Cultural Heritage Reconstruction using Virtual and Augmented Reality

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Abstract: Augmented reality and virtual reality (commonly abbreviated as AR and VR respectively) are reality technologies that either enhance or replace a real-life environment with a simulated one. AR enhances your surroundings by adding digital elements to a live view, usually by using the camera on a smartphone. VR is a completely captivating experience that replaces a real-life environment with a simulated one. This article presents the connection between the reconstruction of medieval architecture and the further improvement of ways to use it effectively, the proper use of architectural monuments to improve travel opportunities is an important challenge. Particular attention is paid to the sustainability of old cities, preserving the buffer zone of architectural monuments, development can improve the tourism industry and convey new opportunities. The first was the creation of a highly appealing visualization system that allows a virtual visit to Aksaray (Amir Timur Palace in Shakhrisabz, Uzbekistan). The second is the possibility of using this technology for a virtual exploration of Aksaray, from a technical and architectural point of view.

1 INTRODUCTION

The current great role of increasing the economic potential of a country's tourism industry is great. The tourism industry is always trying to keep track of new technologies, as the new generation of travelers are active smartphone users who use smart devices to access social platforms. New technological improvements such as “virtual reality” (VR) and “augmented reality” (AR) can improve the tourism industry and open up new opportunities. Recently, various fields of tourism, have already introduced augmented reality technology.

AR is an interactive experience and evolving technology that overlays computer-generated enhanced images or virtual objects onto a live real-world environment in real time, thus providing a composite view.

The technology that makes AR possible is now much more powerful than ever before and is compact enough to deliver AR experiences to tourist sites through smart devices, making AR more sociable, communicative and inclusive, combining art, culture, architecture, design with projections and preservation of architectural landmarks with surrounding sound and special effects.

Augmented reality tools that superimpose digital content on a real environment are a key component of Industry 4.0.

All over the world the scientific research on the expedient use of architectural monuments pays much attention to the preservation and restoration of historical monuments, increasing their durability.

Active measures are being taken to solve the problems related to urban planning, design and architecture, further improvement of education and science in construction, innovative development of construction, preservation of architectural monuments and their appropriate use.

In this regard, the preservation of architectural monuments of the Middle Ages and the further improvement of the ways of their effective use, the proper use of architectural monuments to improve the possibilities of movement are important tasks.

The aim of the project is VR technology, to enrich the gaps in the study of cultural heritage sites related to the buildings of Amir Timur and Temurids in the Middle Ages in the historic cities, using a graphic reconstruction and creation of visual animation. The project proposal is implemented on the basis of historical sources and the results of archaeological research (Figure 1) [1].

Figure 1: Amir Timur's Aksaray Entrance Peshtak.

2 VIRTUAL REALITY FOR THE CULTURAL HERITAGE

The integration of the research in the area of computer graphics, computer vision and 3D survey systems found as a common action field the virtual reconstructions of Cultural Heritage.

The current virtual technologies (VR and AR), devices and sensors are able to immerse the user in a virtual environment, offering the possibility of interacting with additional contextual heritage data (reality-based 3D model, pictures, technical documents, historical information, tourist guides, etc.) [2]. The VR applied to Cultural Heritage has already become a potential tool for 'tourist' users to navigate and interact in a virtual scene in total symbiosis with the environment. The system has an attractive impact for dissemination purposes because it adds extra information and allows a direct and intuitive access of digital objects [3].

VR offers more than a replica of the real context; it allows virtual hypothetical reconstructions of the past aspect that can be developed for different epochs and can be related or overlaid with the archaeological surviving evidences [4]. VR creates a direct connection between tangible data (museum collection, archaeological remains etc.) and ancient invisible space, reproducing the scene, the environment and the atmosphere of past context in an immersive and attractive mode [5].

The potentiality of VR applications to promote knowledge Cultural Heritage is proven by the development of a significant number of projects in this research area [6].

3 CASE-STUDY: AMIR TIMUR'S AKSARAY IN SHAKHRISABZ

In 1976 archaeologist Sultonov X.T. began archaeological excavations in Aksaray building for the reason of the outstanding structure and conservation of the architectural building 3-4 meters south of the ruins of the entrance. At a depth of 1.5 meters above the current earth surface it was discovered a wonderful combination of different colored tiles on the surface of the building (Figure. 2).

Figure 2: Archaeological excavations in Aksaray.

During the excavations numerous ceramics have been found which decorated rooms of the palace. These include limestone glazed and poured with gold water fragments of cornices and embossed epigraphic ceramic tiles with patterns, carved marble tiles and molding's out of ganch and ceramics.

