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Practice of using virtual reconstruction in the restoration of monumental painting of the Church of the Transfiguration of Our Saviour on Nereditsa Hill

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Abstract— **There are many architectural monuments and old relics, the restoration of which is an unrealizable task. This may be due to the great amount of hard work to be done, complexity of the work, lack of information about the object and other reasons. In such cases, the virtual reconstruction is an effective tool.**

Saint-Petersburg State University developed a method of restoration of partially or completely lost monumental paintings. As an example and a practical application of new technology there was completed the virtual reconstruction of fresco paintings of the Church of the Transfiguration of Our Savior on Nereditsa Hill.

The church was almost completely destroyed during the Second World War. It appeared to be possible to reconstruct an architectural view of the church according to the old drawings, but rare frescos of the XIIth century had been irretrievably lost. The extant parts of frescoes consist of 325,000 pieces. Although they are being on restoration now, but this work is still far from completion. In this case the method of computer-based reconstruction is much more efficient, it helps us to avoid mistakes and find a compromise decision on the issue of reconstruction or restoration of the object.

As a result of the project, a fairly accurate reconstruction of the object has been produced and a method of reconstruction of the lost fresco painting has been developed. The basis and sources of virtual reconstruction were archaeological materials, archival and contemporary historical, architectural and art papers, scientific research in this field.

In the process of virtual reconstruction there were used two main methods: a technology of computer graphics as well as analog pictorial reconstruction. The first method makes it possible to complete the work of reconstruction with complete fidelity, whereas the second method helps us to convey the artist's style, to reproduce the form, direction and strength of the artist's touch and texture of the frescos.

The results of the project can be used for further practical work for the restoration of the object. The methodology, developed by authors of the project, may open new possibilities for the restoration of other fresco ensembles.

Keywords-virtual, reconstruction, restoration, monumental, painting, architectural, cultural, heritage

I. RECONSTRUCTION OF ART AND CULTURAL MONUMEMENTS

Historical sites of the Russian monumental art, due to their centuries-long life, undergo inevitable changes in color and structure of frescoes, destruction or alteration of the original architecture. Numerous natural, climatic and anthropogenic reasons bring about significant changes, partial or complete destruction of works of art. Despite the fact that it has been 65 years since the end of the Second World War, many ancient Russian art masterpieces still have not been restored to an acceptable display state. A considerable amount of materials is stored in museums waiting to be reinstalled in interiors of churches.

Nowadays wide experience in the exploration and restoration of monuments, as well as modern technologies allow to integrate the information in specific areas of knowledge, making it easily accessible to the public. In our case, we refer to architectural monuments of ancient Russia. Information about this objects is dispersed across many sources: books, articles, drawings and sketches, located in different storage locations, and sometimes even in different countries. An integrated information database will enable the use of all currently available information. Creation of a single source of information based on reconstruction of a monument will help to understand the historical context and conditions under which the object was built, to reproduce the lost and missing data on each monument, and to update the existing traditional art databases. With enough data it becomes possible to present a monument at various stages of its construction and development, to analyze and demonstrate options for its reconstruction, to illustrate the features and history of its painting. The method of sequential computer reconstruction allows not just to review the virtual model of the monument, but also to get details, associated with the whole life of the object.

Creation and demonstration of historical reconstructions, as a progressive method of presentation of ancient exhibits, makes it possible to achieve a new level of preservation and transmission of cultural heritage.

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II. ABOUT THE NEREDITSA PROJECT

The "Nereditsa. Link of Times" research project currently takes place under development in the St. Petersburg State University.

Major museums and cultural institutions, such as: the State Russian Museum, the State Historical and Architectural Reserve-Museum of Novgorod the Great, the Institute of History of Material Culture of RAS, and Ilya Repin St. Petersburg State Academic Institute Of Fine Arts, Sculpture and Architecture take part in this research.

The project is dedicated to a unique monument of ancient architecture and art, the Church of the Transfiguration of Our Saviour on Nereditsa Hill. In 1992 the Church of the Transfiguration of Our Saviour on Nereditsa Hill was included into the UNESCO World Heritage List, along with several other monuments of Novgorod the Great and its surroundings[1].

