2009 13th International Conference Information Visualisation

Virtual reconstruction and real-time interactive visualization of the Monumental area between Thien Mu Pagoda and Van Thanh Temple in Hue City (UNESCO site), Vietnam

Issini G., Polverini D., Pugnaloni F.
Università Politecnica delle Marche – Dardus, 60131 Brecce Bianche St., Ancona (Italy)
{g.issini@univpm.it, dariopolverini@wp.pl, f.pugnaloni@univpm.it}

Abstract

This paper describes the work carried out from 2007 to 2008 by the research group of Dardus about the virtual reconstruction and the communication of the Temple area between Thien Mu and Van Thanh in Hue City, Vietnam. This site is located in the West side of Hue City, that is Unesco World Heritage site since 1993.

The first aim of this work was to realize a Virtual Reconstruction of the temple area, including all the historical building and the surrounding environment, starting from different fonts and data.

The second aim was to define a system of friendly and real-time application of the Virtual Environment, in order to join it with other documents made by the research activities, and to allow an organic understanding of the historical architectures features. The final product will be used in the city museum and it will be published on the research website.

1. Introduction

Dardus Department of the Polytechnic University of Marche in Ancona city, Italy, works on research activities in Hue City, Vietnam on the field of study and documenting historical architectural sites and environment.

The research carried out by Dardus, together with the Hue Monuments Conservation Centre and the Department of Architecture of the Hue College of Sciences, is finalized to document the architectural quality of the cultural heritage of Hue City, through low cost and quickly methods for survey, modeling and visualization. The research activity here presented is focused on the Temples area along river Huong of the Hue City between Thien Mu Pagoda and Van Thanh Temple.

This system is formed by three historical complexes: the first is Thien Mu , the second is Vo Thanh and the third is Van Thanh. Near this area there are two others minor buildings: Cong Thanh temple and Khai Thanh Temple. The three complexes of temples where we worked are very important for the Vietnamese identity keeping, due to the quality and quantity of architectural and landscape They testify the historic tradition of the Vietnamese culture.

The different steps of the carried out research, were composed by several activities: an accurate and meticulous philological survey based on the collection of documents from Vietnam and France, the registration of oral testimonies such as those from old people of Hue City, the study of satellite maps and historic papers in order to understand how the area changed in the years, the archaeological research through non invasive or semi-invasive surveys, which helped following archaeological excavations done in Hue Monuments Conservation Centre, the survey of the original or reconstructed emerging parts, the survey of the area, of the landscape and of the botanic species; the formulation of reconstruction hypothesis of the temples, totally or partially destroyed and of the original appearance of the whole historic urban landscape. The studied archaeological area plays a key role for the urban development of Hue City, because it is located next to the dense city and it represents an integral historic landscape. Consequentially the archaeological area between T

hien Mu and Van Thanh area is one of the most visited site in Hue City and the local administrators aim to define an exploitation plan including new buildings for tourist services (museum, shops, restaurants, etc.). Moreover, the local authorities want to enhance the knowledge of this sites, creating a dedicated section in the local museum.

In this context the Italy-Vietnam joint staff studied the original characters of the whole area. Moreover it created a database of documentations and knowledge that is the historic base to keep the visual and physical integrity of the historic landscape integrated to new contemporary architecture to be built in the future.

978-0-7695-3733-7/09 $25.00 © 2009 IEEE
DOI 10.1109/IV.2009.101

Figure 1 The research area

3. Features of the Monumental Complexes

Hue City is a unique model of a monumental city where the landscape, the architecture and the human activities are strictly connected in an harmonious system. It was declared a World Heritage Site by UNESCO in 1993. The Thien Mu, Vo Thanh and Van Thanh complexes of temples were oriented along the main axis of the historic town and they were faced to the Huong River side. The fusion of architecture, landscape, natural elements and social and religious traditions is the added value of the these monumental sites, according to the Vietnamese feng-shui rules.

The chronology of all temples go back to XIX century, with the exception of Thien Mu Pagoda that is older. The monumental identity of Hue must be attributed to Nguyen Dynasty. These Emperors reigned from 1802 with Gia Long (the first Nguyen Emperor) to 1945, with the last Emperor Bao Dai, and erected almost the totality of temples system of Hue. Their reign was characterized by an important influence of Chinese culture on Vietnam that is evident on architectural style of the three complexes.

