Navigation and Interaction in the Virtual Reconstruction of the Town of Otranto in the Middle Ages

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Abstract— **The main goal of the Human-Computer Interaction technology is to improve interactions between users and computers by making computers more usable and receptive to the user's needs. This paper focuses on an application of navigation and interaction in a virtual environment using the Wiimote and the Balance Board of Nintendo. The aim is to make the interaction easier for users without any experience of navigation in a virtual world and more efficient for trained users. The application has been developed for the navigation and interaction in the virtual environment of the MediaEvo project. The MediaEvo Project aims at developing a multi-channel and multi-sensory platform for edutainment in Cultural Heritage.**

Keywords-component; user interface, cultural virtual heritage, Nintendo WiiMote, Nintendo Balance Board

I. INTRODUCTION

Edutainment, a neologism created from the combination of the words education and entertainment, refers to any form of entertainment aimed at an educational role. The videogame is one of the most exciting and immediate media of the edutainment applications because the game enables a type of multisensory and immersive relationship of the user through its interactive interface; moreover, the cyberspace of the videogame is a privileged point of sharing and socializing among players.

Edutainment is an up-and-coming field that combines education with entertainment aspects; thus, it enhances the learning environment and makes it much more engaging and fun-filled.

One of the most important applications of edutainment is undoubtedly the reconstruction of 3D environments aimed at the study of cultural heritage; the use of Virtual Reality in this field makes it possible to examine the three-dimensional high-resolution environments reconstructed by using information retrieved from the archaeological and historical studies and to navigate in these in order to test new methodologies or to practically evaluate the assessment. Virtual Reality (VR) technology makes it also possible to create applications for edutainment purposes for the general public and to integrate different learning approaches.

The building of three-dimensional renderings is an efficient way of storing information, a means to communicate a large amount of visual information and a tool for constructing collaborative worlds with a combination of different media and methods. By recreating or simulating something concerning an ancient culture, virtual heritage applications are a bridge between people of the ancient culture and modern users.

One of the best uses of the virtual models is that of creating a mental tool to help students learn about things and explore ancient cultures and places that no longer exist or that might be too dangerous or too expensive to visit. In addition, it allows students to interact in a new way, using many possibilities for collaboration. A very effective way to use VR to teach students about ancient cultures is to make them enter the virtual environment as a shared social space and allow them to play as members of that society.

The development technologies of video games are today driven by strong and ever-increasing request, but there are very few investments related to teaching usage of such technologies, they are still restricted to the entertainment context. Several VR applications in Cultural Heritage have been developed, but only very few of these with an edutainment aim.

The Human-Computer Interaction (HCI) technology is concerned with methodologies and methods for designing new interfaces and interaction techniques, for evaluating and comparing interfaces and developing descriptive and predictive models and theories of interaction.

The HCIs improve interactions between users and computers by making computers more usable and receptive to the user's needs.

Researches in HCI field focus on the developing of new design methodologies and new hardware devices and on exploring new paradigms and theories for the interaction. The end point in the interface design would then lead to a paradigm in which the interaction with computers becomes similar to the one between human beings.

II. Previous Works

The techniques for navigation within virtual environments have covered a broad kind of approaches ranging from directly manipulating the environment with gestures of the hands, to indirectly navigating using hand-held widgets, to identifying some body gestures and to recognizing speech commands. Perhaps the most prevalent style of navigation control for virtual environments is directly manipulating the environment with gestures or movements of part of the user's body.

Some developed systems are based on a head-directed navigation technique in which the orientation of the users head determines the direction and speed of navigation [1]. This technique has the advantage of requiring no additional hardware besides a head tracker, but has the disadvantage that casual head motions when viewing a scene can be misinterpreted as navigation commands. In addition, a severe drawback of this and other head-based techniques is that it is impossible to perform the common and desirable real-world operation of moving in one direction while looking in another.

Another direct body-based navigation technique is found in some systems that use sensors to measure the tilt of the user's spine or the orientation of the user's torso in order to determine the direction of the motion and to enable the decoupling of the user's head orientation from their direction of movement [2].

Another category of techniques for motion control is based on speech recognition. Speech allows a user to indicate parameters of navigation and can often be used in conjunction with gestures to provide rich, natural immersive navigation controls [3]. Speech controls should play a role in virtual environment navigation, but it is also critical to support an effective navigation based on speech-free techniques.