The Church of the Transfiguration of Our Saviour on Nereditsa Hill is one of the most famous monuments of ancient Russian culture. The church was built by Prince Yaroslav Vladimirovich's order in 1198 and a year later, in 1199, its interior was decorated with fresco paintings. Exceptional art value, unusual unique iconography of the monument have earned it a worldwide fame.

Like the Saint Sophia Cathedral, representing the XI century, and the St. George Cathedral of the St. George's Monastery, representing the early XII century, the Church on Nereditsa Hill is considered to be a typological and stylistic architectural standard of the late XII century[2].

During the Second World War, the temple was almost destroyed. Only half of masonry and 15% of frescoes were preserved. According to old drawings it was possible to restore an upper part of walls, arches and dome, but the rare frescos which had covered the entire church until the twentieth century, have been irretrievably lost[3].

Archival material contains of: preserved fragments of frescoes, photos interior of the temple, detailed descriptions of the monument, made by experts from the State Historical and Architectural Reserve-Museum of Novgorod the Great and historians from Saint-Petersburg State University, copies of frescos, carefully preserved in the State Russian Museum, in combination with modern technologies provide a unique opportunity for a virtual revival of the lost masterpieces of ancient art - frescoes of the Nereditsa Church.

The Church of the Transfiguration of Our Saviour on Nereditsa Hill has been an object of scientific art research at St. Petersburg State University for many years. As a result, a lot of research materials about the history of the church, it's architectural features and frescos has been collected. Scientific research of this monument has been provided at the St. Petersburg State University, Novgorod State Museum, State Russian Museum for several years.

The first expedition was organized by the Saint-Petersburg University and the Russian Archaeological Society in 1910. After the architectural restoration in 1903-1904, a number of scholars, including M.I. Artamonov[4], turned to studying its paintings. After being almost destroyed by the Nazis, the Church was restored in 1958, and researcher's attention was again focused mostly on the architecture[5].

Many thousands of fragments of frescos has been collected during restoration, architectural and archaeological work. At present, they are kept in museum collections. It does not seem possible to restore the fresco decoration in its original form[6]. But using methods of virtual restoration, we can achieve significant results in solving this problem. Three-dimensional graphics technology, art modeling and virtual reality provide artistic reconstruction of the lost (partially or completely) cultural heritage with any specific scientific precision.

III. VIRTUAL RECONSTRUCTION OF THE CHURCH OF THE TRANSFIGURATION OF OUR SAVIOUR ON NEREDITSA HILL

In 2008 the materials describing the history of the Church, stored in various museums and archives, were collected and investigated under the "Nereditsa. Link of Times" project.

In 2009 the main publications on the history of the Church were collected and digitized, its frescos were analyzed and its restoration history was described.

In 2009 a three-dimensional model of the Nereditsa Church as well as artifacts and household objects associated with the history of the Church of Our Saviour on Nereditsa Hill were produced *"*Fig. 1".

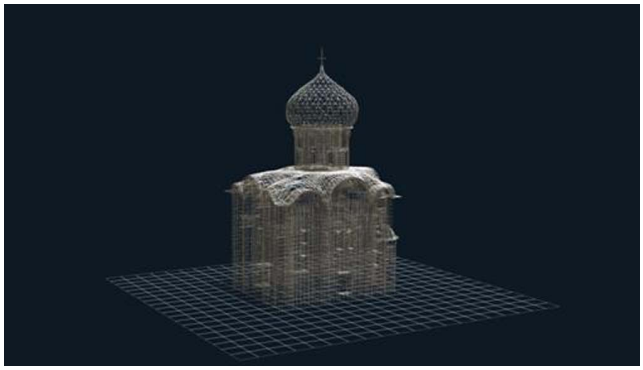

Figure 1. A three-dimensional model of the church Spas-na-Nereditse.

At the present time the frescos are being restored. Restoration of this paintings is a serious problem. The extant parts of frescos are strengthened and preserved. Many thousands of fragments, which were collected in the course of restoration, architectural and archaeological works are kept in museum's collections.

