Interactivity in Multimedia Information Systems for Cultural Heritage

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***Abstract*–The article looks at the use of interactive elements in the design of various internet resources, including multimedia information systems. The feasibility of using such elements is illustrated by an interactive interface for a particular project of cultural heritage preservation -- multimedia information system Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity (XVI-XVIIth Centuries).**

I. INTRODUCTION

Interactivity, as a way of more reliable and thorough immersion of the user into an information environment, as well as the option for selecting one of many scenarios, has turned into an essential component of various Internet projects.

As a rule, those interface elements that are responsible for choosing between various scenarios of viewing the information without re-loading the web-page are considered interactive.

Visual representation of the interactive elements is determined by their informational content and the form that the designers consider appropriate for achieving the necessary quality of perception. Here's a non-exclusive list of very effective forms of representation:

- Visualization of nodes and links through a graph (e. g. the very popular social graphs);
- Representation of a chronology through a timeline, with additional interactive options;
- Representation of the objects on a map (using GIS) or a chart.

A 2D or 3D graph is a reliable tool of visualizing the data links in various combinations. A grant from the Russian Humanitarian Science Foundation (project 12-01-12041, 2012–2014) funded our design of a multimedia information system for the ancient fortresses of the North-West of Russia [1]; one of its components is a social graph that visually represents the connections between the fortresses of the North-West of Russia and the scholars who conducted research therein. Fig. 1 features an element of this social graph.

Timeline allows to represent the chronology of certain events at the so-called temporal key points in a visually attractive way. An example of professionally designed historical timeline is the history of the cruiser Aurora (Fig. 2) available at its portal [2].

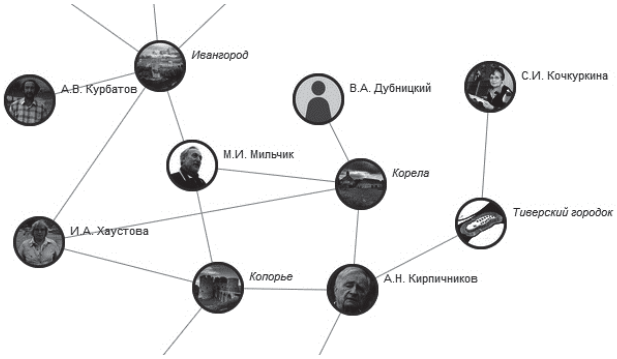

Fig. 1. A graph, visualizing the information on the scholars who have researched the ancient fortresses of the North-West of Russia (fragment)

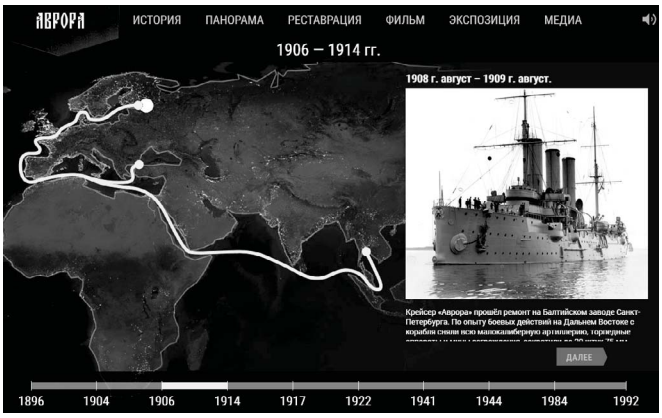

Fig. 2. Historic timeline, featuring The Aurora Cruiser

Apart from software, interactivity can be achieved through various high-tech devices, such as virtual reality headsets, motion capture systems etc. Virtual reality systems ensure the necessary degree of immersion, that enhances the user's involvement in the process of data perception.

A successful example of combining virtual and augmented reality is the project of research group INKA [3]. Using virtual reality helmet Samsung gear VR, they have designed a prototype for an immersive virtual reality application. With this prototype, the user can watch the performance of Jupiter Symphony by W. A. Mozart, with the inbuilt augmented information, filmed at Konzerthaus Berlin in Video 360 format (Fig. 3) [4].