Thien Mu was dedicated to Buddhist worship. By historical sources, we know that the original structure of the temple was erected in 1601. All the monument, during the centuries, was submitted to restoration activities and adding new architectural elements.

The whole area of pagoda is bordered by a wall and includes buildings harmonized with gardens within. Along the main axis, passing the access gate we find the Phuoc Duyen Tower, erected in 1844 by King Thieu Tri and recently restored. It's octagonal shaped base, 21 meters in height divided in seven floors. It is surrounded by four stele-houses dedicated to King Thieu Tri and his wife on base of historic sources and inscriptions in Chinese characters.

Ahead there is the Dai Mon gate. This gate is the principal one within the bordering wall of Thien Mu area. It's characterized by a triple entrance joined with a minor building at right and another on the left. Also in this case there are decorative dragons on the corners of roof. After the gate there is a large open area surrounded by a wooded garden. In this zone the floor show a walk brick-made joined with garden-made zones. In axis with the gate there are the three main temples. All of them was restored in recent times and preserve only few wood elements in the inner space.

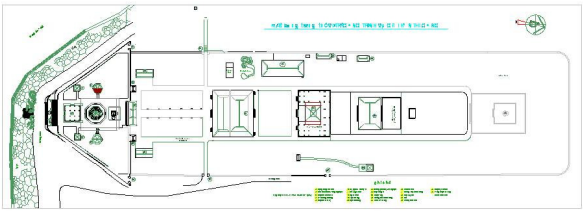

Figure 2 Plan of the Thien Mu Complex

The second temple of the system is the Military Shrine of Vo Thanh. It was constructed in the Minh Mang year of 16(1835). Now it is completely destroyed. According with the filological analysis made by the research staff, it is possible to affirm that the surrounding wall was made of bricks.

The main gate in the south side was quite similar to the gate of temple of Literature (Van Mieu Mon). The Chancel was the main house which was made by three compartments and two wings and the forecourt was made in five compartments. In front of the main house two apartments were built, on the right and on the left with five compartments each. All the compartments were used to worship the renowned Chinese and Vietnamese generals.

In the center of the temple were erected three big monuments, in Vietnamese called "Bia". These monuments were put up in Minh Mang year of 17 (1836) and Tu Duc year of 2 (1849). They were put on rectangular stones meticulously carved. There were stones to write about the brilliant feat of arms of the generals of Nguyen Dynasty. After the Nguyen Dynasty became extinct, the temple was left unused and damage occurred.

Now only the stones and a short part of the wall remain. Due to the importance of the temple, it was put in the UNESCO list of International Heritage in Hue, also it was acknowledged as National Heritage by Vietnam Ministry of Culture and Information.