The survived parts of painting consist of 325,000 fragments, and now they are being on restoration, which is still far not complete *"*Fig. 2".

According to enormous complexity and lack of effectiveness of the "manual" method of search and selection of fragments, it was decided to use a computer reconstruction of the fresco. This method allows to avoid mistakes and find a compromise decision on the issue of reconstruction or restoration of the object.

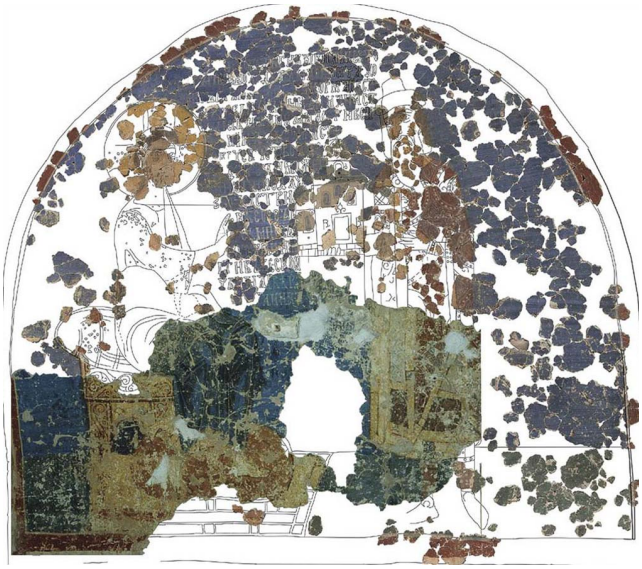

Figure 2. The process of fresco's restoration.

The choice of virtual reconstruction answers the practical needs of science and education. One of the most important points of the whole research is the question of choosing the method of reconstruction - analogue or computer reconstruction.

A. 1-st method - a documentary historical reconstruction (virtual restoration).

In this case, reconstruction is the creation of a virtual object model, based only on extant fragments. This model can be completed with some objects (fragments of frescos, interior objects stored in museum's funds and collections), if they are mentioned in archival documents.

This method provides keeping historical accuracy, and it abandons reconstruction of the lost fragments by analogy.

B. 2-nd method - analog reconstruction.

The monuments of culture which survived to our time, are often partially lost. Because of a lack of documentary evidence their recovery is a problem, that could be solved only through art and historical analysis. This ensures the authenticity of reconstruction. But in this case, the result can not pretend to be absolute reproduction of the original.

Moreover, it should be clear that, based on various documentary sources of information, we can reach several possible versions of the analog reconstruction, and all of them will be grounded on theory at the same way.

The practical implementation of the analog reconstruction requires the involvement of experts in different fields of knowledge – not only specialists in computer graphics, but, first of all, artists, architects and archaeologists. This is due to the fact that without deep understanding of architecture and proportions of the object, it's authentic virtual analogue can not be created.

This work requires high professional theoretical and practical knowledge of all project developers.

Starting working on restoration of the murals, you need to develop a methodology for recovery of losses, combining two methods - using of documentary materials and restoration of color and form, based on the study of analogues.

Specialists are attempting to determine the role of reconstruction in preservation and promotion of monuments. It is important to develop main principles of virtual reconstruction, such as:

- Applying the method of complex restoration, when the monument is taken as a system of architectural, painting, interior and exterior spaces.
- Development of main theoretical principles of admissibility and limits of application of modern technologies in recreating monuments of historical and cultural heritage in terms of ethical, legal and aesthetic aspects of reconstruction;.
- Providing further reconstruction in accordance with these formulated principles on the basis of archival, historical, design, technical, literary, scientific, restoration, art, copied and other materials using computer technology;

This main principles are being tested on the example of reconstruction of the lost paintings of the Church of the Transfiguration on Nereditsa in Novgorod the Great.

IV. Reconstruction Method for the Church of the Transfiguration of Our Saviour on Nereditsa Hill

A. Collecting the supporting information for the project:

Searching, analyzing, structuring of archival, historical, technical, literary, scientific, art and other documents which contain any information (photos, drawings, pictures, descriptions) about the frescos of the church.