In the last few years, systems based on locomotion interfaces and on control navigation by walking in place for the navigation in a virtual environment have also been developed.

String Walker [4] is a locomotion interface that uses eight strings actuated by motor-pulley mechanisms mounted on a turntable in order to cancel the displacement of the walker. String Walker enables users to maintain their positions while walking in various directions in virtual environments because, when the shoes move, the strings pull them in the opposite direction and cancel the step. The position of the walker is fixed in the real world by this computer-controlled tension of the strings that can pull the shoes in any direction, so the walker can perform a variety of gaits, including side-walking or backward walking

The CirculaFloor [5] locomotion interface uses a group of movable floors that employ a holonomic mechanism in order to achieve omni-directional motion. The circulation of the floors enables users to walk in arbitrary directions in a virtual environment while their positions are maintained. The CirculaFloor creates an infinite omni-directional surface using a set of movable tiles that provide a sufficient area for walking and a precision tracing of the foot position is not required. This method has the potential to create an uneven surface by mounting an up-and-down mechanism on each tile.

Powered Shoes [6] employs roller skates actuated by motors and flexible shafts and supports omni-directional walking, but the walker cannot perform a variety of gaits. Powered Shoes is a revolutionary advance for entertainment and simulation applications, because it provides the proprioceptive feedback of walking.

III. The MediaEvo Project

The MediaEvo Project aims to develop a multi-channel and multi-sensory platform in Cultural Heritage and to test new data processing technologies for the realization of a digital didactic game oriented to the knowledge of medieval history and society [7].

The game is intended as a means to experience a loyal representation of the possible scenarios (environments, characters and social roles) in the historic-geographical context of Otranto during Frederick Age (XIII century).

We chose Otranto as an example town; Otranto is located in the easternmost tip of the Italian peninsula, in Puglia, in the so-called Italy's heel,. Due to its geographical position, Otranto was like a bridge between East and West.

Otranto was a Byzantine and a Gothic centre, later ruled by the Normans, Swabians, the Anjou and the Aragonese. After a long siege, on 14 August 1480 the town was caught and the inhabitants were massacred by the Turkish army. This mix of history can be seen in the enigmatic mosaic of the Cathedral, a Romanesque church built during the Norman domination in the 10th century on the axis that joined Rome to Byzantium. The mosaic, done by the monk Pantaleone in the 12th century, covers almost the entire floor of the Cathedral, for over 16 metres; its size is nothing compared to the complexity of images and references that mixes Biblical narration from the Old and New Testaments with some pagan elements and others of Eastern derivation.

The implementation of an edutainment platform is strongly influenced by the definition of the scenery that is the world in which the framework is placed with the related learning objects and learning path, the characters, the scene's objects, the logic, hence, the rules of the game, the audio content, the texts and anything related to its use.

The framework will have features of strategy games, in which the decision capabilities of a user have a big impact

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on the result, which in our case is the achievement of a learning target. Nevertheless, the strategy and tactics are in general opposed by unforeseeable factors (provided by the game), connected with the edutainment modules, in order to provide a higher level of participation, which is expressed in terms of the ease with which it is learnt. The idea is to provide a competition between the players, during their learning.

The system, on the basis of a well-defined learning target and eventually based on the knowledge of the user, will continuously propose a learning path (learning path composed by a sequence of learning objects), in order to allow the achievement of particular learning results.

A Digital Terrain Model (DTM) that has been produced using ESRI ArcGIS, containing all historical information like sea level, rivers, etc. It has been saved in .dif format and imported in the game engine.

For building and street modelling, we first used AutoCAD, 3ds Max, Cinema 4D. Characters and animation are made using 3ds Max.

Once defined a list of modular elementary residential units, according to the local medieval unit system, we composed the urban landscape in which monuments, infrastructures and situations are located.

For the building of the virtual environment we used the Torque Constructor editor of GarageGames in order to create 3D architectural contents for the Torque 3D engine. The choice of the Torque Constructor was prompted by technical considerations regarding the ability of software to perform a direct mapping of the files ".map", the compatibility level with the Torque Game Engine chosen to develop the game, the immediacy and the usability of internal tools.

