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Implementation of technology for creating virtual spatial-temporal models of urban development history

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Abstract

Based on the pre-developed technology for creating spatial-temporal models of urban development, in this paper, we have developed a database, which represents a collection of three-dimensional models of cultural and historical heritage objects located in the central part of Tambov (Russia), both existing and completely or partially destroyed. They include the elements of Tambov fortress of the XVII century (towers, walls, church), elements of the «Market Square» area (public house, merchant's rows, tavern) and others. Currently, the database includes information on more than 200 objects and their elements. This database can be used by undergraduate, graduate and postgraduate students, tutors and lecturers. The library of three-dimensional models can also be used at creation of multiuser three-dimensional virtual worlds in such software systems as OpenSimulator, Second Life and others.

Keywords: cultural heritage, database, cultural heritage objects, 3D-models, case-study of old Tambov.

Introduction

In the paper [1] we provide a virtual modeling technology for objects of cultural and historical heritage. Its elements include: development of an information model of an object from a complex of historical and cultural heritage; method of data processing and stages of creating a realistic spatial model of a territory.

In this paper, we consider the implementation of the proposed technology using software that allows creating virtual reconstruction of historical buildings under the conditions of uncertainty and discrepancies in the initial data.

Virtual reality (VR) raised great expectations for solving this problem: the possibility of (re)creating environments, buildings, objects, etc. It can be used for conservation, study and restoration of works [2]. In addition, objects, sites and monuments can be accessible to a wider audience employing network and computer technology. In the last decade 3D digital models for virtual access to Cultural Heritage have been widely used for the increasing interest on their application.

The use of modern information technologies for preserving historical and cultural heritage objects has been extensively discussed in the literature.

The general purpose of [3] is to provide an idea of making museums available for those who cannot visit them physically, whereas the main purpose is to protect the original cultural heritage, i.e. the artifact, by reproducing the same artifact with respect to the original size as well as various dimensions. Digitization can be accomplished in many ways such as photography, panoramic display or by saving 3D coordinates of the art object.

This research by Shaw and Krug [4] was conducted as part of the project designed to offer guidance on the development of a youth oriented online space for a popular

Canadian museum of heritage and immigration. This space would allow young people to learn about heritage, ethnicity, and cultural identity, and, ideally, aid in the development of a positive ethnic identity.

As demonstrated in several case studies 3D digital acquisition techniques may greatly help in documenting an archeological site and the related findings. An accurate reality-based representation may be also used as the starting point for creating a scientifically sound virtual reconstruction of the site, embedding historical information of different provenances. The paper by Guidi et al [5] describe this whole process step by step, focusing on the iterative feedback that can allow us to reach the best virtual reconstruction solutions, helping the archeologists to better focus their reasoning through a detailed visual representation, and the technological experts to avoid misleading details in the final virtual reconstruction. The methodology has been experimented on a group of Cham temples located at MySon, an UNESCO archeological area in central Vietnam

Sequeira and Morgado [6] present an overview of four different approaches to virtual archaeology projects that are present in Second Life®, and its open source counterpart, OpenSimulator and that have been publicly discussed and analyzed; in particular, the last type shows a novel approach to virtual archaeology which is not found in other platforms, and explains how researchers have managed to extend the concept to new areas and develop methodologies to incorporate the validation of historical accuracy to encompass these areas.

A collaborative virtual museum and library exhibit tour in the virtual world of Second Life is described in the paper by Hill and Mystakidis [7]. Colleagues from the University of Washington's Certificate in Virtual World course created Maya Island, a simulated environment which represents aspects of the ancient Mayan civilization. Through collaboration with librarians across the globe, the virtual museum was exhibited at the Community Virtual Library and live tours were provided for avatar visitors. This collaborative project demonstrates potential for virtual museums in libraries and education along with predictions for future virtual museum and library projects and environments.

Flotyński et al. [8] present a method of modeling and dynamic multi-platform presentation of interactive 3D web content. The method is based on a multi-platform extension of previously developed Flex-VR approach, which provides a rich data model for 3D content, covering both the geometrical and the behavioral aspects. Based on the model, interactive 3D presentations can be dynamically generated in different formats, allowing seamless presentation of 3D content on different platforms—different web browsers with different capabilities and sets of plug-ins.

The research work by Rua and Alvito [9] is a useful contribution to historical research, specifically to the study of architectural history. Its purpose is to create a series of methods and tools for testing and analyzing theories and hypotheses for historical scenarios through the use of 3D modeling tools and VR engines. The project was developed in two stages: The first was the creation of several 3D models, each representing a different theory or hypothesis. The models were based on accurate Computer Assisted Design (CAD) (Autodesk® AutoCAD) models for the reconstruction of the buildings, and Geographic Information Systems (GIS) (ESRI®) for the recreation of the terrain, thereby creating a realistic representation of what exists now, and a close approximation to what may have once existed. In the second stage, a simplified version of the models was imported into a VR game engine (Bethesda Softworks®) to create the ambience of the villa at the time, allowing full exploration of the space. It also includes fauna and flora, as well as Artificial Intelligence (AI)-driven avatars.