Figure 3 View of Vo Mieu Archaeological site

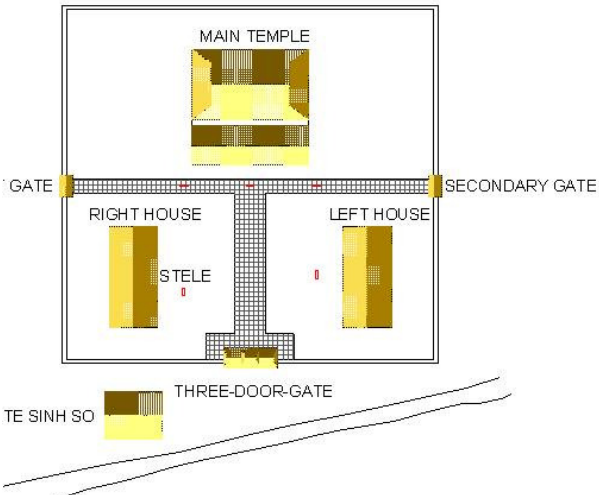

Figure 4 Plan of the Vo Mieu Complex

The third examined Temple complex is Van Thanh. Built by Nguyen Dynasty in XIX century, was dedicated to important people of Confucian philosophy. Also this temple rise on the right side of the road and was linked with the river by a staircase partially exposed by archaeological excavations of HMCC. The general state of preservation is quiet good, even if the original wood structures are lost and substituted with restorations in piling. The templar area was bordered by a wall that is preserved in some traits. A staircase bring to the first gate, after that there is an open space with another staircase to the second gate. Both gates are monumental with decorative dragons on the roof and a triple access. After second gate we find a large garden passed through by a brick made walk starting from the gate. This walk is crossed by another brick made walk starting from two secondary gates in each long side of border wall, forming a typical T-shaped walk. The most interesting element of this temple is the presence, side by side T-shaped walk and behind stele houses, of basements not yet excavated but partially visible on the ground. Two basements are visible on each side of stele rows, and another bigger one behind stele houses near the short side of border wall.

Figure 5 Dai Thanh Gate, Van Mieu Complex

2. Research objectives

The overall objectives that the present work intends to achieve:

- The implementation of a instrument aimed to help the local policies of urban planning and management of cultural sites.
- To promote the worldwide knowledge of the Temples sites, through the use of the web;
- To rebuild the original image of the sites, in order to keep the Vietnamese cultural identity and its transmission to the next generations.

The specific objectives are the followings:

- To realize the 3D reconstruction of the whole area. This work has to be based on the direct survey for the existing parts and on the hypothesis of visual reconstruction, made by the historian of the research staff, for the destroyed or damaged parts. The reconstruction hypothesis have to study the architectural shapes, the structural and non-structural materials, the relationship between architecture and surrounding environment, the vegetation and the urban ways. The final products has to enhance the contents of the Hue Museum, and it has to be also used by web based systems.
- Allow the visual preview of the new interventions' impact on the architectures and signs of the territory in order to verify the compatibility with the consolidated image of the monumental complex and the surrounding context. To acquire through the interventions' simulation, a feedback from the city inhabitants, from the historians, from landscape architects and therefore share with them the planning and valorization intervention on the area;
- To define and to experiment a web-based and friendly visualization system to use the virtual environment of the Temples area as instruments for a better understanding of other contents, made by other research field. This system of assisted visit will be also used in the Hue Musuem.

3. Modeling process

The work started with the implementation of the Virtual Environment as it should have been in the past and as it appears now. To the models, data and information collected in the previous survey analysis were added, such as geographic information, morphology of the land, the relationship between the water system and the temples, Huong River and obviously the temples in the actual state of conservation,

and the signs useful to determine the presence of temples partially or totally destroyed such as Vo Thanh and Van Thanh temples. The modeling, even integrating different data typologies, was developed in limited dimensions, because of the interventions to be carried out in the next phases. For this reason OpenSource software as Blender were used because particularly adapt to implement flexible works for the 3D modeling based on Linux, a pre rendering of the texture was carried out in order to allow a likely visual perception, and in the same time in order to make the model not so heavy and the rendering in real time of the lights and shadows processing. This decision was considered proper to the visualization territorial scale of the Thien Mu Historic Urban Landscape. To model the historical building and the boundary walls of the three Temple complexes we used two different kind of fonts: the first consists in the direct survey of the existing buildings or part of them. We included in this group just the original or congruent with the original ones. The surveys have been realized using different methods: The first is the prompt photogrammetry. The system of prompt photogrammetry has proved itself specially useful as it is based on some certain measures and on digital photographs taken in the appropriate way. We applied this method for the survey of the monument complex of Thien Mu Pagoda, composed by the Main Pagoda, the Stele houses, the Buddist Temples along the main axis and the service buildings in the sides of the monumental area, and in the existing part of Van Than Temple (main and secondary gates). Moreover we obtained a quite good two-dimensional survey of buildings, complete with the representation of crack status and local damage status of masonries. The research team used also more detailed survey methods. The scanner laser 3d was used for the buildings part where we found particular richness and irregularity of shapes. But we used also more classic instruments as the total station or the gps receivers to acquire general measurements of the area. The second kind of fonts consisted on historical and archive documents and not-invasive investigations. These documents are composed by drawing, historic pictures, texts, ancient and new cartographies, etc. The patient work of combining of different documents and the philological analysis allowed to propose an hypothesis on the original status of the lost Temples. The hypothesis concerned the shape and proportion of the buildings, the materials adopted, the Temple complexes location in the natural environment and landscape and the geographic directions. During this work the data obtained by geo radar and datafusion system were very useful. They shown the size and position of the underground basement s and the walls of the lost temples, avoiding the archeological excavations.

