

Visualization of Former Images of Destroyed Orthodox Churches Against the Background of Modern Reality Using Augmented Reality Technology

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Abstract

Currently, virtual reality and augmented reality are among the most prospective technologies that are being implemented in many areas of human life. Augmented reality allows embedding virtual objects into real physical world. At the same time, it uses three principles of building augmented reality: Marker Tracking, Location-Based coordinate tracking and Image Tracking. In recent years, augmented reality technology has been widely used for preservation and reconstruction of cultural heritage. This article briefly examines the history of construction, operation and destruction of three of the seventeen churches in the city Tambov that existed at the beginning of the XX century: the Church in honor of the Intercession of the Holy Mother of God, the church in the name of Archdeacon Stephen (Utkinskaya Church) and the church in the name of the Great Martyr Barbara (Varvarinskaya Church). Based on available historical materials, the authors established a connection to famous people of Russia who lived and worked in the Tambov Region in the late XIX-early XX century and often visited these cathedrals, which were genuine decorations of the city. Reconstruction of destroyed Orthodox churches of the city of Tambov was carried out in the software for visualization of architectural projects Twinmotion. The images created by Twinmotion were then used to visualize the former images of destroyed Orthodox churches on the XXI century background using augmented reality technology, which provides integration of virtual objects into real physical world. The use of modern information technologies contributes not only to restoration and preservation of historical memory of Orthodox churches, but also to development and popularization of local history and museum activities, especially among the younger generation.

Keywords: virtual reality, augmented reality technology, history of memorable places, Orthodox churches of Russia, Tambov, Church in honor of the Intercession of the Most Holy Theotokos, Church in the Name of Archdeacon Stephen the First Martyr, Church in the Name of the Great Martyr Barbara.

Introduction

Currently, one of the main tasks of the museum activities to find new ways to interact with the audience, taking into account modern technological trends, in particular virtual and augmented reality technologies [1-3]. Virtual Reality (VR) is a hardware and software technical system that provides the effect of a three-dimensional interactive environment in which the user experiences a sense of presence (immersion) [4-7].

Augmented Reality (AR) is a technology that integrates virtual objects into the real physical world. Special augmented reality glasses, such as Magic Leap [8] or Microsoft HoloLens [9], can be used to implement this technology. There is a method of demonstrating augmented reality on large screens, for example in shopping malls or at public transport stops.

Currently, smartphones and tablets are used as devices for demonstrating augmented reality objects. Modern mobile devices are equipped with a GPS/GLONASS receiver, compass, accelerometer and gyroscope, which allows for tracking the movement and position of the device in space. Using the built-in camera, they receive a video stream of the real surrounding space. Then, with the help of special software, virtual content is superimposed on the video stream received from the camera (in particular, three-dimensional models, animated scenes, videos, photographic images, etc.), taking into account the change in the position and orientation of the device in space. The final combined video stream is displayed on the screen of the mobile device.

In the presented work, the authors consider the issues of using augmented reality technology for former images of destroyed Orthodox churches against the background of the 21st century reality. The use of modern information technologies allows people who live today to see what people who lived 120-140 years ago saw back then [10].

Augmented reality technology for visualization of lost objects of cultural and historical heritage

Currently, the most common way is to use web-based applications (Web Based App), which allow demonstrating augmented reality directly in the browser of a phone or a tablet. To do this, users do not need to install any additional applications, but just click on the link. One of the tools for creating AR applications for the web is AR.js [11]. This freely distributed software, developed in the JavaScript programming language, uses three principles of building augmented reality based on: Marker Tracking; Location Based tracking; Image Tracking.

Specially prepared images serve as a marker (label) when using the "marker tracking" principle. The labels should be high-contrast (usually black and white), and the images on them should not have central symmetry. For example, a single image of a symbol, letter or number, simple geometric shapes such as a square or triangle, as well as a bar code can serve as a marker. Such markers can be printed, for example, on a book page or in an advertising booklet. When pointing the camera at the marker, the user sees virtual AR content projected onto it. The disadvantage of this method is that it is necessary to place pre-printed markers in the required places of the real physical world in advance. However, the recognition quality of such special tags is very high and, importantly for mobile devices, does not require large computational costs.