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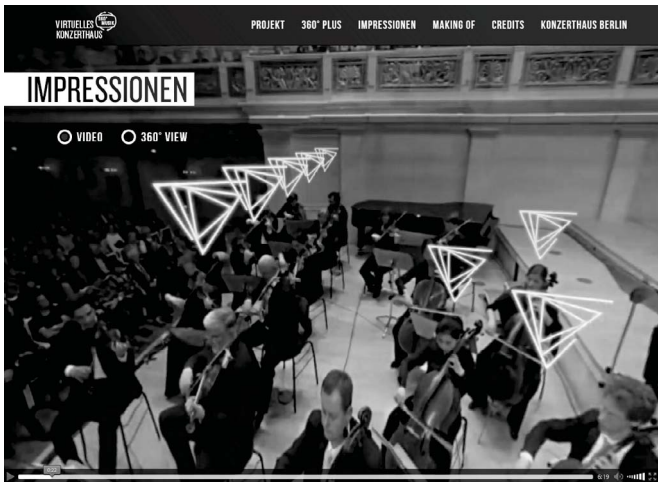

Fig. 3. A symphony concert filmed at Konzerthaus Berlin in Video 360 format with augmentation

While discussing various interactive systems in the context of preserving the digital cultural heritage, we should not overlook the mobile platforms that can be used for showcasing various products that are developed, for instance, for tourist industry (eTourism).

With the help of Location Based Service that uses various technologies (GPS, satellite systems, Wi-Fi etc.) to determine the specific location, the user can navigate the cultural heritage site, taking advantage of the technologies of augmented reality.

A good example of such product is Open Karelia Network (Fig. 4), a cultural heritage information system that was developed within the framework of Euregio Karelia Museum Hypertext project [5]. It's an open system that other museums from Russia, Europe and CIS can join. The cultural institutions, members of Open Karelia Museum Network, have their own web portal, optimized for viewing on various devices.

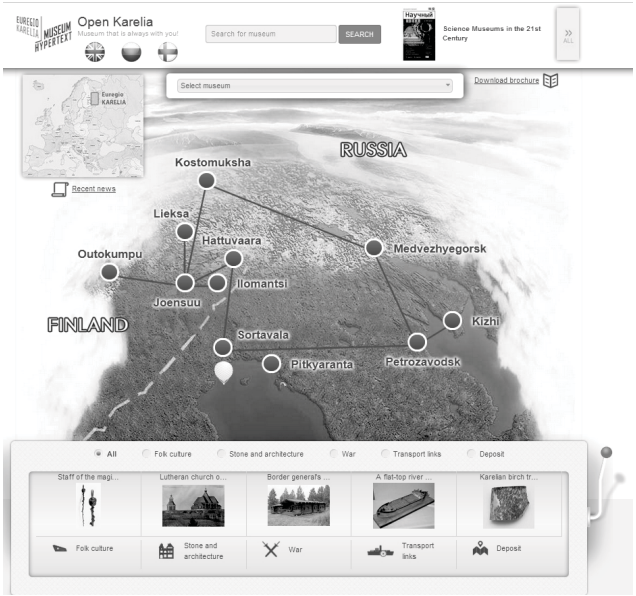

Fig. 4. Homepage of Open Karelia Network

Open Karelia system is based on Geo2Tag platform. Geo2Tag is the most popular open source LBS platform in the world [6]. This platform can be used for building desktop and mobile applications for processing (or just using) geographical and map data and for integration with popular social networks and services [7].

The above listed technologies and devices are used successfully for the design of various information resources that deal with the preservation of cultural heritage. The goal of digitizing and virtual reconstruction of the objects of cultural and environmental heritage is to create online educational, scholarly and research resources.