Virtual reconstruction of particularly significant objects of the city of Tambov

Nowadays, the problem of preservation and reconstruction of lost or modified monuments of historical and cultural herit-

age is important not only for Russia but for the entire world. Some of them have been lost completely, while others were subjected to alteration and reconstruction at various historical periods, and so on.

The problem is also relevant for the existing historical objects, which may be lost due to the influence of negative factors ranging from the lack of funding for their conservation and restoration to the changes in political regimes and local military conflicts.

The use of modern information technologies makes it possible to solve these problems and also to attract interest to the monuments of historical and cultural importance and formation of their modern image. They help not only to preserve the current image of historical objects for future generations, but also to show the descendants various stages of their existence [10]–[12].

One way to provide information about the objects of cultural and historical heritage is virtual museums - specialized web sites designed to display various types of museum materials: pieces of art, historical artifacts, monuments, etc. This information includes not only textual information, but also images, sounds, videos, animation [13]. Often, these sites are information resources of the existing museums. Standard WEB-browsers can be used to view these sites.

Another trend is to use 3D-technology for virtual reality simulations. Three-dimensional modeling allows recreation of lost or partially damaged historic sites, unrealized projects and architectural monuments that have disappeared. In 1990 a term “virtual archeology” was introduced; its purpose is application of computer technology for creating of high-quality images of archaeological sites and promotion of archaeological research [14]. Modern information technologies make it possible to reconstruct the objects that were destroyed or damaged as a result of the archaeological excavations.

Technically, a virtual 3D-reconstruction of a historical object can be represented as a sequence of the following steps.

At the initial stage of reconstruction, it is necessary to study information about the monument in detail and to explore historical materials and archival information about the object in museum collections and archives.

Using 3D-modeling programs (Google SketchUp, Blender, Maya, Autodesk 3Ds Max) 3D-models of historical objects (buildings, houses, etc.) are built based on known parameters (dimensions, material). Graphics editors (GIMP, Adobe Photoshop) are used for texturing of the objects.

Using landscape design programs (L3DT, Terragen) a 3D-model of the landscape is constructed based on available topographic data (maps, plans, diagrams, images from space).

Then, on the basis of these 3D-models of objects and the landscape a final virtual space is created using software systems for creating three-dimensional multi-user virtual worlds (OpenSimulator, Second Life, Unity3D). With the help of a specialized software client (Cool VL Viewer, Singularity) users control the movement of an avatar (virtual character) in a simulated virtual world.

The authors have developed a three-dimensional reconstruction of Tambov fortress of the XVII century. Tambov was founded in 1636 at the confluence of the rivers Students and Cna as a military fortress on the southern borders of Moscow State. Figure 1 shows a perspective view of the fortress area, Figures 2 – 4 show its individual elements.

OpenSimulator was used as a platform for creation of a three-dimensional virtual world [15]. OpenSimulator is an international project, which aims on creating an open technology platform for building three-dimensional virtual worlds, which are similar to Second Life. OpenSimulator uses an innovative feature such as a three-dimensional Web. OpenSimulator project has an open-source code (under the BSD license) and is distributed free of charge.

Thus, the technology for creating a three-dimensional virtual world allowed the authors to perform a historical reconstruction of Tambov fortress of the XVII century.