In order to build the ancient monument, it was selected a flat topography and the stable ground for the construction. The foundation of the building is ribbon-shaped and choosing its shape results from the distribution of the mass of the building onto the ground (Figure. 3). To increase the bottom surface area of the foundation in historical monuments trapezoid and curved forms were used. The foundation is 7 meters deep, and the material consists of large stones. (Figure. 4)

In order to ensure equal resistance in the structures of the monument it was used same materials or materials with similar physical and mechanical properties. The main building material was burnt brick which was laid using special type of mortar - ganch. The brick used in the construction of the monument was square shaped, measuring 24 to 28 cm on each side, 3 to 5 cm thick.

The restoration of the monument is an endless, continuous work of repairing, cleaning and replacement that has to be documented to help future activities. The modern answer to this necessity is the management of all the works inside a BIM system, as it combines the digital three-dimensional or

multidimensional representation of an object with an information database (spatial position, technical features, properties of the materials, realization phases, maintenance operation, etc.) [7]. Thanks to this working method, it is possible to create a proper geographic and informative system of the heritage, including the management of its life cycle, from the phase of the project, to the phases of the use and maintenance.

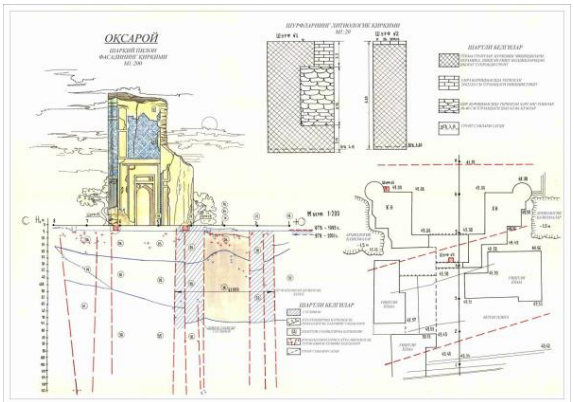

Figure. 3: The foundation.

Figure 4: Stacking of stone rocks.

Therefore, the main effort was spent in the last years to build a dedicated BIM system with this specific goal: supporting to the operations of the restoration yard.

3.1 Virtual Reconstruction

AR focuses on the simplicity and ease of providing an explanation experience, scientific researchers and tourists can gain knowledge and skills through 3D simulations generated by computers and other electronic devices, more so than in traditional ways. AR can explain architectural styles, graphics, or designs of palaces, mausoleums and mosques (Figure 5) [8].

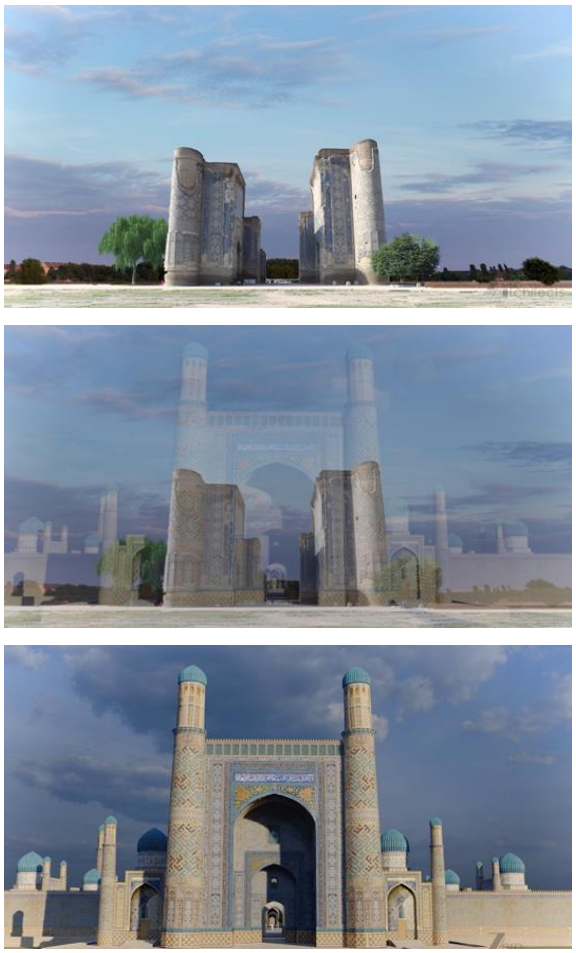

Figure 5: Virtual graphic reconstruction of Aksaray, performed by author.