The data fusion investigations technique has been mainly used on the Van Than sites, because the ground hasn't been transformed by the river floods. It is based on high resolution satellite view (VHR, Very High Resolution) as Ikonos and Quick Bird, that provide the aerial covering of all the world. The satellite pictures are characterized by a resolution ables to allow the visibility of all the territory. Through the optimization of the visible and panchromatic infrared bands, it's possible to join the advantages of the thermic band and visible band. In this way we supposed some hypothesis and then we verified them through local inspections on the site. It has been possible to locate ruins of totally superficial lost architectures. Through this method we found the traces of the central temple (Literature temple) and of the secondary buildings. Moreover we obtained data about the wooden structure grids of the temples and the constructive system, thanks to the knowledge of the frame model and dimension. The Ground Penetrating Radar investigation (G.P.R.): The georadar investigation has been realized on the Vo Thanh site. In fact this site undergoes each year many flooding events, due to the nearness with the Huong River and the low level of land, compared to the river. The investigation has been realized to survey the buried part of the temples foundations and basement. The research staff realized many prospecting, in according to orthogonal acquisition grids, one meter long wheelbase, to survey hypothetical linear target, but with small dimensions. By the elaborated radargrams many meaningful reflections were visible. They allowed to suppose the originally position and dimensional hypothesis of the building objects into the monumental complex.To define the geometry of the volumes that compose the templar area, we used the .obj file type. Each .obj file is linked to a .mtl library that gives information about illumination, color and texture.The mapping process is done using "bake render" system: every mesh that compose the model is rendered alone with Blender internal rendering engine. At the same time the mesh is unwrapped and placed ideally in a 2d plane. The render result is, in this particular situation, a 2D image where we can recognize every face of the mesh. This image is attribuited to the mesh using the coordinate of every vertex obtained in the unwrapping process.In this way, we can obtain a good photorealism for the entire scene due to the shadow and the Ambient Occlusion. So we decided to deactivate all the illumination feature in the .mtl file: every texture has in itself the result of raytracing process from the same illumination system. Obviously we lose the real -time shadowing features, but they aren't fundamental in the architectural exploration

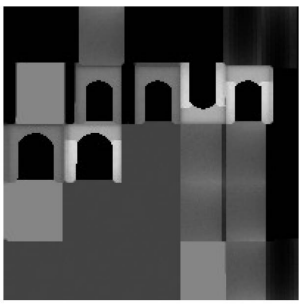

Figure 6 Bake render of a Vo Mieu mesh

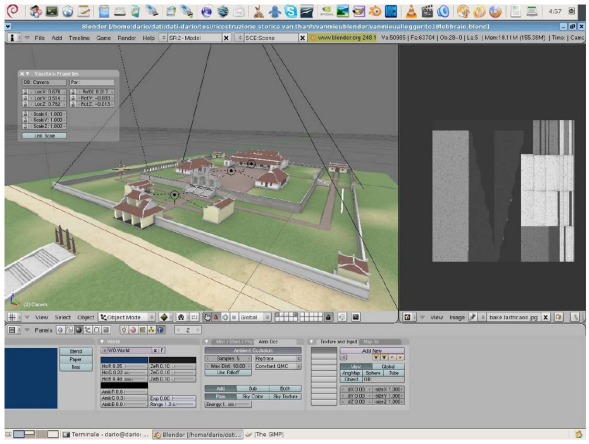

Figure 7 Van Mieu mapping using Blender

A specific work has been carried out to model the landscape around the templar sites and to define the original vegetation. First of all the earth has been modeled starting from the Quickbird satellite view of the area. It provides 3D points in the knots of a 90x90 meters grid. After this preliminary row model, we deepened the model through the overlapping of a landscape survey made by gps receiver and a survey made by the local geographic institute in 1997. The interesting aspect of the landscape model is that it is extremely changeable, due the action of Huong River floods. During the rain season the Huong River moulds the land each year. Thanks to the excavation carried out in 2007, we discovered the level of the earth in the age of Temples building was 160 centimeters lower then now, due the continuous overlaying of mud layers. So, the earth 3D model considered this phenomenon in order to propose a likely land shape. Concerning the vegetation, we gathered data about the local vegetables species, provided by the Hue College of Agriculture. Particularly, we knew which is the species who raise along the river embankments and in the hill close to the river.

