



BUILDING A VIRTUAL TIME MACHINE FOR THE ANCIENT RUINS OF JIAOHE

Britt Lonneville^{*}, Nina Vanhaeren, Annelies Vandenbulcke, Alain De Wulf, Philippe De Maeyer

Department of Geography, Ghent University, Krijgslaan 281, 9000 Ghent, Belgium. Britt.Lonneville@UGent.be;
Nina.Vanhaeren@UGent.be; Annelies.Vandenbulcke@UGent.be; Alain.DeWulf@UGent.be; Philippe.DeMaeyer@UGent.be

Abstract:

The goal of this work in progress is the virtual 3D reconstruction of one of the temples of the Ancient Ruins of Jiaohe (China). This site, considered as one of the key locations on the Silk Road, is slowly deteriorating due to erosion and human activity. One of its buildings, the Northwest Small Temple, was partially reconstructed as part of the Master plan for preservation and restoration as proposed by the UNESCO/Japan Trust Fund. Furthermore, a replica of the temple was built at the site entrance.

The UNESCO master plan serves as the starting point for the 3D reconstruction, which is performed in three phases. The first phase comprises an initial 3D reconstruction of the temple based on floor plans and sections, and the placement of this reconstruction in a low-resolution 3D model of Jiaohe. The second phase consists of a field campaign at the site, in order to acquire the necessary data to complement the initial reconstruction: a high-resolution 3D model of the current state of the Northwest Small Temple, 3D models of the statues inside the replica of the temple and imagery of the murals inside the replica. After combining the data from phase one and two, a 3D model of the Northwest Small Temple, completed with textures and statues inside, will be placed on a 3D model of its surroundings. This final 3D model will then be made available to a broad audience as a virtual time machine, allowing the visitors to both experience the site as it is today, as the way it used to be at the peak of the site's civilisation.

Key words: Jiaohe, Yar City, digital heritage, 3D reconstruction, 3D modelling, erosion studies

1. Introduction

Many of the earthen heritage sites that remain along the route of the Silk Road are decaying due to environmental factors such as erosion (Li *et al.* 2011). In order to preserve these sites for future generations and monitor the decline of the earthen structures, creating virtual models of some of the key buildings of such a site can be a starting point (Barton 2009). This can be done by adopting various techniques, such as topographic measurements or photogrammetry (Yastikli 2007; Remondino 2011).

On the other hand, by projecting virtual 3D models on the site, visitors are able to explore what the site and its buildings used to look like before (Addison 2000). Such an augmented reality system allows visitors to get access to valuable information and improves the visitor's experience (Kounavis *et al.* 2012).

Both aspects of the creation and application of virtual 3D models will be explored throughout this work in progress, as a 3D model of an ancient temple will be created using existing construction plans, and newly acquired data will

allow the creation of a 3D model which will then be used to monitor the erosion of the temple.

2. Research area

The Ancient Ruins of Jiaohe in northwestern China (Fig. 1) used to be a key location on the Silk Road. The city was founded in the second century BC and flourished for over 1500 years. It was of great military, cultural, political and economic importance and today it still has a high historical and scientific value (Fig. 2). However, due to erosion and human interference, the site is slowly deteriorating (Shao *et al.* 2013). Consequently, data should be available to monitor the destructive processes and preserve the site for future generations.

Between 1992 and 1995, the UNESCO/Japan Trust Fund launched a surveying and restoration campaign to perform research on the site and make it more accessible to visitors. As part of this campaign, the Northwest Small Temple was partly restored on the site and a replica was built near the site entrance (Fig. 3). The presented research expands on this campaign. It attempts to virtually reconstruct the Northwest Small Temple in 3D, based on the master plan published by

^{*} Corresponding Author: Britt Lonneville, Britt.Lonneville@UGent.be

the UNESCO Beijing Office (UNESCO Office Beijing 1999) and additional field measurements.



Figure 1: Location Ancient Ruins of Jiaohe.

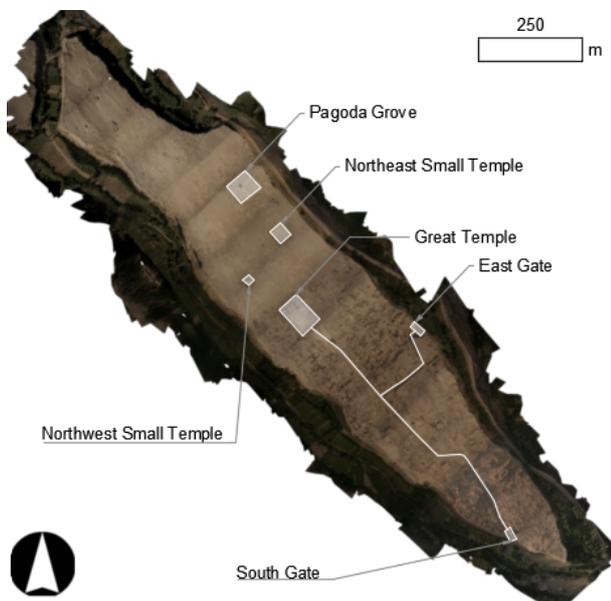


Figure 2: Layout site and most important buildings.