Basic historical materials of the Nereditsa Church are kept at the State Russian Museum, the Novgorod State Museum, the Institute of History of Material Culture Sciences, methodological foundation of the State Academic Institute of Painting, Sculpture and Architecture named after I.E. Repin. The leading experts are: historians, art historians, restorers, muralists, keepers of these organizations have assisted authors of the project and helped to find, analyze and collect a lot of important information.

At the stage of collecting information about the object it is very important to find as much facts about the monument as possible, to make the fullest possible description. Qualitative archival photographic and illustrative material, knowledge of the exact coloring of paintings, permanent free access to all fragments of the frescos make the process of reconstruction more accurate, correct and fast.

Over a thousand archival photos of the church were investigated. Most of them are stored in the Novgorod State Museum. These photos capture all stages of restoration of the temple, which took place at the beginning of XX century.

Collections of unique architectural details and structural elements of the temple, such as plinfy, brick, stone, etc. were analyzed in the Novgorod State Museum. According to the curvilinear shape of the wall surface, these materials are

needed for correct scaling of photos and liquidation of distortions. Also this information is important to analyze the character of wall surface as a basis for painting.

Authors have carefully studied unique materials - fragments of frescoes, collected in the restoration workshops of the Novgorod Museum, which present the process of actual restoration of the frescos of the church.

Archival material stored at the Institute of History of Material Culture of the Russian Academy of Sciences were also studied by authors – this material consists of negatives and photographs taken in the church before the Second World War.

The main source of information about the coloring of paintings were watercolors that have been stored in collections of the Russian Museum. These images are in fact the copies of frescoes, made before the war.

Copies of frescoes, created in various Russian churches, are stored in the methodological foundation of St. Petersburg State Academic Institute of Painting, Sculpture and Architecture. These materials are also necessary for recreation of color palette of fresco painting.

B. Measurements and photographing images of the existing interior condition and images from museum collections.

Before starting any restoration it is required to measure the object and to make various photographic images from different sides.

The church was measured, the drawings were presented. The whole interior of the church and fragments of frescos were photographed. Elements of paintings, which were kept in museum's collections were also studied and photographed.

It is important to take all photos frontally, using the same scale. All pictures were made in two versions: with lighting similar to interior's lighting of the church, and with lighting which helped to introduce the most accurate reproduction of frescos.

C. Making a single tone image based on archival photographs

The next stage of the process is making a single image of the wall, using archival documents.

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Figure 3. Monochrome image of the wall.

On the basis of few extant paintings on the walls of the church and archival black-and-white photographs, completed before 1941, a single monochrome image of the wall was produced "Fig. 3", "Fig. 4".

Figure 4. Monochrome image of the wall, completed witn pictures from archival photographs.

Images obtained from the photographs were corrected according to the saved fragments of frescos.

Efficiency of this stage depends on the number of fragments remaining on the wall (reference points). In practice, it turned out that the main photographs taken before the war, were not frontal, and they had distortions, so it made the work more difficult.

The exact place of every fragment was defined according to concerned author's drawing. It is necessary to emphasize that at this stage there is no artistic interference. Created materials may help the restorers to project the image on the wall and to draw the contour of the lost mural, so that it would be a base for collecting separated fragments of frescoes.

The monochrome image, completed with fragments from photographs is the documentary base for further reconstruction of color and pattern of lost parts. From this moment all the activities can be called the analog reconstruction.

D. Producing a coloristic painting process map.

The next important stage is the producing of technological coloristic map of murals. The color system of paintings was deeply studied and a palette was created, and it became a basis for further reconstruction, and then restoration.

E. Producing of linear patterns at a scale 1:1 (performed only in artistic reconstruction, as the basis for paintings)

After this stage we begin an analog reconstruction of frescos, which is actually a process of painting of all lost fragments, based on archive materials and analogues. We create several templates with outlines, produced at a scale 1:1. These templates repeat the expected author's drawing, based on previous computer reconstruction.