Figure 1. General view of the model of Tambov fortress in the XVII century

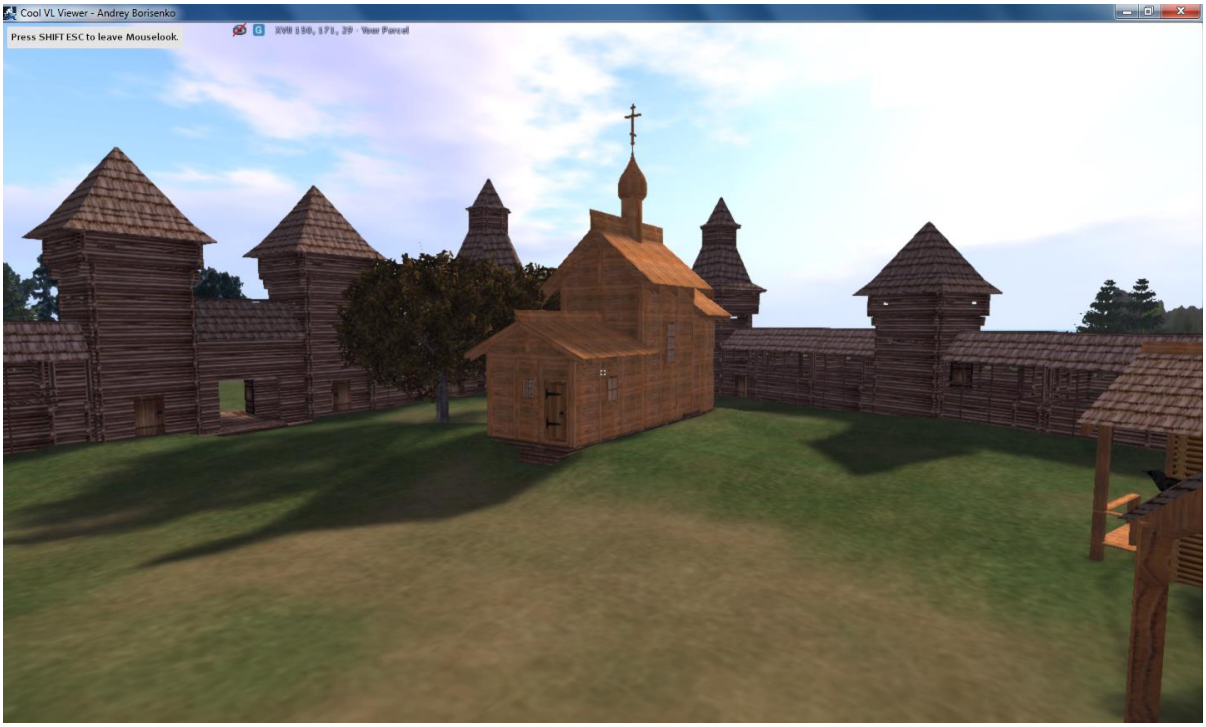

Figure 2. View of the church model

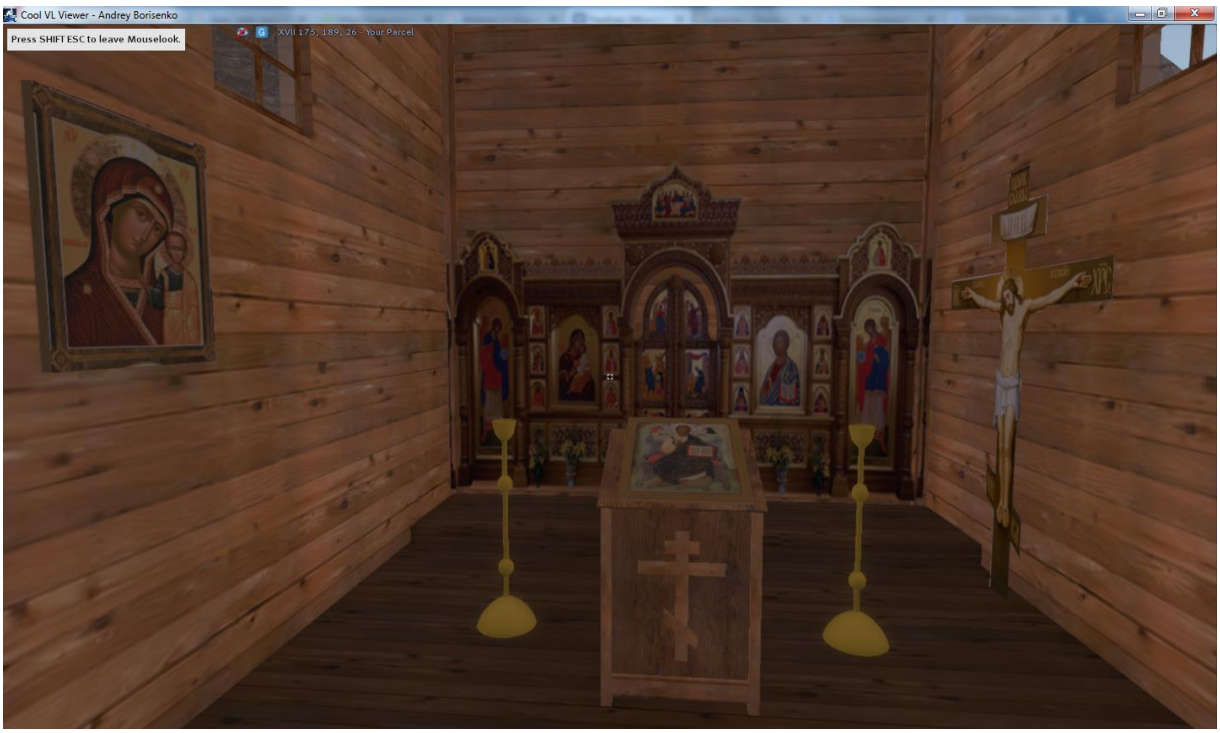

Figure 3. Interior decoration of the church model

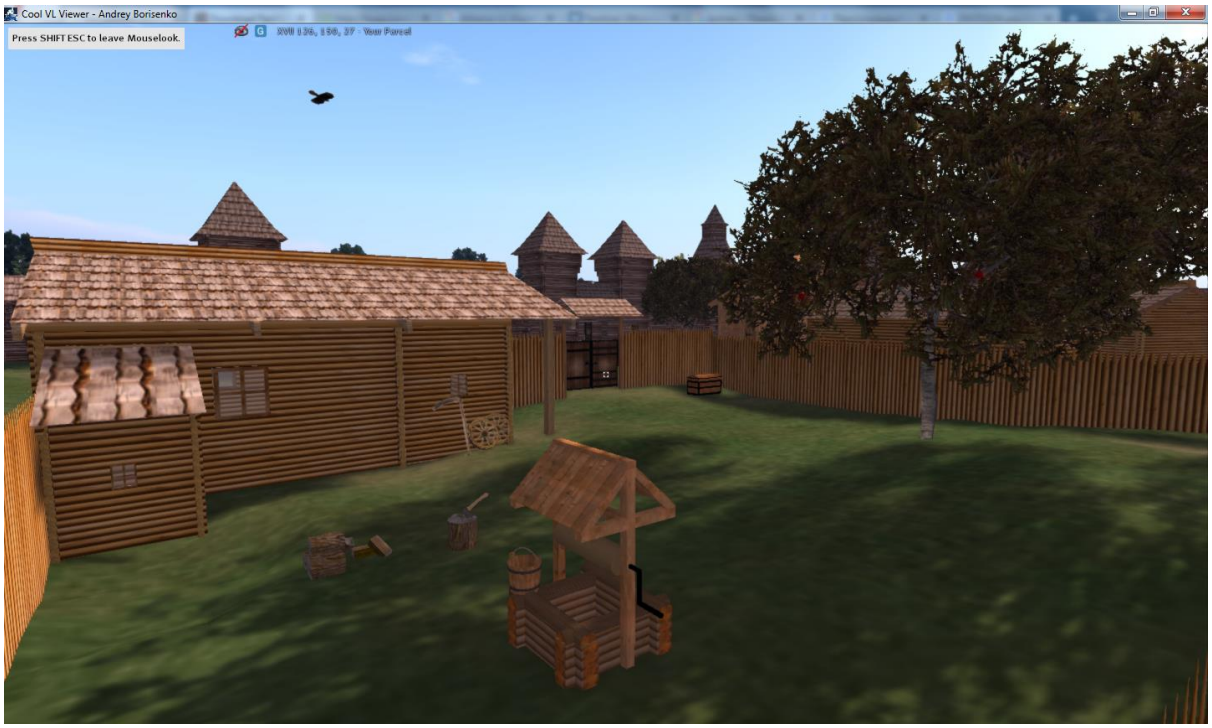

Figure 4. Visualization of the eastern part of the fortress model

Figures 5-7 represent the fragments of virtual reconstruction of the «Market square" area of the city of Tambov at the initial stage of its urban development in the middle of the XIX century.

Figure 5. Visualization of the «Public house» model


Figure 6. Visualization of the «Merchant's rows» model

Figure 7. Visualization of the «Tavern» model

Conclusion

In this paper, the authors have proposed a technology for creating a virtual three-dimensional reconstruction of Tambov fortress of the XVII century and the «Market square» area of the city of Tambov at the initial stage of its development in the middle of the XIX century that includes consistent use of the following software: 3D-modeling programs (Google SketchUp, Blender, Maya, Autodesk 3Ds Max) for building of spatial 3D-models of historical objects (buildings, houses, etc.) based on known parameters (dimensions, material); landscape design software (L3DT, Terragen) for building of a 3D-model of the landscape based on available topographic data (maps, plans, diagrams, images from space); software systems for creating of three-dimensional multi-user virtual worlds (OpenSimulator, Second Life, Unity3D) in order to form a final virtual space on the basis of 3D-models of objects and the landscape. At the same time, with the help of specialized software client (Cool VL Viewer, Singularity) user controls the movements of an avatar (virtual character) in a simulated virtual world.

With the use of this technology, the authors plan to perform virtual reconstruction of all objects that have ever been built on the given territory up to the present and, thus, to reconstruct the history of urban development of the central part of the city of Tambov during the whore period of its development. In the future, this technology can be used for virtual reconstruction of other especially significant objects of the Russian Federation cultural heritage.

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