When using the "coordinate tracking" principle, the user sees virtual AR content in specified locations based on data received from GPS/GLONASS receivers built into the phone or tablet. Virtual AR content is linked to a key point with previously known geographical coordinates (latitude and longitude). It should be remembered that the maximum accuracy of GPS/GLONASS positioning does not exceed 3-5 meters. In practice, the positioning accuracy is influenced by a lot of factors (density and type of urban development, weather conditions, the presence of radio interference, etc.) and it can decrease to several dozens of meters. Therefore, we are not talking about any precise positioning of objects. The maximum that can be obtained in this mode is to provide access to certain AR content when the user is in some area of a given radius around the key point.

When using the "image recognition" principle, real objects are recognized, the images of which were captured by the camera. Compared with the recognition of special markers, this task is much more demanding on the computing resources of a smartphone or tablet, while the reliability of recognition is lower.

The problem of using augmented reality to preservation and reconstruction of cultural heritage is widely discussed in the literature. In the study [12], the authors developed a geolocation-based AR application to demonstrate the Roman Baths of Ankara, Turkey. The data source for building the model of the baths were photographs and geographical coordinates obtained from a drone.

The city of Bandung in Indonesia has a large number of historical buildings. The authors have developed an AR application based on coordinate tracking, which helps to study the history of this city more deeply [13].

In [14], the authors conducted a study of the effectiveness of using augmented reality in the study of history. In the course of the research, a mobile application developed by the McCord Museum was used, which allows finding historical sights of Montreal based on tracking geographical coordinates.

Currently, significantly detailed virtual models of cultural heritage sites, which naturally include many complex elements in terms of their visualization, have a volume of more than 10 MB. At the same time, recommendations for downloading 3D models in augmented reality mode to ensure the best user experience are as follows: the recommended total size of 3D files uploaded to the platform should be less than 10 MB (10 MB => 10 seconds of downloading from 4G /5G /Wifi). It is important to minimize the size of the 3D file before uploading it [15]. This limitation is related to the technical capabilities of modern computing technology, in particular cell phones and tablets, as the results of the authors' work are aimed for users of these devices.

In this regard, during this study, the authors simplified the three-dimensional models described in the work so that they could be quickly downloaded via a mobile network and displayed with acceptable quality on the screens of cell phones and tablets in augmented reality mode against the background of a real area. GLB (GL Transmission Format Binary file) files were used to store 3D models. The GLB format is a binary version of the GLTF format, which, in turn, is based on JSON (JavaScript Object Notation). A single standalone binary GLB file contains all information about 3D model geometry, scenes, lighting, materials, node hierarchy, and animations. To reduce the size of the GLB file, the following approaches were used: reducing the number of polygons of the model; smoothing (reducing the number of nodes) of the grid; removing invisible parts of the model; minimizing the number of materials to reduce the number of textures used; if possible, replacing the textures of materials with a simple fill with a monochrome color; if filling with color is undesirable due to a decrease in the quality of visualization, then reducing the resolution of the textures was used; compressing textures into jpeg format; if possible, deleting all animations;

if it is undesirable to completely remove the animation, then reducing the number of keyframes. In the process of optimizing GLB files, it is necessary to monitor intermediate results using a viewing program in order to assess changes in the quality of visualization.

Let's consider the application of the technology described above for visualization of former images of destroyed churches against the background of the XXI century reality on the example of three of the seventeen temples of Tambov that existed at the beginning of the XX century: the Church in honor of the Intercession of the Blessed Virgin Mary, the church in the name of the First Martyr Archdeacon Stephen (Utkin Church) and the church in the name of the Great Martyr Barbara (Varvarinskaya Church).

Justification of the choice of research objects

The scientific research conducted by the staff of Tambov State Technical University within the framework of the RNF grant (project No. 19-14-00044) touches on certain points in the biographies of famous people whose destinies were once connected with the city of Tambov. Among them: a scientist of world importance, the founder of the doctrine of the noosphere V.I. Vernadsky, a public figure, lawyer, historian Chicherin B.N., a political and statesman, diplomat Chicherin G.V. [16], composer, pianist, conductor Rachmaninov S.V. [17], entrepreneur, public figure Aseev M. V. [18], winner of the Stalin Prize, Doctor of Medicine, professor, famous archbishop-surgeon St. Luke (Voino-Yasenetsky) [19].

