3D DOCUMENTATION OF NATURAL HERITAGE FOR VIRTUAL ENVIRONMENTS AND WEB — CASE STUDY: VALLEY OF GEYSERS, KAMCHATKA

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ABSTRACT

The article presents a project on a 3D documentation of the Valley of Geysers, Kamchatka (UNESCO Natural Heritage). The 3D document serves for virtual ecotourism, ecological education, scientific modeling and visualization.

KEYWORDS

Virtual Reality, Natural Phenomena Modeling, Scientific Visualization, Neogeography, Situational Awareness

1. INTRODUCTION

This paper presents a project of development of the 3D document “Virtual Valley of Geysers”. The terrain is modeled using high resolution satellite imagery. The content includes texts, photos, videos, vector models and dynamic animations. Scientific data like seismic activity, geothermal system structure and thermal water outflows catalogue is visualized.

The principal scheme of a 3D document was enhanced to support two representations of the 3D document, one for public Web access and the other — for Virtual Environment (VE) stereo projection systems. Both versions represent generally the same information but use different terrain models. The VE version is developed using open source software OpenSceneGraph (OSG) [OSG] and AVANGO [AVANGO]. The Web version is based on Google Earth and is publicly available at www.valleyofgeysers.com.

The project contributes to the development of approaches for building Virtual Natural Heritage environments. It also provides a shared cyberspace for effective interdisciplinary communication of researchers from different branches of science.

2. 3D DOCUMENTATION OF NATURAL HERITAGE

The principal scheme of a 3D document is shown on 0Generally, it is a 3D model of an object and an information system linked to the 3D model. Set of information also often includes a large amount of semi-structured data, embedded in the 3D model directly or via linking files.

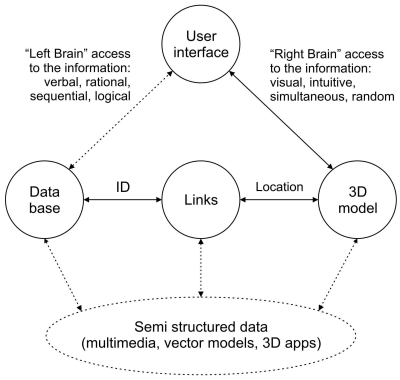

Figure 1. The principal scheme of a 3D document.

The concept of a 3D document is presented in the publications of Dieter Fellner [Fellner, 2007], Fabio Remondino [Remondino, 2010] and others. Methods of 3D documentation are being developed most actively in the field of Virtual Cultural Heritage — virtual museums, archaeological reconstructions, visualization of complex architectures [Havemann, 2009], [Remondino, 2009]. The same principle could be implemented for the development of Virtual Natural Heritage applications.

First of all, Natural Heritage site is a landscape. So the 3D document in this case is based on a 3D model of a terrain. The terrain can be reconstructed precisely using historical topographic maps, satellite data, aerial photogrammetry or aerial laser-scanning depending on technical and financial constraints [Boehler, 2001]. Aerial methods are more precise and thus better, especially for small areas [Buckley, 2008]. Reconstruction of the terrain for large areas usually involves satellite imagery [Chen, 2010], [Deng, 2008], [Mao, 2008]. The methods can be combined to create a 3D model of a large territory with enhanced resolution for some particular areas of interest.

Given the precise and geo-referenced 3D terrain is built, further process of 3D documentation of a natural area involves development of an information system connected with the 3D terrain and building user interface to provide access to the 3D document.

3. RELEVANCY

The Valley of Geysers is the second largest geyser field in the world [Sugrobov, 2009], [Bryan, 1991]. It is located in Kamchatka peninsula on the Russian Far East, in the Kronotsky Reserve, that is a part of the UNESCO World Heritage Site "Volcanoes of Kamchatka" (N 765 bis). In 2008 it was voted as one of the seven Wonders of Russia.

The Valley of Geysers is a renowned tourist destination. But its average attendance is only about 3000 people a year because of its remote location and reserve status. It is only a tiny percentage of those who would like to see it. It makes necessary to develop virtual ecotourism for this place.

The massive landslide on June 3, 2007 has dramatically changed the landscape of the Valley of Geysers. About half of all geysers were destroyed. A large set of interdisciplinary research was started after 2007 in order to analyze and forecast further landslide hazard [Pinegina, 2007], [Leonov, 2007], [Lobkov, 2008], [Dvigalo, 2009], [Kugaenko, 2010]. Careful 3D documentation of scientific data as well as physical modeling and visualization is needed to provide effective interdisciplinary communication.

