An enhanced navigation kit for virtual heritage exploration using a game engine

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Abstract—**This paper proposes a new way to navigate inside virtual architectural environments such as those used in the field of Virtual Archaeology. This approach is based on the study of human movement inside real buildings to design a computer aided navigation system that could help visitors of virtual reconstructions to take their journey inside digital 3D environments in a more human-like manner.**

***Index Terms*—Navigation, game engine, virtual model**

I. INTRODUCTION

Videogames have been one important field of application of Computer Graphics since their very beginning and, from more than a decade ago, they have fostered the advance of graphic hardware more than any other computer related technology.

By means of the use of modern graphic cards, one can display three dimensional environments in real time with unprecedented realism. Simulations of virtual spaces and digital buildings now have a quality reserved to frame-by-frame animations just a few years ago.

Nowadays, game engines are becoming popular as a mean to develop high-end, real time presentations of virtual environments not necessarily related to the game industry. Many examples of their use in the field of architectural and urban visualization can be found, and therefore, virtual reconstruction of historical heritage using game engines has been the logical next step in the direction of their use in Virtual Archaeology.

On one hand, videogame engines such as Unreal Engine, Unity3D or CryEngine provide the author of visual simulations with very powerful tools to develop interactive presentations of a 3D environment, including:

- Complex shaders for extreme realism in the appearance of the materials
- A character system, both in first and third person view to control the player/user interaction within the environment
- An input system that can deal with all sort of control devices, from mice to gamepads, touchscreens and depth cameras (such as the Kinect system)
- A programming environment specially designed to produce exploratory and interactive experiences
- High resolution display for a wide variety of device configurations, from monitors to smartphones, including HMD's such as Oculus Rift.

Many interesting examples can be found today. They create visual recreations of archeological reconstructions using videogame engines being mainly centered in achieving a high visual quality, while offering the possibility to walk through the virtual recreation and the capability to interact in different ways with the virtual replica, from the display of metadata to the activation of mechanisms and simulation of phenomena. (1,2,3,46)

Nevertheless, until today, little attention has been given to the study of the walkthrough itself, crucial for the ease of exploration of the environment; in fact, the movement of a game character in a virtual space is far away from the manner in which human explore the built space. The general approach to a character movement (being it an avatar or simply a first person camera) consist in letting the user move forward or stop and turn, and rotate the camera view in any desired direction with movements that are often impossible to achieve by a human neck.

In this paper describes the work in progress being done by the authors to develop and implement a new way to navigate inside virtual architectural environments such as those used in the field of Virtual Archaeology. The approach will be based on the study of human movement inside real buildings trying to mimic the human attention process. It will be implemented on a computer aided navigation system to help visitors of virtual reconstructions walk through 3D environments in a way more related to human movement.

II. METHODOLOGY

In most part of the literature related to human exploration of the environment two concepts stand out: *navigation* and *wayfinding*, being the first a type of the latter. Although they are sometimes used indistinctively due to the fact that the cognitive, behavioral and neuronal processes are similar, there are important differences between them (7). Navigation is more related to the use of reference points, landmarks and even other aids such as maps. The importance of such reference points comes from visual, cognitive or structural factors (8) and its presence is crucial to attract the interest of the user to any given direction.

On a given environment, the analysis of the presence of such elements in a zone surrounding the user, can be used to model the amount of attention that the area that contains every element may arise from the user. Any environment may have elements that are worth to be observed to some degree. The designer of the virtual experience can enrich the virtual environment by identifying the objects, places, spaces, etc. that make the visit interesting, especially considering that in many cases, the user does not know where to go or what to look for when he or she enters the virtual place.

This identification can be done in a way invisible to the user. We have implemented this by designing an element that can be placed anywhere in the virtual model called *attractor*. This element is defined by several parameters that include interest, range of attraction, decay and other variables that describe the willingness to look at it based on the distance to the user and direction in the scene relative to the character's sight direction.

The presence of several attractors in the viewable area surrounding the user can be weighted using models from the field of Psychology of Perception such as the one proposed by Lewin (9) that defines a *hodologic* space (the space surrounding the user that contains zones that push or pull his or her attention based on personal interest related to each one). In Lewin's model every area has a *valence* that quantifies the attractive effect to the user. The resultant of all forces of attraction describes the final intention of the subject to point his or her attention to a particular direction. Nevertheless, Lewin did not describe a particular method to calculate the valence nor did he explain a procedure to weight the attracting forces.

We are actually researching in a formulation to reproduce this effect, obtaining interesting results by turning the continuous Lewin's space into a discrete one, populated with attractors with given interests, and considering every attractor as generator of a field of attractive force, being the geometry of this field a function that involves distance, direction relative to user's sight and two values of willingness for distance and angle described earlier. Then, a vector of attention of this attractor is defined, being the valence the value of its module.

The center of attention is then calculated as a center of force, and will be used to drive smoothly the user sight toward it when no turning input is detected. By placing attractors in every interesting point, the movement of the user can be controlled by the system based on the characteristics of field of attention that surrounds the user in every moment. Interest of atractores can decay with exposure to the user contemplation.

The effect of using the system is that when the user releases the control of the turn and limits to input when to go forward and when to stop, the system will lead his or her view to the most interesting point of its surroundings. By pressing forward, the system will take him or her toward that point. The center of attention is being recalculated every frame considering the change in location and orientation of the user.

Since the user can always retake the full control of the input, and move as he or she wills, every situation in the virtual model is different, since every location and view direction provokes a different suggestion of what to look at.

The system is implemented as an autonomous agent inside the character representing the user in the game environment. This agent subtly modifies the view and movement direction based on the presence of attracting elements in the scene. The user is aware of this intrusion, which only takes place under his or her consent during the simulation, taking place only when the input system does not detect any action from the human.

By placing attractors and calibrating them adequately, it is possible to design walkthrough experiences suited for different kind of users based in their particular interests

III. RESULTS.

The system is implemented on the Unreal Engine 4 game engine as a toolkit for designers of virtual environments. In this working environment, any 3D model can be imported, so the designer can place attractors to influence the way that the model has to be travelled.

Actually, tests are being done on a model of a 4^{th} century roman villa made as a virtual installation for an interpretation center. The system is combined with a Kinect2 depth camera to get the input from the user from slight movements of his or her arms. The combination of natural interaction ann enhanced navigation using the procedure described here makes the walkthrough on this model extremely easy and intuitive. This is a must considering that the visitor of the exhibition is expected to drive the virtual travel with zero previous training.

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