INTUITIVE AUGMENTED REALITY NAVIGATION SYSTEM DESIGN – IMPLEMENTATION BY NEXT-GENE20 PROJECT

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Abstract. The objective of this paper is to implement Augmented Reality framework in the navigation system of NEXT GENE 20 project. As a result, users can navigate and explore 3D virtual reality environment or scene in a more intuitive and interactive manner.

Keywords. Navigation system, Augmented Reality

1. Introduction

While virtual navigation systems developed by computer are widely found at museums and exhibition places, the application of Virtual Reality (VR) also evolves for further extension. This is when Augmented Reality (AR) takes place (Lee, 2006). Similar as the use of computer, existing virtual system is mainly operated with traditional input equipment such as mouse, keyboard, or joystick. This causes a sense of distance to the users and it is less intuitive. In this paper, we aim to examine the application of AR framework in the virtual navigation system of NEXT GENE 20 project. By using real objects to control virtual scene, we hope to explore different navigation experience if possibly in existence.

NEXT GENE 20 – Audi Housing Project in Taiwan is an ongoing International Architecture Project of collective creation. In this paper, we define it as an event of architecture exposition, which the basis the navigation system is developed upon. The design of such system follows steps below:

1. Outline a scenario as a motivating example to re-define the system requirement.
2. Accomplish virtual core system.
3. Integrate real and virtual System.

The outcome of this research is an AR Navigation System of NEXT GENE 20 which using tangible user interface. In this way, user can navigate and explore 3D virtual reality scenes in a better intuitive and interactive way. With the real object controllers circulate around the navigation map, user can experience intuitively the perfect interaction between the "real" navigation map and "virtual" 3D scene.

2. LITERATURE REVIEW

2.1. NAVIGATION SYSTEM

Navigation is the guiding media between visitors, spaces and objects. By means of arranging information intentionally, navigation can help visitors to completely acquaint with the information of the space/scene. Therefore, visitors can keep good sense of direction without losing orientation or recognition capacities (Shen, 2006).

Basically, visitors rely upon navigation system to provide sufficient information such as direction, circulation, facilities, exhibits, else tourists, relevant services and so on when they visit some places. Visitors expect true freedom and autonomy. This does not mean that visitors intend to look around aimless. Instead, visitors would like to perceive the environment systematically and structurally through "Free Choice between Alternative", "Suggestion of an Outline", and "Logical Organization" so that they can enjoy the freedom of arranging their circulation, and even anticipate possible outcomes in the process (Hsieh, 2000).

Three elements are relevant to visitors' orientation and circulation (Bitgood, 1989):

1. Conceptual Orientation: It is also called Theme Orientation. It is about providing information for visiting objects.
2. Wayfinding: Wayfinding is to help visitors find out or point out the location on graphic map or topographic chart.
3. Circulation: Circulation is to help visitors with the direction of movement.

The formats of navigation system presents in diverse forms from traditional personnel and publishing guides to audio and multimedia guides through the facilitation of prevailing development of digital technology and internet networking. Nowadays, navigation system has evolved to become more dynamic in media application and integration. For example, in its content provision, navigation system transforms from information-oriented to be more interactive in its content presentation; and to have users more active, rather than passive in deriving information. Furthermore, digitalized navigation system has visitors experience in a way that hardly achieves in the real environment. For example, 3D surrounding navigation and internet real time participatory tools greatly enhance the visibility and comprehension capacities of the exhibiting objects. On the other hand, digitalized navigation also makes digital art to be even prosperous in different types of exhibition around the world.

2.2. AUGMENTED REALITY

Doubtlessly, it is very common for virtual navigation system to be designed by computer in museums and exhibition places (Lee, 2006). While digital contents become more extensive as a result of boundless network application, AR takes place as a variation of advancing VR. Basically, VR technologies completely immerse a user inside a synthetic environment where spaces and objects are all virtualized. Therefore, user can not see the real world around him. In contrast, AR technologies allow user to see spaces and objects coexists in reality and virtuality through computer programming. All are interactive in real time in the 3D environment. (Azuma, 1997).