As some of the UNESCO World Heritage sites change irretrievably due to natural processes, they can be preserved only in the form of evolving 3D documents. Precise reconstruction with use of Neogeography [Turner, 2006] and VE will allow saving a lot of data about this areas and their dynamics.

Some results of the project were published in our previous article [Leonov, 2010].

4. FUNCTIONAL SCHEME

Precise and visually realistic reconstruction of a landscape is a necessary condition to achieve good immersion effect in VE system. But higher resolution means larger amount of data and thus more difficult Web access. It is a basic contradiction in the process of 3D documentation of large natural areas.

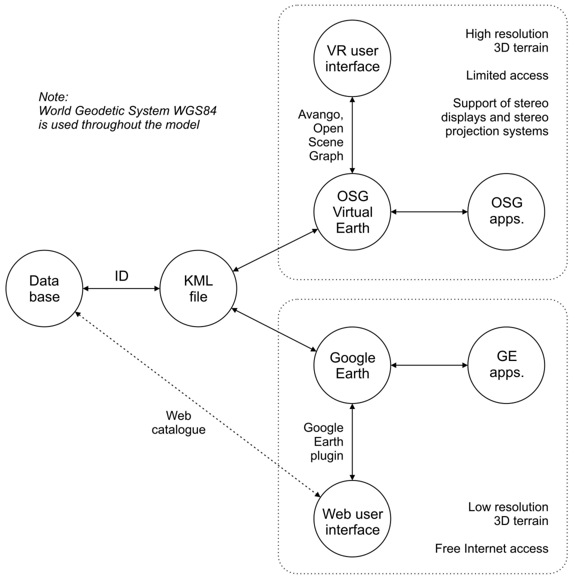

Figure 2. The scheme of a 3D document with dual representation.

To solve this contradiction, we have enhanced the principal scheme of a 3D document to support dual representation of the 3D document, one for Web access and the other for VE systems. We use precise terrain model for VE application on the local stereo projection system, and we use open Google Earth terrain to provide worldwide access to the information. The information is linked with terrain models by a KML file that provides correct positioning of data on both virtual globes (OSG and Google Earth). Both versions represent generally the same information, with some additional applications in each version, 0

5. VIRTUAL TERRAIN

The virtual terrain was built using GeoEye and Cartosat satellite imagery. The resolution of the digital elevation model (DEM) is 2.5 m and the texture resolution is 0.5 m. The imagery and DEM are courtesy of R&D Center ScanEx and GeoEye Foundation, Inc. The terrain was precisely geo-referenced in the world coordinate system ITRF/WGS84 using field GPS measurements. The coordinates of the twelve reference points were measured with an absolute accuracy of about 0.1 m. Differential corrections were implemented with use of the two backbone GPS base stations of KEMSD GS RAS. The accuracy of positioning of the terrain model in the world coordinate system reached 0.2 m on the horizontal plane and 3 m on the Z axis.

6. WEB AND VE REPRESENTATIONS

A web representation is based on the Google Earth virtual terrain, 0 Public access is organized on our website www.valleyofgeysers.com using the Google Earth plug-in. Web control menu is developed in JavaScript. The menu is generated automatically on the web page using information from the KML file. The menu allows control of the 3D document and switching on/off visibility of layers and objects. The size of the initial KML linking file is only about 500 KB, all other information is downloaded on demand (after a layer is set visible or an object description is opened). It makes it easy to browse the 3D document on-line. Rough terrain model is the main drawback of the public Web representation. Google Earth terrain data (SRTM 90 m [SRTM]) cannot be refined by the user. Low resolution of the virtual terrain reduces dramatically the effect of immersion. Moreover, Google Earth software does not support a stereo mode. The main aim of the public Web representation is to provide free worldwide access to the information about the Valley of Geysers.

Figure 3. Examples of data in the Web version: georeferenced photo, 3D models, 3D video, and landslide animation.

A VE representation is developed in OSG and AVANGO software. It uses the high resolution virtual terrain model embedded in the OSG Virtual Globe. The KML file links the terrain model and the web information system. Thus users of the VE application have full web access to the same information as Web users. A 3D mouse with six degrees of freedom is used for free travel through the terrain. Limited access is the main drawback of the VE representation. A large amount of the high resolution terrain data requires dedicated web server to provide comfortable web access. This version is intended for stereo presentation and provides good immersion effect. It is now demonstrated in the public museum of the Kronotsky Reserve. Several specific 3D applications such as geothermal system structure, 3D geyser activity animation, landslide models, and local seismic activity visualization are also being developed in the VE representation.