Figure 8 Vo Mieu Virtual Reconstruction

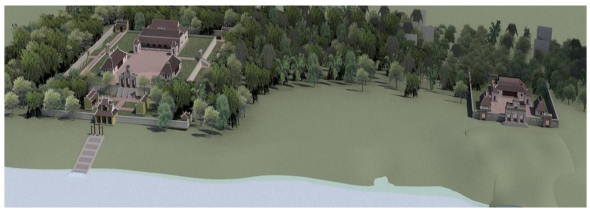

Figure 9 Overview of virtual environment

5. Visualization system

The aim of the Virtual Reality (VR) is to create, through computer, worlds and objects which represent the digital transposition of real or imaginary environments. Moreover, it studies the methods of interaction between the user and the real world such as navigation systems, instruments of the 3D vision, tool for the virtual object manipulation etc.

The simulation is completely perceived by our senses, in particular sight, then sense of hearing and touch. One of the main problem with the immersion in the virtual reality is the interaction with the navigation system: an interface with a keyboard, joystick or mouse is always needed. The virtual reality exploration uses manual devices which transforms the actions: for example typing on a keyboard the user will go forward, or a mouse rotation makes the user rotating. These actions even if are easy to make and to learn, represent an obstacle for a beginner user who is at his/her first experience with virtual reality.

In case of immersive virtual reality, this problem is overcome because user's movements in the real world are similar to those in the virtual one: for example with the use of HMD (Helmet Mounted Display) each head movement changes the point of view of the user both in the real and virtual world. A particular case of immersive virtual reality is the Augmented Reality (AR) which deals with the combination of real-world and computer-generated data. The perception of the environment is "augmented" by the addition of computer-generated graphics which gives further information on the real environment. The virtual reality simulates 3D environments where the user can move and act. With the AR the problem is different: the real environment is integrated with computer-generated images which are mixed and overlapped to real-world elements. Augmented Reality is a natural way to explore 3D objects because it brings the virtual object in the real environment instead of teaching the user how to navigate in a computer. Using a computer and simple tools for video acquisition, it is possible to see in the same time the real world and the virtual world elements. It is possible to move inside the environment, see the model, the animation from different point of view and it creates automatically the alignment between real and virtual world.

In the case of the Temple complex of Thien Mu, Van Thanh and Vo Thanh, our idea is to use the augmented reality methods to link the visualization of the Virtual Environment with the visualization of real things (object or places), creating a mutual aid in the contents understanding. Together they allow an organic understanding of the architecture contents. The AR systems aid to increase the quality and quantity of information we can obtain from traditional documents, like drawing, pictures etc.

The application we realized starts from the researches carried out by the Human Interface Technology Laboratory New Zealand (HIT Lab NZ), hosted at the University of Canterbury, New Zealand.

It can be applied to the object and panel of a Museum, but also for the distance use by internet. In this case the guest can simply print some papers and, through the on-line use of the AR system, the real drawing are improved with virtual interactive information.

