specify commands (voice or gestures) through an intermediary. The agent can be a person or a virtual agent controlled by the computer.

In a VE, most manipulations are compound by two tasks: selection and action, though sometimes these two operations are executed simultaneously.

B. Navigation

For many virtual reality developers the goal is an interface that mimics physical interactions with the real world. In this sense they try to use physical movements for travelling. However, though physical movement may seem the most natural, these types of interfaces are, in some cases, very complicated and expensive. Besides people are capable of learning new interfaces less natural but more simple. In any case, an interface should be easy to learn and intuitive for most of people.

The navigation interface usually includes tools to aid in the process of wayfinding (key landmarks, distance measures, mapping information, etc. which can greatly help the user to navigate the virtual world and build a good mental model of their environment. However different people use different navigation strategies, so a wayfinding system usually includes multiple aids.

There are many ways of navigation in a VE: using position sensors (trackers), input devices (joysticks), treadmills, etc… and several navigation techniques: hand-directed, dynamic scaling, gaze-directed, physical control, virtual control, conducted objects, discrete selection and teletransportation.
C. Other ways of interaction

These other ways of interaction are related with multi-user concept and a new concept defined in many works as metacommands [7]. This interaction is not a physical interaction; it is a high level interaction with independent elements of virtual environment (different users immersed inside of the same VE simultaneously and commands to control system variables).

III. The Problem of Interaction

VR technology has evolved in a spectacular way, developing not only more powerful computers but also generating a great variety of interaction devices to implement all those issues described in the taxonomy. But, after this review of technological development in the field of 3D virtual interaction, a question arises: which is the result of all this development? It is not clear that these huge technological advances have lead to the success of many VR applications. In fact, most of the developed VR applications have not gone out of the lab in which they were conceived.

Basically, there are two kinds of VR applications that have successfully gone out of the lab. One of them consists of flight simulators and other machine simulators. The other one consists of all those applications whose goal is to give to the user the feeling of being immersed into the VE. That is to say, to elicit presence.

What are the common characteristics in these two sets of successful applications? The answer to this question could help to overcome the present standstill of VR application development.

A. Machine simulators

Most of the flight, car, truck or crane simulators have in common a very important characteristic. They use to implement a physical interaction paradigm: the physical control. That is to say, a like-real cockpit is physically recreated. Hence, the user interacts with the machine in a natural way, as it is done in the real world. The virtual world is reduced to the world outside the cockpit.

B. Applications requiring presence

When a psychologist treats a patient with phobia using a VR application, very immersive devices are necessary. Within this therapy, the patient is exposed to the situation causing the problem, which is virtually recreated. Obviously, the main requirement of this application is the capability of eliciting presence.

When playing a VR videogame, we look for feeling inside the game scenario. The best game is that in which we feel more present. Again, the goal is to elicit presence.

These are two good examples of the second kind of successful application we referred to. Other examples of this group are VR movies and VR in architecture.

C. Interaction

Although the previous discussion is not systematic, it can throw light on this issue. Analysing the successful applications we can find as a common factor among them: the interaction within the virtual world is implemented through a recreation of real systems or consists of simple navigation mechanisms.

Most of the applications that try to use complex selection and manipulation mechanisms do not go beyond just prototypes. Sometimes, most of the efforts in an application development are devoted to the design of the virtual world and the modelling and implementation of objects, avatars and situations. However, the importance of interaction mechanisms is often underestimated, assuming that using the common VR devices the problem is solved.

We do not think that this is the case. Interaction in VR deserves a special consideration. However, much more research should be done in this field, and new interaction paradigms should be conceived to provide developers with new ideas and concepts that could be used in the design of interaction mechanisms within a VE.

IV. Searching for New Paradigms

The light pen is an interaction device that has been used at least since 1954 [16]. It was firstly demonstrated by Sutherland in his PhD Thesis in 1963. Two years later the mouse was developed in the Stanford Research Institute. The light pen uses the screen as a metaphor of a paper in a very natural way. However, it is obvious that the mouse has become the killer application in the field, substituting the light pen in the most of applications.

Having this in mind, we think that new ideas are necessary in 3D interaction. Natural interaction doesn't have to be the best solution. So, the scientific community should devote more efforts to search new concepts and develop new paradigms for interaction within a 3D VE.

Nevertheless, it should be taken into account that interaction mechanisms adapted to the human have a lot of gained ground. On the other hand, sometimes, a little adaptation of the human is not a problem, as in the case of the mouse.

Finally, videogame industry is a good source of ideas. Sometimes, the game industry contributions are not taken into account as they should be. However it is a very active area in the field of human computer interaction.

V. Conclusion

Summarising the ideas put forward along this paper, although a lot of work has been done in the field of 3D interaction within VE, we think that new concepts and ideas in this field are necessary to overcome some of the present problems of VR regarding with interaction.
Finally, the future of VR necessarily goes through putting together specialists coming from different areas, working in multidisciplinary teams.

REFERENCES