In the past, AR technologies are more often seen by integrating virtualised information into user's display in example of "Head-Mounted Display (HMD)" (Steven, 2002). HMD allows image to be enlarged in a small display in front of user's eyes. If we view real and virtual environment as a closing continuum, somewhere in between the two opposite ends can be called Mixed Reality (MR) as figure 1. We can understand the position of AR through this RV continuum.(Milgram al etc. 1994).

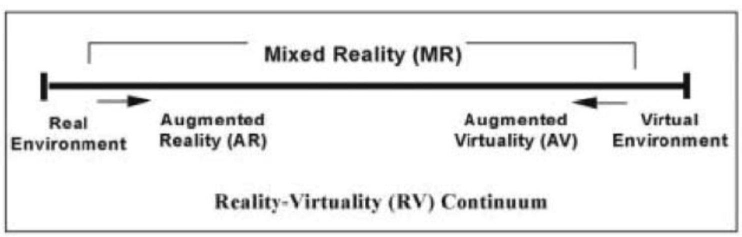

Figure 1. Simplified representation of a RV Continuum. (Sources: Milgram al etc. 1994)

In latest development, AR systems further expand to be applied in both virtual space vs. real objects and real space vs. virtual object cases. Several potential AR applications have been explored commonly including medical visualization, maintenance and repair, path planning, military and entertainment and so on (Azuma, 1997). As ubiquitous computing is everywhere in the real world, all sorts of behavior in daily life could become more intuitive through the merge of real and virtual factors. AR technologies can leverage tangible media to manage virtual objects. Such interactive technologies engaging both virtual and real world are now the trend in future (Chen, 2007).

3. Question and Objective

Most of the existing virtual navigation systems still follows the general user's patterns as computer usage (i.e. mouse, keyboard or joystick), in addition to some cases using alternative equipments such as Head-Mounted Display (HMD) or glove type sensor. Such behaviour patterns cause barriers to users because it is less intuitive and interactive. Therefore, more and more AR systems are designed to remove these barriers. Our paper intends to explore the possibility of different user experience when AR interface is introduced into virtual navigation and virtual environment is controlled by real object.

4. Methodology and Steps

NEXT GENE 20 – Audi Housing Project in Taiwan is an ongoing International Architecture Project located in north-eastern Taiwan. Coordinated by Professor Yu-Tung Liu from NCTU, totally 10 Taiwanese and 10 worldwide foreign well-known architects participate in this project. They work collectively to present what is so-called "landscape" architecture in this natural and scenic site. NEXT GENE 20 implying the gene of next generation, is initiated to explore the future image of human environment, lifestyle and inhabitation on collective creation. When first stage plan is completed in 2009, 20 different styles of architecture pieces will be presented in front of the world. This is the first time ever in Taiwan when so many architects are all in together to compete and share their concept and creation. These buildings will bring specific dialogue and new view of future residence. We would like to define this project the first international architecture exposition in Taiwan.

The research methodology of this paper is to re-define the user's navigation demand for NEXT GENE 20 through scenario simulation and then implement the system via two steps: 1. Accomplish virtual core system. 2. Integrate real and virtual System.

4.1. OUTLINE A SCENARIO AS A MOTIVATING EXAMPLE TO RE-DEFINE THE SYSTEM REQUIREMENT

NEXT GENE 20 project is planned to have its first stage completed 20 buildings partly sales for private residency, partly lease for commercial villa and partly open for the public. Under such foundation in conjunction with Bitgood's three key factors of navigation system including Conceptual Orientation, Wayfinding and Circulation, simple scenarios are simulated to find out visitor's demands:

TABLE 1. Scenario outline.