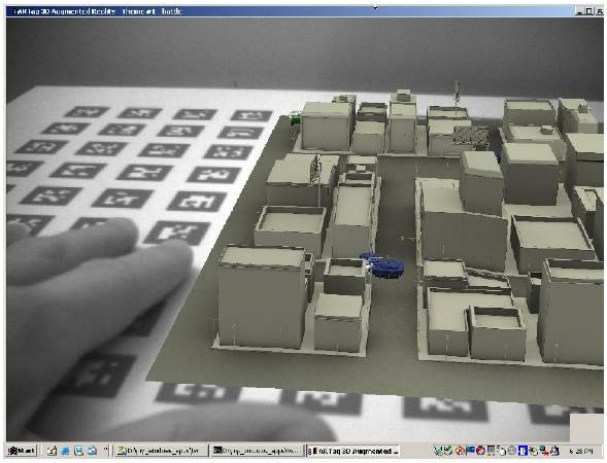

Figure 10 Example of AR architecture exploration

The idea is to create a prototype of a flexible, interactive system which could allow users from all over the world to explore the volumes and spatial qualities of the area. For this reason it was decided to use technologies easy to be found: AR systems normally requires sophisticated video devices but in this case a simple computer and a webcam or a mobile phone camera were used. In particular mobile phones are very useful because thanks to Bluetooth technology, the images are transferred without cables: the AR tracking is very sensitive to shadows therefore it is important to move freely and without objects creating other shadows (for example cables). Fiduciary markers for example, a simple paper with b/w patterns, are necessary in each building because appearing in the image produced, represent a point of reference or a measure. The object will be put on the fiduciary marker which, for better visualization of the archaeological park, are positioned in a scale 1:1000 on the aerophotogrammetric of the area. In this way the user perceive a map enriched with information of the 3D volumetry of the buildings' architecture.

Figure 11 Sample of fiduciary marker

Figure 12 The marker in the real world and the Temple in the virtual world

The technology allows to have the necessary fiduciary markers and in the same map it is possible to visualize the whole project of the archaeological park. The limit is given by the hardware ram in fact a correct visualization needs high memory to store the data. The markers are simply leaned on specific positions above the drawings; in this way they can be substituted and it is easy to move from the historical reconstruction to the actual state. Moreover each single fiduciary marker can be withdrawn in order to study the architecture in a closer and detailed way. Therefore in order to explore the area, it is sufficient to move the tool of video acquisition over the map or move the fiduciary marker in front of it. In both cases the fluidity of the exploration depends on the video acquisition quality: a major number of frame for second of video acquisition, assures a better navigation. The system quality depends also on the quality of lighting: a good lighting without light points allows a optimal focus even with common webcam

which are very flexible in terms of exposure. The software used in the implementation of the Virtual Reality are open-source:

- software: Debian, GNU/Linux
- modeling software: Blender and engine
- Image processing software: The GIMP
- Tracking software: ARToolkit
- 3D real-time software: OpenSceneGraph.

Figure 13 Vo Mieu and Van Mieu complexes on AR

7. Conclusions

The work we carried out can be considered the appropriate conclusion of a long research process started four years ago on the Templar area along Huong River, between Thien Mu and Van Thanh. In fact, the 3D Virtual Environment is able to collect many results of the research activities. These results were developed on different scientific fields who need a common way of communication. The more interesting outlook of this work will be the possibility to overlapping of different information layers in the same Virtual Environment and and between reality and Virtual Environment, and in the same time it has to be interactively on line visited. Moreover, the VR has to allow different levels of detail, according to the user interests and skills. The most famous product on this field is Google Earth, but for the study and communication of cultural heritage documentations this instrument doesn't allow yet to communicate in real-time the large quantity and quality of information available. So, it's important to experiment new instruments and methods in order to exploit the web capacities for the architecture representation and communication.

References

[1] GALLUZZI P., VALENTINO P.A.. I formati della memoria. Beni culturali e nuove tecnologie alle soglie del terzo Millennio. Giunti, Firenze 1997.

[2] MIGLIARI R., Frontiere del Rilievo: dalla matita allo scanner 3D. Gangemi, Roma 2001.

[3] GAIANI M.. Metodi di prototipazione digitale e visualizzazione per il disegno industriale, l'architettura degli interni e i beni culturali. Polidesign, Milano 2003.

[4] VELTMAN K.H. Hypermedia: New Approaches to Cultural Heritage and Knowledge, The Global Village Conference. GIVE, Vienna 1997.

[5] BRAIL R., KLOSTERMAN R., Planning support systems: integrating geographic systems, models and visualization tools. Esri press, Redlands 2001.

[6] AA.VV. E-arcom. Sistemi Informativi per l'Architettura. Atti del convegno. Alinea Editrice, Firenze 2007.

[7] HAUBER, J. Ph.D. thesis, Computer Science and Software Engineering, University of Canterbury. Supervised by Dr Andy Cockburn, Dr Mark Billinghurst, Dr Holger Regenbrecht and Dr Dean Owen.

[8] LEE, M., GREEN, R., BILLINGHURST, M. In Proceedings of the 23rd International Conference Image and Vision Computing New Zealand, Lincoln, Christchurch, New Zealand. November 26-28 2008.