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HOLY SPIRIT CHURCH RECONSTRUCTION AND FORMATION OF ITS SURROUNDING LANDSCAPE USING THREE-DIMENSION VISUALIZATION TECHNIQUES[1]

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Summary. In this paper, there was used a three-dimensional visualization method in order to create a reconstruction of the oldest Ukrainian wooden church located in village of Potelycz in Roztocze. Three-dimensional visualization techniques in terms of the surrounding landscape were examined as well. Plant species were proposed for fighting erosion and formation of the esthetic value of landscape as well.

Key words: reconstruction, 3D modeling, wooden church, landscape formation, Roztocze

INTRODUCTION

These days three-dimensional (3D) reconstruction of architectural objects recently becomes more actual in investigating cultural heritage within landscape [Berndt and Carlos 2000]. Based on terrestrial photogrammetric and historical documentation it is possible to reconstruct cultural objects, including some elements of their structure that might have been destroyed. Researches on cultural heritage can benefit from high precision of three-dimensional reconstruction of architectural monuments in order to ensure greater protection, to examine possible changes in their structures and finally to improve their conservation.

Three-dimensional reconstruction of relics provides an enormous perspective for presenting cultural heritage, including wooden churches, their belltowers and landscape that surrounds it.

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The aim of this work is to illustrate three-dimensional visualization techniques [Bell 2004] in landscape formation around the church of Holy Spirit, in its reconstruction and in showing how to plant species capable of fighting erosion and forming the esthetic value of landscape as well.

MATERIAL AND METHODS

Ukrainian wooden temples as monuments of sacral architecture are considerable spiritual centers and unique architectural objects. They should be reconstructed not only in the ordinary manner, but with the use of three-dimensional technology as well. Currently, the majority of those well-preserved Ukrainian wooden churches are located in Western Ukraine [Slipchenko and Mohytych 2005]. For instance, only in Lviv province there are 767 wooden churches and in one Javoriv district in Roztocza – 46 of them.

We have chosen to analyzed the oldest of them – the wooden church of Holy Spirit in village of Potelycz, Zhovkva district, Lviv province in Ukrainian Roztocze. Currently, this is the oldest functioning Greek Catholic church in Ukraine which is covered by State's protection as an architectural relic of national significance. It was built in 1502 [Slobodyan 1998]. The church of Holy Spirit was built out of private funds by local potters, whose products were well-known in Europe. The village of Potelycz was found in 13th century (in 1498 the town Potelycz was given Magdeburg Rights that was in force during four centuries). At the moment, it is in Potelycz Reserve, which is deemed to be an important landscape.

The church of Holy Spirit is an example of *boyko* type architecture. In 1736 the pyramidal dome was replaced by baroque one. The interior of the church is dominated by an old iconostasis with an icon of Deesis, painted by Ivan Rutkovicz in 1683. On the walls there can be still found a preserved polychrome (traditional wall-paintings) from around 1630's presenting the scenes from the Passion of Christ. The oldest and the most unique is however the icon of Borys and Hlib from the end of 15th century and traditional icon of „Bohorodycja" since 17th century. A bell-tower on a square plan (4.4 × 4.4 m), whose height is 20m is located on nine posts, next to the church. This bell-tower built in 1736.

The stages of the church's development were illustrated in this article on the grounds of historical and graphical documents. The process of creating 3D-models of the church, its bell-tower and their surroundings was based on current digital photography. On the basis of photographic documents it was possible to reconstruct the church (Fig. 1A) from the outside (Fig. 1B). In the modeling process the method of terrestrial photogrammetric was used [Shashi and Jain 2007].

The process of 3D reconstruction of the church consists of several stages: data acquisition concerning current state of the church; 3D modeling of current state of the church together with the landscape it is situated in; the evaluation

of the alterations that have occurred with particular elements of the church and creating models of those already non-existing (e.g. the model of non-existing pyramidal dome till 1736; Fig. 1C); creating a central 3D model out of every single element that makes up the church (temple porch, nave and the altar), bell-tower and its landscape.