The fate and work of each of them was somehow connected with the city of Tambov, which during their lifetime was the administrative center of one of the largest provinces in terms of area and population in the European part of the Russian Empire. nobles Chicherins lived in their city estates, going to their ancestral estate, the village of Karaul, for the summer. The famous manufacturer M.V. Aseev lived there almost constantly with his family. The great scientist V.I. Vernadsky, who is known far beyond the borders of Russia, visited Tambov because of the fulfillment of his public duties related to the activities of the Provincial Zemstvo Assembly. The famous Russian composer S.V. Rachmaninov also visited Tambov, although his visits to the provincial center cannot be called rare. During the Great Patriotic War, the renowned archbishop-surgeon St. Luke (Voino-Yasenetsky) served and revived the Tambov diocese, and tried to restore the temples of the city of Tambov.

In the course of scientific research, the authors collected the necessary information on those places in the Tambov region that were touched upon in the biographies of the above-mentioned famous people of Russia [20-23]. Later, on the basis of the collected information, the authors developed virtual museums using modern computer technology tools, in particular the Twinmotion software environment [24], including the museums at the place of residence of the Chicherins and Aseevs in the city of Tambov [25]. However, it can be argued that all of the noted famous compatriots have been in the immediate vicinity many times or were in certain places of urban facilities, which it was simply impossible to avoid. First of all, these include the Orthodox churches of the city of Tambov. There were 17 of them in the patriarchal, provincial city of Tambov at the beginning of the XX century. The photo of the end of the XIX century shows a significant part of them (see Fig. 1) [26].



Fig. 1. View of the Orthodox churches of Tambov from the side of the Tsna River (photo of the end of the XIX century)

It was these urban sites that were more or less well known to famous people, which were mentioned above. Each of them knew well such Tambov temples as the Transfiguration Cathedral - the oldest church in the city of Tambov, the Intercession Churches on the banks of the Tsna River, the Utkin Church of the First Martyr Archdeacon Stephen, located in the very center of the city at the intersection of Dvoryanskaya and Dolgaya Streets, the Cathedral of the Nativity, located on the Bazarnaya Square, and the Varvarinskaya Church in the southern part of the city.

A number of temples have survived to the present day, but most of them were demolished during the years of so called "militant atheism". But at the time when the Chicherins and Aseevs lived in Tambov, when Rachmaninov and Vernadsky often visited him, these temples were the decoration of the city. These temples have always served the cause of faith - the glorification of God and testified to the beauty of God's world, they embodied the culture of the Russian people, their understanding of beauty. Of course, these creations could not leave famous people indifferent, to whom this scientific work is devoted. At its conclusion, a number of virtual developments were carried out, which allow us, living in the XXI century, to imagine what people could see with their own eyes 120-140 years ago, whom descendants remember with due respect and love in our time.

The results of the study

The church in honor of the Intercession of the Most Holy Theotokos. Let's start with the church, which since the XVII century was called the Temple in honor of the Intercession of the Blessed Virgin Mary. It has always been called simpler by the people – Pokrovskaya. The importance of this temple was great for the townspeople, as it was a kind of symbol of the protection of the city, which, as a fortress city, was consecrated on the day of the feast of the Intercession of the Blessed Virgin Mary. The first written information about it was discovered in the middle of the XIX century in the description left by voivode Polevoy in 1659. It was noted there that the wooden church was located in Pokrovskaya Sloboda on the riverbank south of the fortifications of the Tonbov fortress [27]. After a fire in 1763, the Intercession Church was rebuilt in stone. The largest information material about this church was published in 2001 in the monograph of the clergyman V.F. Lisyunin "The History of the Intercession Cathedral of Tambov" [28].

From this work, readers can learn that the building of this church, with some internal alterations made in different years, has survived to the present day. The latter was very important for us, because it left no doubt that the appearance of the temple had not changed over the past 150 years. By the 40s of the XIX century, the number of Orthodox believers in Tambov had become so large that it could not match the total volume of prayer rooms of all Tambov churches operating at that time. Only the construction of a new church could change this situation. The Holy Synod gave permission for its construction in 1843 [28]. The construction process itself was associated with a number of engineering problems that led to its shutdown and resumption after significant changes in the design documentation. The construction was carried out with funds left by the Tambov merchant I.M. Baykov. The new Intercession Church was located just a few meters from the old church behind the bell tower to the west of it. The question remains unclear as to why the new church was built near the old one. It was much larger in volume and dominated the background of the old church. The latter is well confirmed by photographs of the architectural ensemble of the Intercession Churches, which were taken at the turn of the XIX and XX centuries. The new Intercession Church existed from 1869 to the end of the 30s of the last century. Figure 2 shows a view of the Church in honor of the Intercession of the Blessed Virgin Mary (photo by P.S. Moskalev printing house).