Scenario	***Objective***	***System***
When visiting the site, users would like to learn about the initiative, site distribution, as well as whose work are presented and so on.	Project Plan *(Conceptual Orientation)*	Display Project Introduction on the tangible map.
Where is the current location?	Location *(Wayfinding)*	Display existing location on the tangible map and Quest 3D.
Which buildings are open for public?	Situation *(Circulation)*	Display the accessibility of individual space on the tangible map.
Where are the crowd and how to avoid them?	Crowd Distribution *(Circulation)*	Display the distribution of the crowd on the tangible map.
Is there alternative way other than the crowded main road?	Route /Boundary *(Wayfinding)*	Display route and boundary on the tangible map.
How the work is so extraordinary and what is its concept behind?	Architect / Concept Introduction *(Conceptual Orientation)*	Display case background on the tangible map.
It is nice to experience navigating an non-accessible building by the system.	Walking Simulation	Use Quest 3D to simulate the experience inside the building.
How does it feel if coming by airplane just like a wealthy person?	Aviation Simulation	Use Quest 3D to simulate the experience of aviation

In order to development a navigation system in fulfilment of above demand, the interface of virtual display and tangible guide map are required. We use real object to represent a visitor and the visitor can control this portable object on a map desk. When operating the object, visitor's location will be showed

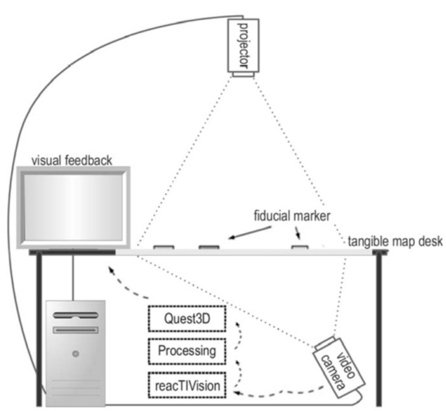

Figure 2. System diagram

and various navigating information will be displayed per visitor's demand on the tangible guide map. Also virtual display will show visitor's location. When visitor move object around the map, virtual display will demonstrate 3D environment for him/her to conduct virtual experiencing.

4.2. ACCOMPLISH VIRTUAL CORE SYSTEM

4.2.1 Marker Tracking and Identification System

In the system development, the AR software – reacTIVision of reacTable technology controls the real object. reacTIVision is a open-source visual engine and uses video camera to build up two-dimensioned marker tracking system. reacTIVision can interpret large numbers of the pre-defined codes about two-dimensioned fiducial markers, axis location and angles. Data captured by reacTIVision can be adopted by alternative visual application programs including C++, Java, Processing, Max/MSP, Flash and so on. In other word, reacTIVision provides a real time and open source mechanism serving as the input and capable of outputting to other visual development software for more applications and outputs.

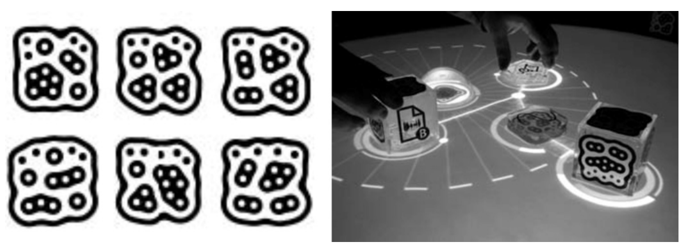

Figure 3. Fiducial marker example (mtg.upf.es/reactable : reacTable website, 2008)

4.2.2 Core Visual Processing Program

In this research, Processing is used as major interface program. Processing is jointly developed by Benjamin Fry from the media lab ACG (Aesthetics and Computation Group) in MIT, USA and Casey Reas from Interaction Design Institute Ivrea, Italy. The objective of Processing is to provide a program interpretation engine on the basis of Java. Processing serves the liberal principle of software sharing and open source code for visual artists to develop and create visual images.

Processing plays a central role in the navigation system. In this system, video camera captures the relevant data of location and angle about the markers real time. reacTIVision analyses them and transmits simultaneously to

Processing. Processing analyses the data and then display the related image information such as Project Plan, Route, Boundary, Case Introduction and so on upon the tangible interface. Wherever marker moves to interactive with different markers, Processing interpret the data and display corresponding information.