7. CONCLUSIONS

We presented a dual approach to 3D documentation of a complex Natural Heritage site with the single information system both for VE applications and for Web access. This approach was implemented for a case study of high scientific and cultural importance: the Valley of Geysers, Kamchatka. The developed 3D document is used for virtual ecotourism, ecological education, scientific modeling and visualization.

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REFERENCES

ACANGO website: http://www.avango.org/

Boehler, W. et al, 2001. Topographic Information in Cultural and Natural Heritage Visualization and Animation. *Archives of ISPRS*, Vol. XXXIV–5/W1, pp. 56-61.

Bryan, S. T. et al, 1991. *The geysers of the Valley of Geysers.* A special report of GOSA Transactions. B&J Printing, California, USA.

Buckley, S. J. et al, 2008. Oblique helicopter-based laser scanning for digital terrain modeling and visualisation of geological outcrops. *Archives of ISPRS*, Vol. XXXVII–B4, pp. 493-498.

Chen, B. et al, 2010. VCUHK: integrating the real into a 3D campus in networked virtual worlds. *Proc. of 2010 International Conference on Cyberworlds*, IEEE CS CPS, pp. 302-308.

Deng, B. et al, 2008. Remote sensing analysis of the status of the Beijing-Hangzhou Grand Canal. *Archives of ISPRS*, Vol. XXXVII–B5, pp. 231-236.

Dvigalo, V. N. and Melekestsev, I. V., 2009. The geological and geomorphic impact of catastrophic landslides in the Geyser Valley of Kamchatka: Aerial photogrammetry. *In Journal of Volcanology and Seismology*, Vol. 3, No. 5, pp. 314-325.

Fellner, D. W. et al, 2007. Guest Editors' Introduction: 3D documents. *In IEEE Computer Graphics and Applications*, Vol. 27, No. 4, pp. 20-21.

Havemann, S. et al, 2009. The Arrigo Showcase Reloaded — towards a sustainable link between 3D and semantics. *In Journal on Computing and Cultural Heritage*, Vol. 2, Issue 1, p. 1-13.

Kugaenko, Yu. A. et al, 2010. Local Seismicity Within the Valley of the Geysers: Results from the 2008-2009 Field Investigation. *In Bulletin of Kamchatka Regional Association "Educational-Scientific Center", Earth Sciences,* No. 1 (15), pp. 90-99.

Kugaenko, Yu. A. et al, 2010. Deep Structure of the Region of the Uzon-Geyser Volcanic-Tectonic Depression Based on the Data of Microseismic Sounding. *In Doklady Earth Sciences*, Vol. 435, Part I, pp. 1460-1465.

Leonov, A. V. et al, 2010. Virtual story in cyberspace: Valley of Geysers, Kamchatka. *Proc. of 2010 International Conference on Cyberworlds*, *IEEE CS CPS*, pp. 247-253.

Leonov, V. L., 2007. Geological preconditions and capability to forecast the landslide of June 3, 2007 in the Valley of Geysers, Kamchatka. *Proc. of scientific and technical conference "Geophysical Monitoring and Problems of Seismic Safety of Russian Far East"*, Geophysical Service RAS, Vol. 1, P.-Kamchatskiy, Russia, pp. 91-95.

Lobkov, E. G. and Lobkova, L. E., 2008. Ecological effects of the landslide in Valley of Geysers June 3, 2007 (first season after). *Proc. of VIII international scientific conference "Conservation of biodiversity of Kamchatka and coastal waters"*, P.-Kamchatski, Russia, pp. 114-140.

Mao, F. et al, 2008. The research and application of spatial information technology in cultural heritage conservation — case study on Grand Canal of China. *Archives of ISPRS*, Vol. XXXVII–B5, pp. 999-1005.

OpenSceneGraph website: http://www.openscenegraph.org/

Pinegina, T. K. et al, 2008. The Valley of Geysers, Kamchatka after the June 3, 2007 Disaster. *In Vestnik DVO RAN*, No. 1, pp. 33-44.

Remondino, F. and Rizzi, A., 2010. Reality-based 3D documentation of natural and cultural heritage sites — techniques, problems, and examples. *In Applied Geomatics*, Vol. 2, No. 3, pp. 85-100.

Remondino, F. et al, 2009, 3D virtual reconstruction and visualization of complex architectures — the "3D-ARCH" project. *Archives of ISPRS*, Vol. XXXVIII-5/W1.

SRTM 90 m Digital Elevation Data: http://srtm.csi.cgiar.org/

Sugrobov, V. M. et al, 2009. *Pearl of Kamchatka — the Valley of Geysers*. Kamchatpress, P.-Kamchatskiy, Russia.

Turner, A. J., 2006. *Introduction to Neogeography.* O'Reilly Media, USA.