F. Producing of artistic coloured cardboards the same size as real frescos or smaller (working models)

The task of this stage is to find appropriate technology of painting, artistic manner, drawing system. It is very important to draw complicated parts (faces, hands, clothes)

as well as more simple parts (backgrounds, ornaments) very precisely "Fig. 5", "Fig. 6".

Figure 5. Fragment of analog reconstruction.

G. Making sweeps of walls

After the reconstruction of frescos it was made a sweep of the western wall of the church "Fig. 7". Lost elements of the interior were also reconstructed "Fig. 8". The basis for the reconstruction was results of scientific research and archival material.

Figure 6. Fragment of analog reconstruction.

H. Visualisation, producing of three-dimensional colour modelling

The final stage of work is three-dimensional color modeling. In future static images, video, interactive models, which allow a user to choose the viewing angle of architecture and frescos are planned to be made up.

So, step by step, we have accurately recreate the frescos of the Church on Nereditsa Hill, which seemed to be lost forever.

Figure 7. A sweep of the western wall of the church (analog reconstruction).

Two main methods of reconstruction: a technology of computer graphics and analog pictorial reconstruction are used at the same time. Both of them have its advantages and disadvantages. The method of computer reconstruction provides maximum documentary accuracy - all manipulations with shapes and colors are made strictly in accordance with historical documents. In addition, each operation can be fixed at any stage of work. At the same time this method can't help us to convey the artist's style, to reproduce the form, direction and strength of the artist's touch and texture of the frescos.

So, especially when we deal with completely lost fragments of frescos, it is better to use the method of pictorial reconstruction. The main disadvantage of this method is its complexity. It is very difficult to provide exact documental accuracy and to find appropriate author's stylistic manner at the same time. Painting has become cyclic: some fragments were redrawn several times according to produced template until reaching expected result.

Virtual reconstruction may be used as the basis for making in future: for producing static images, videos, interactive models enabling users to choose a camera and viewing angles when browsing through architecture and artistic decorations.

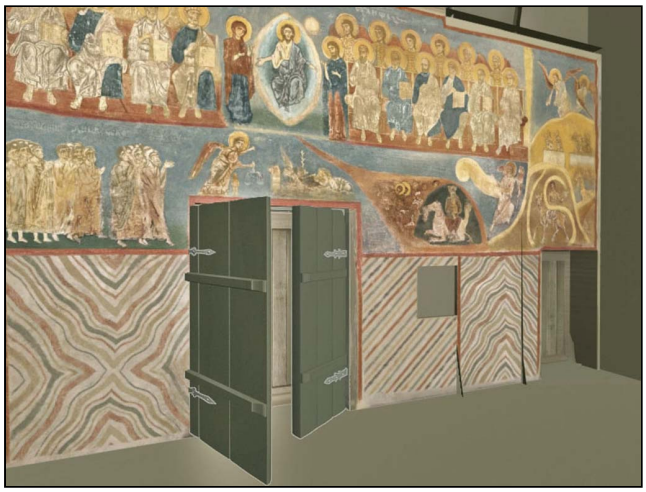

Figure 8. Western wall of the church (result of reconstruction).

In contrast to the widespread practice of relative approach to documentary materials, a specific feature of the project is maximum approximation of the model to the actual original appearance of the monument. Documentary precision of the material provide usage of the results in practical work for the restoration of the object in future. Moreover, the method used in the project may open new possibilities to solve restoration problems of other fresco ensembles of the medieval Novgorod, also lost during the War.

The results of the project can be used for further practical work for the restoration of Nereditsa Church.

Virtual model of the church may be used in future as a basis for producing virtual exhibition. Using modern technologies, such as multi-projection systems, holograms, and augmented reality systems, information about the monument can be produced in interesting interactive form. Such information center can be organised in the Nereditsa Church, the Novgorod State Museum or any other complex.

The results of the work are presented at the educational portal of St. Petersburg State University http://sakai.spbu.ru/portal/site/169dd5df-93bd-4150-9a01-86f567045218 or http://www.nereditsa.ru in the form of educational resource Nereditsa.

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