4.2.3 3D Virtual Reality Environment

Quest 3D software is used in this paper for 3D virtual reality environment simulation. Firstly, 3dsMax completes the site model and then output to a specific file format (.X) after axis reversal process. Next, Quest3D inputs the site model to conduct parameters controlling including location scale and dimension via Quest3D tree-like framework. After models are all input in correct orientation and scale, Quest3D starts with objects property setting such as material mapping and objects knocking to accomplish an elementary 3D VR scene of NEXT GENE 20.

Figure 4. The scene of Quest3D

In Quest3D technology, a software camera is structured to imitate visitor's eyes in this virtual reality environment. Therefore, camera's location, viewing angle and lens navigation are all according to navigation demand. In this paper, we suppose visitors can have two visiting options including walking or aviation.

4.3 INTEGRATE REAL AND VIRTUAL SYSTEM

With all the preparation done, system implementation starts with building up the real site. The system requires a semi-transparent table, a video camera, a projector for projecting real map interface, a LCD monitor for displaying virtual site and a computer.

When proceeding with real object and system integration, the location of the projector and video camera are adjusted against the table in the centre. After all hardware are in position, we need to modify the display scale on the map interface from Processing default, as well as the corresponding proportion of the marker location caught by video camera.. Most important of all, we need to match the real object location into Quest3D environment. By doing users can simultaneously navigate, operate and walk around in the Quest3D environment when the video camera conducts real time tracking on the location and orientation of the marker moving around the real map.

After all hardware and system are ready, we have Processing to output relevant marker information into a text file where Quest3D can immediately access the location data. There data gives good control to the software camera serving just like the visitor's eyes, in this way Quest3D environment can be navigated without using keyboard or mouse. Instead, visitor can enjoy real time and perfectly interactive navigation from the display through the marker, just like where he/she moves around in the real map.

Lastly, we check the system to ensure all markers match all demands outlining in the scenario design. When visitor come to the exposition, he/she is provided with a personal handheld device (i.e. marker). We design a beginning animation in the system so that the visitor recognize where he/she is when approaching. Visitor can place this handheld device in specific locations on the map to obtain information including the overview of the project, or opening details, path, architect introduction and so on. On the other hand, visitor can

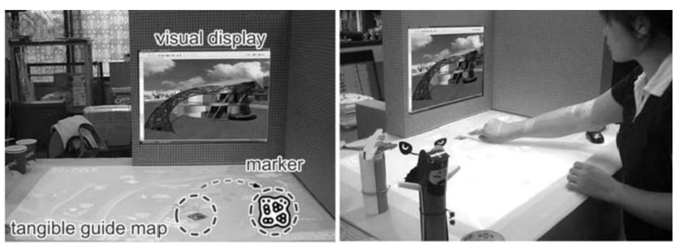

Figure 5. System Implement

Figure 6. The information to be displayed when the handheld device knock against different objects.

have its marker move around the map. He/she can experience moving around in the exposition site, or even walk into the building as long as visitor put the marker closer some building. If visitor would like to have luxurious experience like rich man taking private airplane on holiday trip, he/she can choose alternative device of aviation type to navigate virtual site by flying. This is the AR navigation system specifically for NEXT GENE 20.

5. Conclusion and Future Research

The outcome of this research is an AR navigation system in which real object is used to navigate a 3D VR environment in an interactive manner. User can utilize a better intuitive and interactive real interface to navigate and control 3D VR environment. Tangible controllers move around on the real navigation map to create perfect connection between the navigation map and 3D VR environment. Through this AR navigation system, we find the benefits of more intuitive user experience when real objects replace keyboard and mouse.

During the process of system build-up, it takes extra efforts to modify the location and scale of marker axis from reacTIVision, the real guide map from projector and the Quest3D VR environment. This is avoidable when simply applying computer or real interface. In addition, system shut down sometimes as a result of timing conflict when Processing outputs the location data to the txt file and Quest3D accesses it at the same time. These are issues to be overcomes in the future study. In addition, we also suggest to consider adding wireless feature to the handheld device is this system were applied to the real case. For example, a handheld card is designed to replace admission ticket. In this way, user can really see the crowd distribution and proceed with the conceptual orientation. It is also suggested to consider collective use of such navigation system to create more interaction so that user’s demands are perfectly fulfilled.

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