At that time, there was an acute shortage of bricks in Tambov for the construction of industrial and military facilities that were being carried out on the outskirts of the city. This was the reason that the New Intercession Church was closed and dismantled, sending the brick for other needs. Thus, nowadays, only the Old Intercession Church of the considered ensemble of the Intercession Churches has been preserved and it is still in operation today. It was in this church where St. Luke (Voino-Yasenetsky) served. In 1944-1946, as Archbishop of Tambov and Michurinsk, he began the revival of the Tambov diocese.

Ten years ago, by decision of the leadership of the Tambov diocese, excavations were carried out at the proposed site of the dismantled New Intercession Church. As a result, the foundation of the church was completely cleared, which made it possible to accurately determine the location of the temple.



Fig. 2. View of the Church in honor of the Intercession of the Most Holy Theotokos (photo by P.S. Moskalev printing house)

The Old and New Intercession Churches, located on the Naberezhnaya street of the city of Tambov, were closest to the city estate of the Chicherin nobles [26]. It was located on the corner of Bolshaya Astrakhanskaya and Pokrovskaya streets in the 55th city block (nowadays Sovetskaya and Kronshtadtskaya streets). At the turn of the XIX and XX centuries, B.N. Chicherin often visited here and remained a religious man all his life. The family members of the Chicherin nobles were parishioners of the Intercession Church, the building of which was no more than 70 meters from their city estate. In Fig. 3 shows the visualization of the image of the destroyed Temple in honor of the Intercession of the Blessed Virgin Mary against the background of the XXI century scenery created using augmented reality technology.

The Church in the name of the First Martyr Archdeacon Stephen (Utkinskaya Bogoroditskaya Church). The second religious object, which at that time was known to all guests and residents of Tambov, was the church in the name of the First Martyr Archdeacon Stephen. The townspeople called it Utkinskaya by the name of I.F. Utkin, a Tambov merchant who was the first to finance the construction of this church. It was votive and was built according to a vow in gratitude for getting rid of the cholera epidemic that swept the Tambov Region in 1771. The first version of the church remained unknown to us. No drawings or pictures have been preserved. In the 30s of the XIX century, the reconstruction of the Utkin Church began. The second variant in appearance embodied several architectural trends in the cult buildings of the middle of the last century. As a result, the exterior of the rebuilt church in 1857 combined elements of ancient Russian architecture, Byzantine architecture and Russian Baroque. At that time it was the largest church in Tambov. It was built according to a cruciform plan. Its geometric structure consisted of simple geometric shapes – a cube that incorporated a prayer room and an altar, a horizontal prism that served as a frame structure for the refectory. The latter connected the main prayer room with the narthex, above which there was a three-tiered bell tower. Already in the second half of the XIX century, the most of the Utkin Church was thoroughly decorated with complex architectural elements that brought extraordinary beauty. These include four-column porticos on three sides of the main cube.



Fig. 3. Visualization of the image of the destroyed Temple in honor of the Intercession of the Blessed Virgin Mary against the XXI century background using augmented reality technology

Porticos with double columns decorated the central drum, towering over the main building, and above its corner points there were 4 domes similar to the central one, crowned with Orthodox crosses. The rich decor throughout the main building made the temple the most beautiful of all the religious buildings of the city of Tambov [29]. In 1873, a chapel was built in the southeastern corner of the church fence, in which a copy of the icon of the Tambov Mother of God was kept, therefore the temple was also called Bogoroditsky. It was considered miraculous. In June 1918, a Socialist Revolutionary uprising took place in Tambov, during the suppression of which the bell tower of this church was used for military purposes for the first time in the history of the Tambov Region. At that time, it had a tremendous negative impact on many residents of the city, leaving an indelible impression in their minds. In 1931, by the decision of the city executive committee, this church was closed. One of the reasons for this was the location of the temple, which blocked the roadway of Mezhdunarodnaya Street at its intersection with K. Marx Street (formerly Dvoryanskaya and Dolgaya).

To date, 9 photographs of the Utkin Church in Tambov have been preserved. All of them were made in the last years of the XIX – in the first years of the XX centuries. The church is depicted on them from all 4 sides, however, it was not possible to take pictures from the south and from the north perpendicular to the walls of the temple – the buildings along Dolgaya Street prevented it. For this reason, the pictures were taken from the side of the Tsna hotel – from the southeast, and from the side of the building of the Noble Provincial Assembly (now the regional drama theater) – from the northeast. These pictures, taken from side angles, clearly reflect the eastern (altar) wall of the temple and partially the southern and northern walls. However, the most important for determining the exact location of the former church are the photographs taken from the western side – from the station along Dvoryanskaya Street (nowadays Internatsionalnaya). Figure 4 shows a view of the Utkinskaya Bogoroditskaya Church of the early 20th century.