The Torque Constructor has proved to be an efficient tool for the direct implementation of 3D graphics models. In particular, it has many geometrical tools for the graphic processing of the reality context and different controls to select the top of the structure or individual brush model.

All units made in the Torque Constructor have been imported into the Torque Game Engine. The initial testing step revealed several problems of navigability of the objects. These problems were related to the incompatibility between the domains of collision associated with the objects imported into the three-dimensional environment and the avatar.

Tests carried out have helped identify and solve these problems by setting the values associated to the collision domains and to the proportions between objects and avatars. At present, all units are properly imported and successfully navigated.

In the context of computer graphics for cultural heritage, a stable algorithm has been implemented to import CAD objects into the Torque Game Engine platform and to ensure navigation into each graphic structure. This technique together with an efficient system for exporting textures and paintings will be used to realize graphic complex environments for the 2D/3D reconstruction in cultural heritage [8].

Figure 1 shows some areas of the virtual reconstruction of the town of Otranto in the Middle Ages.

Figure 1. Parts of the virtual reconstruction of the town of Otranto.

IV. THE NINTENDO WII

Wii is the last console produced by Nintendo; it was released in October 2006 and, according to official data of 2010, has surpassed 70 million units sold. The reasons for this success can be undoubtedly found in the new approach that the gaming console gives the user in terms of interaction that effectively makes it usable and enjoyable by a large part of users. The secret of this usability is the innovative interaction system; the Wiimote (word obtained as a combination of "Wii" and "Remote") replaces the traditional gamepad controller type (with cross directional stick and several buttons) with a common object: the remote

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control.

The Wiimote is provided with an infrared camera that can sense the infrared LED of a special bar (called "Sensor Bar") and it can interpret, by means of a built-in accelerometer, the movements of translation, rotation and tilt.

The Wiimote has been equipped with a series of accessories that increase its potential, such as the Balance Board, that, by means of four pressure sensors at each corner, is able to interpret the movements of the body in order to control the actions of the user in a videogame.

Figure 2 shows the interaction modalities of Wiimote and Balance Board.

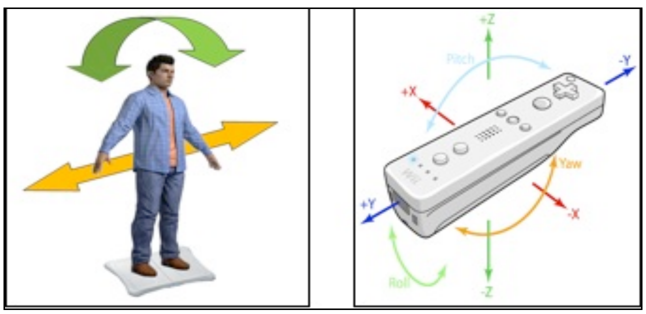

Figure 2. Interaction modalities of Wiimote and Balance Board.

Since the frequency of communication between the Wii console and the Wiimote/Balance Board are those of the standard Bluetooth, these devices can be used as tools to interact with any computer equipped with the same technology. Appropriate libraries have been realized in order to allow the interfacing between these devices and a computer.

V. THE DEVELOPED APPLICATION

This paper presents an application of navigation and interaction in a virtual environment using the Wiimote and the Balance Board of Nintendo. The aim is to make the interaction easier for users without any experience of navigation in a virtual world and more efficient for trained users; for this reason we need to use some intuitive input devices oriented to its purpose and that can increase the sense of immersion.

Because we walk on our feet, controlling walking in Virtual Reality could be felt as more natural when done with the feet than with other modes of input. For this reason we used the Nintendo Balance Board as input device for navigation that offers a new and accessible way to gain input. It is a low-cost interface that transmits via Bluetooth the sensor data to the computer and enables the calculation of the direction the user is leaning to.

In addition, in order to implement the control of different views and to change the point of view of the user, in our application we use the Nintendo Wiimote.

A software layer that allows to use the Balance Board and the Wiimote as input devices for any application that runs on a computer has been realized. The aim is to allow to receive signals and commands from the Wiimote and the Balance Board and to translate these into commands for the computer in order to emulate the keyboard and the mouse.

Figure 3 shows the use of Wiimote and Balance Board in the MediaEvo game.