An example of a full-fledged comprehensive virtual reconstruction of a cultural heritage site is the reconstruction of the anthropogenic landscape of Abrau Peninsula (North Caucasian coast of the Black Sea) in the Antiquity (4 cent. BC – 1 cent. AD).

An interdisciplinary team of research fellows of Historical Informatics Department, Faculty of History, Moscow State University; Department of Classical Archeology, Institute of Archeology, Russian Academy of Sciences and others has created a virtual reconstruction that includes, apart from various archeological monuments, structures and utensils, the reconstruction of the ancient landscape with authentic vegetation (Fig. 5,6) [8].

Fig. 5. A 3D reconstruction of the fortifications of Rayevsky Fort [5]

Fig. 6. 3D-reconstruction of residential structure in Turluk [5]

Another interdisciplinary project is the design of multimedia information system Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity

(XVI-XVIIth Centuries), a joint effort of the researchers from ITMO University, St. Petersburg State University and Solovetsky Architectural Museum and Natural Reserve (funded by Grant of Russian Foundation for Humanities No. 16-01-12022). The goal of the project is to design an information resource that will represent, in an interactive form, the cultural heritage of the Solovetsky Monastery, taking the user on the virtual tour of the Monastery that would blend two time periods, our days and XVI-XVIIth centuries. The work in progress is to be found on the website: solovky.ifmo.ru [9].

II. Multimedia Information System «Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity (XVI-XVIIth Centuries)»

The history of Solovetsky Islands and the Solovetsky Monastery features a vast number of highly significant events that have shaped the history of Russia. In the XVth century the Solovetsky Monastery was the spiritual, cultural and political center of the Russian North, playing a crucial part in the emergence of the economy and maritime practices of Pomorye region (Fig. 7).

Fig. 7. Architectural ensemble of the Solovetsky monastery

The Solovetsky Monastery features some remarkable monuments of ancient Russian architecture – Assumption Church with the adjacent Refectory and Treasury (1552-1557), Cathedral of Transfiguration of Our Savior (1558-1566), gatehouse Annunciation Church (1601). In late XVIth century the Monastery was fortified by a wall made of boulders, one of the strongest in Russia. Solovetsky Fortress is a pentangle with the round turrets at the corners. The defense system of the Monastery includes moats that were dug at the "vulnerable" (Southern and Northern) sides of the Fortress.

This historic and cultural site is a unique natural and architectural monument. The Solovetsky Monastery was a repository of numerous historic artifacts – icons, works of applied art, blackletter books etc. The unique items that once belonged to the Solovetsky Monastery are now kept in the leading museums and archives of Russia: in the Russian Museum (St. Petersburg), Museum of History of Religion (St. Petersburg), Moscow Kremlin Museum, Russian National Library (St. Petersburg), archive of the Institute of the History of Russian Academy of Sciences (St. Petersburg) etc.

Solovetsky Archipelago has long become an important research destination for many Russian universities and academic societies. In the late XIXth century there was a Biological Station of St. Petersburg University at the Monastery, as well as a meteorological unit and a lifesaving station of the Russian Lifesaving Society (Fig. 8).

Fig. 8. The Solovetsky Monastery. Biological Station. Photo, late XIXth cent

The Decree of the President of the Russian Federation (6 December 1995) granted Solovetsky Museum and Natural Reserve the status of the Highly Valuable Object of Cultural Heritage of the Peoples of the Russian Federation. Session 16 of the UNESCO Committee for the Protection of Cultural and Natural Heritage (14 December 1992) added the architectural ensemble of the Solovetsky Monastery to its World Heritage list.

The first stage of designing the multimedia information system Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity (XVI-XVIIth Centuries) involved preparatory work of two kinds:

1) The staff of Solovetsky National Historic and Architectural Museum and Natural Reserve prepared the content for the 3D model of the Solovetsky Monastery in XVI-XVIIth centuries and for the multimedia information system for the monastery: the iconography of the Solovetsky Monastery, photographs, records of archeological excavations, designs for the restoration of monuments, architectural measurements and blueprints, historic descriptions, inventory lists of the Monastery, accounting and donation books etc.