A thorough analysis of old photographs, as well as a copy of the Tambov city plan, made in 1914, made it possible to determine with high probability the location of the former most beautiful Orthodox church in Tambov. This city plan was the first to mark the locations of the main stone buildings in the central city blocks. The plan shows that the western wall of the Utkin Church was in line with the western wall, the above-mentioned second house on the north side of the street, and on the opposite side on the same line was the western end wall of the building that has survived to the present day.

Visualization of the image of the destroyed Utkin Bogoroditskaya Church against the background of the XXI century scenery using augmented reality technology is shown in Fig. 5.

The Church in the name of the Great Martyr Barbara (Varvarinskaya Church). The third Orthodox church in Tambov, which we paid attention to in our scientific research in order to introduce it into the register of virtual museums of the city of Tambov, was the church built in the name of the Great Martyr Varvara (Varvarinskaya).

The first mention of it is found in the documents of 1806 [30]. The church was located on the southern outskirts of the city and was a center of the new development that appeared around it. By the end of the 19th century, the dilapidated building required major repairs, which could not be carried out due to the lack of necessary funds.

The required funds were provided in 1909 by the Tambov manufacturer M.V. Aseev, who had been elected by the parishioners the year before as the head of the church community. Together with another Tambov philanthropist L.V. Vysheslavitsev, all ex-

penses in the amount of 32 thousand rubles were paid. By that time, it was the largest monetary investment for church needs in the city of Tambov.

Some drawings for major repairs on the Varvarinskaya Church executed by the city architect I.F. Fedorovsky have been preserved [31, 32], from which it became known that the total length of the church building was 23 fathoms, and the height was 15 fathoms. During the renovation, the church was surrounded by a fence made of metal sections. The view of the Varvarinsky Church is shown in Fig. 6.



Fig. 4. View of the Utkinskaya Bogoroditskaya Church



Fig. 5. Visualization of the image of the destroyed Utkin Bogoroditskaya Church against the XXI century background using augmented reality technology



Fig. 6. View of the Varvarinsky Church

In 1929, a long process began to involve the city's public in the issue of closing this church [32]. It was positively resolved and in 1935 the Varvarinsky Church was dismantled.

We found only 4 pictures of the Varvarinsky Church. Three of them were made from the north side, and the fourth one shows the church from the northwest side. The location of the church was known from schematic images on old maps of the city of Tambov. It is difficult to determine this from the photographs, since none of them have specific images of any buildings located near the Varvarinsky Church. It is known for sure that the church stood in the southern part of Varvarinskaya Square, which was crossed by a dirt road that served as the beginning of the Astrakhanskaya road. Later, the road was moved to bypass the church, placing it on the southern side of the latter. Presumably, the church stood perpendicular to the axis of the square and was divided into two approximately equal parts by it.

Visualization of the image of the destroyed Barbarian Church against the background of the XXI century scenery using augmented reality technology is shown in Fig. 7.



Fig. 7. Visualization of the image of the destroyed Barbarian Church against the XXI century background using augmented reality technology

Conclusion

As a result of the conducted research, it was found that of the 17 Orthodox churches in Tambov, a significant part was destroyed during the years of so called "militant atheism." These temples were the decoration of the city and have always served not only religious purposes, but also embodied the culture of the Russian people, their understanding of beauty. Of course, these creations could not leave indifferent the famous people of Russia who lived and worked in the Tambov region in the late XIX – early XX century.

The authors of this work have presented what people who lived 120-140 years ago could see with their own eyes to their descendants living in the XXI century, who remember their ancestors with due respect and love.

As an illustration of augmented reality technology, readers of the magazine are invited to restore the image of one destroyed Orthodox church in Tambov, the Church in honor of the Intercession of the Blessed Virgin Mary, on the plane of the page of this article. To do this, use your smartphone to scan the QR code in Figure 8, then go to the page of the specified site using Chrome or Safari browsers, allow access to the phone's video camera and point the camera at the marker. An image of the temple will appear on the phone screen.



a)



b)

Figure 8. QR code (a) and marker (b) to restore the image of the Church in honor of the Intercession of the Blessed Virgin Mary using augmented reality technology

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