This work in progress consists of three phases:

- (i) 3D reconstruction of the Northwest Small Temple based on the UNESCO master plan, and connection to previously created (low-resolution) 3D models of the Ancient Ruins of Jiaohe (captured during field campaigns in October 2014 and October 2015) (Vanhaeren *et al.* 2016).
- (ii) Survey campaign at the Ancient Ruins of Jiaohe to create high-resolution 3D models of the remains of the Northwest Small Temple and the sculptures inside the replica, and to gather imagery of the murals.
- (iii) Update of the initial 3D reconstruction of the Northwest Small Temple with 3D models of murals and sculptures, connection to the new (high-resolution) 3D model of the temple and publication of 'virtual time machine' of the site.

Furthermore, the collected data will also be used in a comparative study that attempts to determine the decay of the site since the measurements performed in the light of UNESCO's master plan. To this end, the photogrammetric data that was gathered in 1993 will be compared to a 3D model generated in 2016. This 3D model will, in turn, form a basis for future erosion monitoring.



Figure 3: Northwest Small Temple after restoration on site (UNESCO Beijing office 1999).

3. Methods

3.1. Phase one

The first phase has already been started with the digitisation of several plans of the Northwestern Small Temple and the 3D reconstruction of the central stupa.

The UNESCO master plan comprises five plans of the Northwest Small Temple: one floor plan, one front view, two cross sections and one longitudinal section. These plans were digitized and scaled in AutoCAD, based on the dimensions provided by the documents. Afterwards, they were put together in one comprehensive plan (Fig. 4).

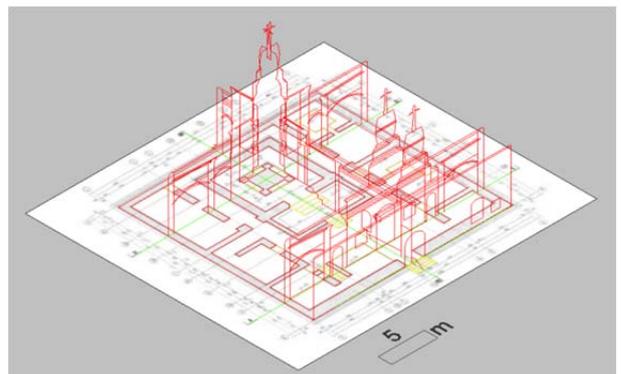


Figure 4: Combination of digitized sections and plans.

Based on these plans, the central stupa was reconstructed in 3D. This process was performed in AutoCAD. Initially, the textures were also assigned in AutoCAD. Later, the 3D model was exported to Blender to add a more realistic texture and to place 3D models of buddhas in the niches of the stupa. Moreover, the reconstructed stupa was combined with the 3D model of the Northwest Small Temple that was created using UAV imagery. This imagery was captured during a field

campaign in 2014 (Vanhaeren *et al.* 2016). However, a more detailed 3D model of the building is needed, as well as more realistic buddha representations and textures.

3.2. Phase two

The second phase will consist of a two-week field campaign to the Ancient Ruins of Jiaohe, which will be undertaken in July 2016. During this campaign, the aim is to generate three end products: a high-resolution 3D model of the current remains of the Northwest Small Temple, 3D models of the sculptures inside the replica of the Northwest Small Temple and imagery of the murals inside this replica, which will then be used as texture for the final 3D reconstruction.

The technique of photo modelling will be adopted for the creation of the 3D models. In order to create a 3D model of the Northwest Small Temple, a UAV will be deployed.

3.3. Phase three

In the final phase, the output of the first two phases will be combined. The initial 3D model from phase one will be supplemented with the 3D models of the statues that were created during the field campaign. Furthermore, textures for this 3D model will be extracted from the gathered imagery of the replica. The finalised 3D model will then be placed on top of the high-resolution 3D model of its environment.

Moreover, the newly created photorealistic 3D model of the ruins of the Northwest Small Temple can be compared to previous measurements on the site, and will be used as a basis for future erosion monitoring.

The data will also be made available to researchers of the Xinjiang Institute of Ecology and Geography for further research and dissemination, by exporting the models in different formats (e.g. Collada or X3D) and providing the necessary metadata.

4. Results

Some preliminary results of the first phase can be seen in Figures 5 and 6. Both images were rendered in Blender. Figure 5 represents the initial 3D reconstruction of the central stupa of the Northwest Small Temple, Figure 6 shows this reconstruction within the (low-resolution) 3D overview model of the site.

The final result will combine the reconstructed 3D model of the Northwest Small Temple, the textures gathered from the replica and the 3D model created through photo modelling of the temple's environment. This will allow the user to not only visit the site in its current state, but also get an impression of what the site and its buildings used to look like over 1000 years ago.