Improving Information and Understanding: Scientific researchers and tourists know that the process of guided tours should focus on inspiration and interaction. Their goal is to get tourists interested in the subject or theme. Tourists should not be mere listeners and passive observers, some tourists, especially teenagers, need practice and hands-on experience.

The ability to connect reality and digital content is improving, opening up more possibilities for academic researchers and tourists.

For example, AR can improve the amount and quality of information about Amir Timur's palace, making the explanation environment more educational, productive and contextual. To improve the quality of explanation by producing and delivering rich, constructive and useful content. With AR, everything about Amir Timur's palace can be explained more scientifically than ever before through interaction with the computer display, sound, text, and 3D effects (Figure 6) [9].

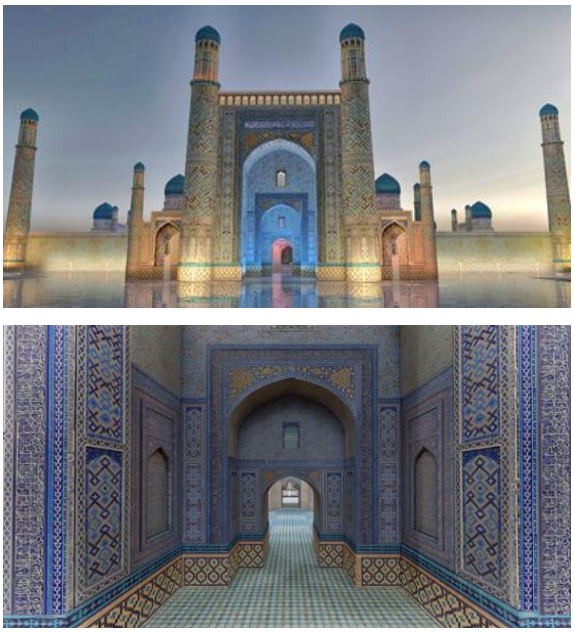

Figure 6: 3D effects.

Figure 7: 3D models (Scheme of schematic reconstruction of Aksaray) by author.

Simplifying abstract concepts: AR has the potential to make tourists more engaged and motivated in learning about restoring history and architectural heritage.

AR technology has the ability to explain abstract and complex concepts by visualizing objects that are difficult to imagine and turning them into 3D models, thereby facilitating the perception of abstract and complex content.

It is especially useful for visual tourists and virtually anyone to translate theoretical material into real-world concepts (Figure 7) [10].

3.2 3D Visual Guide

Visitors to museums and heritage sites can access AR applications via smart devices and discover historical content related to the sites in the form of 3D digital media, videos and images (Figure 8). AR simply provides instant and relevant enriched information about what they see to increase their motivation to learn and their level of understanding.

Moreover, AR offers an enhanced combination of different types of historical sources and visualizations, including 3D models, images, text, video, animation and sound, along with traditional methods to enhance the tourist environment.

Figure 8: Aksaray 3D animation and sound.

4 CONCLUSIONS

The research presented here aimed at applying new VR immersive techniques to the field of architecture and facility management. The main goal was to evaluate how VR could be used in the sector of Cultural Heritage as a support for conservation and maintenance activities. The work represented the follow-up of the previous research activities of survey and modelling of the Amir Timur's Aksaray in Shakhrisabz. The research work led to the creation of a complete high-resolution 3D model, currently used as a support of the maintenance activities of the Amir Timur's Aksaray in Shakhrisabz. Furthermore, in order to promote a wider use of the 3D virtual model to a larger group of users also including non-experts of 3D, an ad hoc building information modelling (BIM) system has been developed. This system is able to connect the modelling software with an external navigation system that encourages a simple and shared use of the 3D model by different stakeholders of the conservation process. It works like a catalyst that collects and connects data and information. The presented work succeeded in adding a further step in terms of virtualization by creating a VR immersive system that not only allows the classical virtual visit of the object, but also provides the technical information stored in the BIM system.

Based on the above historical data it is possible to schematically create restoration drawings of the layout of Amir Timur's Aksaray in Shakhrisabz. AR technology is becoming more and more accessible and therefore more widespread. Despite the growing use of VR in many businesses these days, AR in tourist orienteering is still new and unexplored. However, the potential of AR in tourist orientation is great, providing new ways to guide as guides gain attention and motivate tourists better, and tourists gain new tools to visualize complex concepts as well as gain practical skills.

Overall, the future of AR as an imaging technology looks positive; more attempts have recently been made to expand the use of AR in tourism guidance, and new AR tools for tourism guidance will continue to be developed as the technology becomes more highly developed and advanced than ever before. In addition, a great deal of research is being done to improve the compatibility and applicability of AR in tourist orienteering.

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