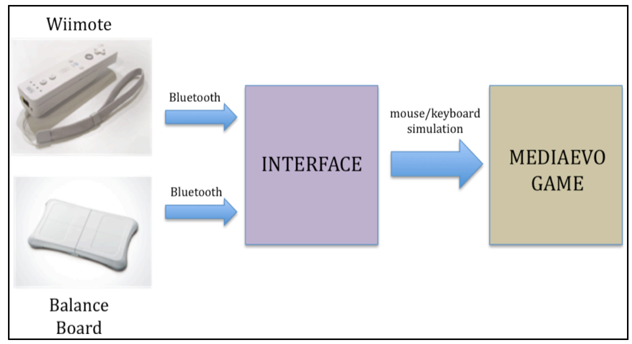

Figure 3. Use of Wiimote and Balance Board in the MediaEvo game.

The application, created to provide a new system of interaction in the virtual world of the MediaEvo project, can be coupled to any application of navigation in a virtual world.

To run the application, it is first necessary to configure the keys able to emulate any type of movement, to set the sensitivity of the Balance Board and then to connect the device; the information on the data received from the device are displayed in real time.

The interface that visualize the data received from the Wiimote and Balance Board is divided into two main sections: the left panels contain the control with all the data received via Bluetooth from the devices, whereas in the right side it is possible to set the associations among the command given to the device and the equivalent command simulated from the computer, the levels of sensitivity and threshold beyond which the interactions occur.

For these operations the software uses two open-source libraries in C# and the WiimoteLib InputSimulator; the WiimoteLib is a library for interfacing the Nintendo Wiimote and other devices (such as the Balance Board) in an environment .NET [9]. The purpose of this library within the application is to simulate the use of a mouse and a keyboard starting from the properly interpreted and translated inputs received from the Wiimote and Balance Board.

Regarding the interaction by means of the Wiimote, the aim is to simulate the mouse using two modalities of interaction.

"Mode 1" uses the movement on the X and Y axes of the accelerometer to move the mouse (and, in the 3D environment, the user’s point of view) on the longitudinal

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and latitudinal axes; the value provided by the accelerometer is compared with the sensitivity set during configuration.

"Mode 2", that is the default mode, allows to move the mouse (and, then, the user's point of view) using the direction arrows of the Wiimote.

Figure 4 shows the configuration interface of the Wiimote and Balance Board devices.

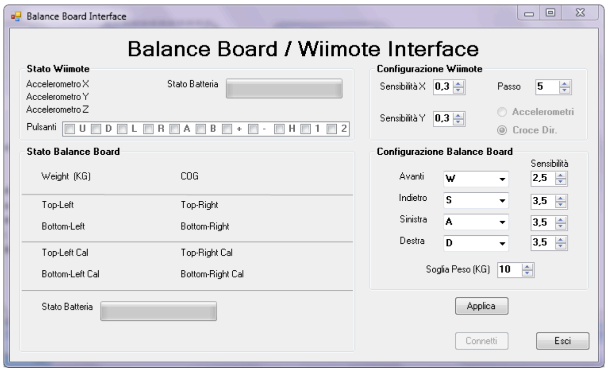

Figure 4. Configuration interface of the Wiimote and Balance Board.

The modalities of interaction provided by the application involve the use of the Wiimote and Balance Board simultaneously. In particular, the user is able to move the avatar in the virtual environment by tipping the scales in the direction where he wants to obtain the move; an imbalance in forward or reverse leads a movement forward or backward of the virtual character, while the lateral imbalance corresponds to the so-called "strafe" in video games, where the movement is made on the horizontal axis while maintaining a fixed pointing direction of the gaze.

The Wiimote, however, is used to impart the look direction of the character.

Figure 5 shows a user during the navigation in the MediaEvo virtual environment using the Wiimote and the Balance Board.

VI. CONCLUSIONS AND FUTURE WORK

This paper presents an application able to communicate with the Nintendo Wiimote and Balance Board and developed in order to provide a new modality of navigation and interaction in the virtual environment of the MediaEvo project. The aim of the MediaEvo Project is the development of a multi-channel and multi-sensory platform for the edutainment in Cultural Heritage.

Possible future developments could include the conversion of the application in external library, by adding specific methods and attributes to be directly integrated into other applications, and the porting of the developed application in a multi-platform language in order to be used in different development environments.

Figure 5. Navigation in the MediaEvo virtual environment.

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