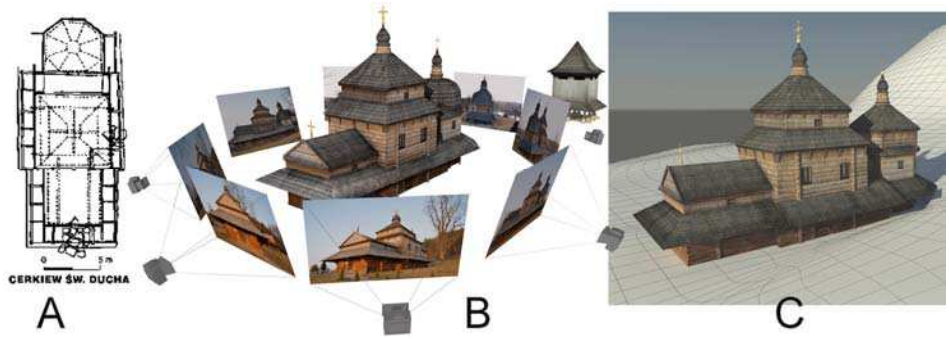

Fig. 1. Technical projection and photography scheme: A – technical projection of the church; B – scheme of photographing from the outside of current church; C – view of the church before 1736

Using photogrammetric techniques enables the construction of 3D models that are based on analysis of existing 2D images. In these circumstances, shape analysis was grounded on the photographs of the church, bell-tower and their surroundings as partially devastated objects [Stojaković and Tepavčević 2009].

2D photography should met the following conditions: fixed focus for photography is 28 mm; 8 photos were located around the church every 45^{o} (Fig. 1B); length, width and high of the church was determined according to field measurements; on the basis of measurements virtual apparatuses were situated in the field with the use of CameraMatch; the Standard Primitives geometry was fitted into the church's structure.

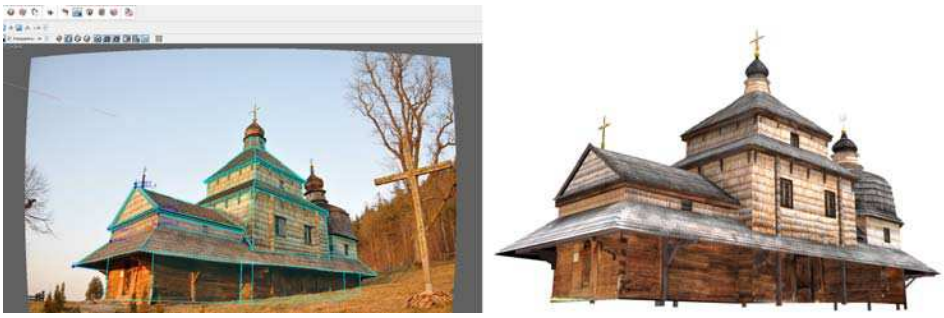

Fig. 2. Photography (left) and 3D geometry (right) of the church

These photographs were imported into the 3D software (3D Studio Max), where it is possible to generate all that complex geometry. Textures were automatically extracted from terrestrial images and then were put into the 3D model.

RESULTS

All individual 3D models were incorporated into the central model which generates a complete 3D image for the church, its bell-tower and their surroundings, including the proposed plant species to be planted out. In three-dimensional model the size of the church correspond to actual sizes from the landscape. The model consists of 1600 polygons. The saving format file (MAX; total volume 7MB contain lighting and texture) can be exported to obj, dwg, dxf format. The model may be applied in Auto CAD designing.

Contemporary techniques of reconstruction (including innovative 3D visualization technologies) and preservation of the landscape that surrounds the church are presented as well (Fig. 3A, B, C). Bell-tower was shown also on this figure.

The renewal of landscape that surrounds such an unique relic of national significance has gradually become even more apparent. However, in reconstruction it is possible not only to show how to improve the esthetic appearance but also how to preserve the soil stability of a hilly terrain. In the 3D model there are proposed some particular plant species, represents for unique beech and pine forests in Roztocze (*Aconitum firmum* Rchb.*; Cerastium pumilum* Curt.*; Symphytum cordatum* Waldst. et Kit; *Dentaria glandulosa* Waldst.et Kit; *Senecio nemorensis* L.*)*, around the church which will firstly comply with the requirements of the hilly and unstable terrain that surrounds that church, and secondly will provide greater protection from possible soil erosion by hardening it.