5. Conclusion and future research

This work in progress attempts to create a 3D reconstruction of the Northwest Small Temple, one of the key landmarks of the Ancient Ruins of Jiaohe (China). In order to arrive at this 3D model, several data are combined: floor plans and sections produced by UNESCO, 3D models created during previous field campaigns, imagery of the replica of this temple and a new, high-resolution 3D model of the temple in its current state. Through this approach, a virtual time machine is created for the site, allowing the public to relive the Chinese empire at its peak and discover various aspects of the way of life at that time through a virtual visit. Moreover, the possibilities of augmented reality to communicate this 3D model to visitors of the site, as discussed by Stricker *et al.* (2010), can be tested. Finally, the 3D model created during the field campaign will be used in erosion monitoring studies of the site.

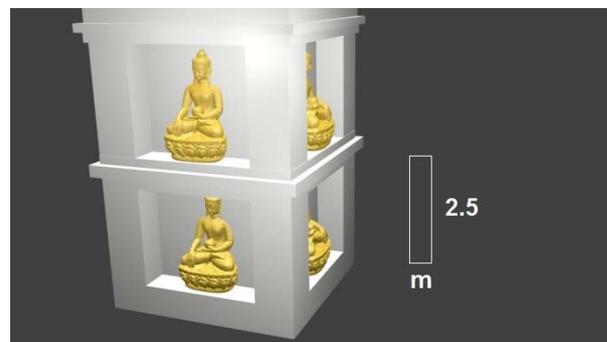


Figure 5: Render of stupa (Blender).

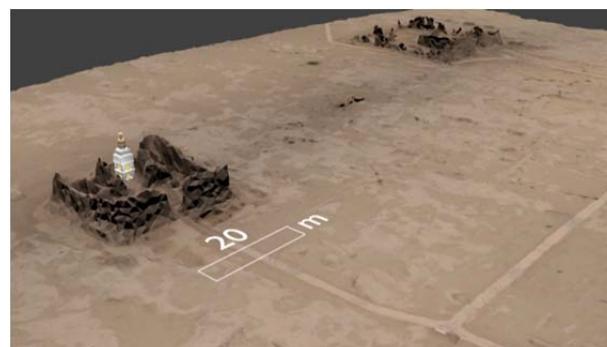


Figure 6: Render of stupa and low-poly 3D model of environment (Blender).

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References

- ADDISON, A., 2000. Emerging trends in virtual heritage. *IEEE MultiMedia*, **7(2)**, pp. 22-25. DOI: 10.1109/93.848421
- BARTON, J., 2009. 3D laser scanning and the conservation of earthen architecture: a case study at the UNESCO World Heritage Site Merv, Turkmenistan. *World Archaeology*, **41(3)**, pp. 489-504. DOI: 10.1080/00438240903112518

- KOUNAVIS, C., KASIMATI, A. and ZAMANI, E., 2012. Enhancing the tourism experience through mobile augmented reality: challenges and prospects. *International Journal of Engineering Business Management*, **4**, pp. 1-6. DOI: 10.5772/51644
- LI, L., SHAO, M., WANG, S. and LI, Z., 2011. Preservation of earthen heritage sites on the Silk Road, northwest China from the impact of the environment. *Environmental Earth Sciences*, **64(6)**, pp. 1625-1639. DOI: 10.1007/s12665-010-0829-3
- REMONDINO, F., 2011. Heritage recording and 3D modeling with photogrammetry and 3D scanning. *Remote Sensing*, **3(6)**, pp. 1104-1138. DOI: 10.3390/rs3061104
- SHAO, M., LI, L., WANG, S., WANG, E. and LI, Z., 2013. Deterioration mechanisms of building materials of Jiaohe ruins in China. *Journal of Cultural Heritage*, **14(1)**, pp. 38-44. DOI: 10.1016/j.culher.2012.03.006
- STRICKER, D., PAGANI, A. and ZOELLNER, M., 2010. In-situ visualization for cultural heritage sites using novel augmented reality technologies. *Virtual Archaeology Review*, **1(2)**, pp. 37-41. DOI: 10.4995/var.2010.4682
- UNESCO OFFICE BEIJING, 1999. Master plan for preservation and restoration of the Ancient Ruins of Jiaohe. Available: http://unesdoc.unesco.org/Ulis/cgi-bin/ulis.pl?catno=145411&set=4B31DD3D_3_9&gp=1&lin=1&ll=1 [3/9, 2016].
- VANHAEREN, N., KURBAN, A., ABLEKIM, A., SHIJIA, A., XIAOLIAN, D., DE SLOOVER, L., LONNEVILLE, B., DE WIT, B., STAL, C., BOURGEOIS, J. and DE MAEYER, P., 2016. Modelling Yar City on the fly: applying UAVs for the creation of archaeological 3D models, *2nd International Conference of Aerial Archaeology 2016*, Rome, Italy.
- YASTIKLI, N., 2007. Documentation of cultural heritage using digital photogrammetry and laser scanning. *Journal of Cultural Heritage*, **8(4)**, pp. 423-427. DOI: 10.1016/j.culher.2007.06.003