Fig. 3. Extract of landscape of Potelycz village: A – general view (3D visualization of the church was inserted in the middle); B – concepts of planting out, view on the church, C – example of plants in 3D

It is important to pay attention on the utilitarian aspects of selected species, particularly those from landscapes of Roztocze, what allows one to be inspired from natural conditions while designing. Plants that were planted, affect human senses and in this manner increase the attractiveness of landscape. What was neglected around the church and rather dull in its perception, with proper care can become a good asset and will emphasize problems with monument conservation to the visitors. The slope, located next to the stairs of the church, is strongly insolated, with dry surface and less fertile habitat conditions. In this place there were proposed plants with less demanding habitat requirements and preferred slopes directed to the south, which while planting on the pattern of colored spots will be visible from remote distances. The area located next to the water course, planted with species for the existing group on Roztocze will be characterized by a palette of colors – from blue flowers *Aconitum firmum*, to yellow *Senecio nemorensis*. Plant selection and their large patches prevent from unnecessary and dangerous soil erosion. The landscape around the church is also formed by reconstruction of the stairs, laying out the path connecting stairs with church's entrance, strengthening stream shores by setting wicker hedge.

DISCUSSION

This type of landscape modeling has an interdisciplinary character – demanding knowledge and skills from a wide range of fields, such as computer modeling, 3D visualization technology, sacral architecture, history of art and plant ecology.

Wooden churches were mostly built on a cruciform plan [Augustyn 1997], usually triple with three chambers. Its architecture has never been separated from outer environment. The structural design is actually within this landscape, reflecting some of its elements by the structure. Due to this fact all architectural forms of the church were constructed in accordance with the surrounding landscape. The natural color of the beams, wall sheathing, wood tile (local name in Western Ukraine – *gont*) – all these elements link the church with the surrounding landscape, not only because of its building material but also by the similarity to the forms of living trees and their crowns. Baroque domes of churches, surmounted with crosses, provide gentle and harmonious transition from architectural volume to surrounding space in the landscape – opened beneath the dome of the sky. This particular surmounting of the church creates the most noticeable and significant religious element [Shcherbakivsky 1970]. For this particular reason, in this article the 3D visualization was presented in relation with the visualization of surrounding landscape's elements (relief, plant species).

For renewal of landscape that surrounds such an unique relict there are proposed some particular plant species in the 3D model around the church which will firstly comply with the requirements of the hilly and unstable terrain that

surrounds the church, and secondly will provide greater protection from possible soil erosion by hardening it. The church and its bell-tower are located in the picturesque mountainous Roztocze, forming together hilarious compilation of harmony of nature and folk art.

CONCLUSION

This article presents an innovative approach towards the reconstruction of a landscape as a whole and each of its individual elements separately. In the landscape is important to expose the values that are becoming increasingly forgotten these days, the reconstruction of what once was full of life. A significant aspect of this kind of activities is to use 3D visualization that apply to the landscape analysis, analysis of sacral architecture and plants with study of their environment. Plant species and different forms of activity that were proposed in this work are essential for fighting erosion and forming the esthetic value of landscape.

The results we obtained, therefore the 3D model of the reconstructed church, are fundamental in terms of their documentation for future. What concerns future research, we believe that there is a great public demand in obtaining new data in culture landscape.

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REKONSTRUKCJA CERKWI ŚWIĘTEGO DUCHA I KSZTAŁTOWANIE OTACZAJĄCEGO JĄ KRAJOBRAZU PRZY ZASTOSOWANIU TRÓJWYMIAROWYCH TECHNIK WIZUALIZACJI

Streszcznie. W artykule wykorzystano metody trójwymiarowej wizualizacji w celu stworzenia rekonstrukcji jednej z najstarszych ukraińskich drewnianych cerkwi, znajdującej się w miejscowości Potełycz w krajobrazie Roztocza Ukraińskiego. Również zastosowano techniki wizualizacji 3D do prezentacji otaczającego krajobrazu. Zaproponowano zastosowanie roślin dla przeciwdziałania erozji i kształtowania estetyki krajobrazu.

Słowa kluczowe: rekonstrukcja, modelowanie 3D, drewniana cerkiew, kształtowanie krajobrazu, Roztocze