2) The staff of the University (in cooperation with experts on Solovetsky Islands) designed the structure for the multimedia information system, prepared the base for the software design and implementation of the information portal, as well as for the virtual 3D reconstruction of the Solovetsky Monastery, and for the filming of a monastery tour in Video 360 format.

The result was the structure of the multimedia information system Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity (XVI-XVIIth Centuries) that includes the following principal components:

1) Homepage featuring the choices menu, theme blocks and an interactive map that introduces the 4D tour of the Solovetsky Monastery (Fig. 9);

Fig. 9. Homepage of Multimedia information system Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity (XVI-XVIIth Centuries)

2) History menu item featuring four educational texts that offer a comprehensive insight into the history of the Solovetsky Monastery:

- Evolution of the Solovetsky Monastery;
- Stone Churches of the Solovetsky Monastery, a Part of Distinguished Heritage of Ancient Russian Architecture;
- Solovetsky Fortress and Its Place amid the Fortifications of Russian North-West;
- Contribution of the Solovetsky Monastery to the Protection of the Russian North and to Russia's Foreign Policies in the Middle Ages.

The texts are accompanied by the video recordings of the interviews with the leading experts on the history of the Solovetsky Monastery.

3) Archive menu item - a review of archival data used at the resource;

4) Reconstruction menu item - the results of the first stage of virtual 3D reconstruction of the architectural ensemble of the Solovetsky Monastery in the period of its highest prosperity (XVI-XVIIth centuries), including the reconstruction of the Solovetsky Fortress and the church complex;

5) Virtual Tour menu item – a virtual spherical tour of the architectural ensemble of the Solovetsky Monastery;

6) Multemedia Library menu item – various multimedia materials: documentaries in 360 Video format that feature various sites of the Solovetsky Monaster, and a photo gallery;

7) Our Project menu item – information on the project participants.

Content Management System Drupal was selected as the information online resource for this project, as one of the most functional, sustainable and popular non-commercial CMSs of the last decade.

The following principles were observed while designing the portal:

- Storing the main content of the website and the administration parameters in the database;
- Representation of media elements in a wide range of formats (video, interactive elements in WebGL and Adobe Flash formats, interactive 3D scenes using Unity 3D plug-in);
- Division of access rights to the content and site parameters;
- Adaptation for operational management by the editors with no special skills in designing web resources;
- Adaptation for forming the structure of the database on the level of creating new entities with their own field sets;
- Software forming of the displayable blocks of information that is generated by addressing the entities of the database through field filtration;
- Realization of adaptive versions of the website's representation for a vast range of devices, including the mobile ones.

III. VIRTUAL 3D RECONSTRUCTION OF THE SOLOVETSKY FORTRESS

What makes this virtual reconstruction particularly topical is that at the moment the real church complex of the Solovetsky Monastery is undergoing major renovation and reconstruction. In the process, the architectural site will inevitably experience certain changes that will further remove this historic and cultural object from its authentic 17—18th cents. look. That's why the curators of the Solovetsky Monastery were so enthusiastic about the creation of the virtual reconstruction of this particular historical period, for it will help to preserve its architectural authenticity in the digital format; besides, the recreated monument will be shown in 3D format on the web site and at Solovetsky Museum and Natural Reserve.

The virtual reconstruction of the central church complex of the Solovetsky Monastery included the reconstruction of Cathedral of Transfiguration of Our Savior, St. Nicholas Cathedral, Assumption Church, Refectory and Treasury; it was based on the carefully selected archival data and conducted in

close cooperation with the research staff of Solovetsky National Museum and Natural Reserve.

One of the main goals we wanted to achieve while reconstructing the church complex of the Solovetsky Monastery was to preserve the realistic look of the unique masonry work of the fortifications that are made of large boulders.

To ensure the authentic rendition of these objects, we resorted to photogrammetry (Fig. 10) and generation of bump maps and normal maps, based on the photographs.

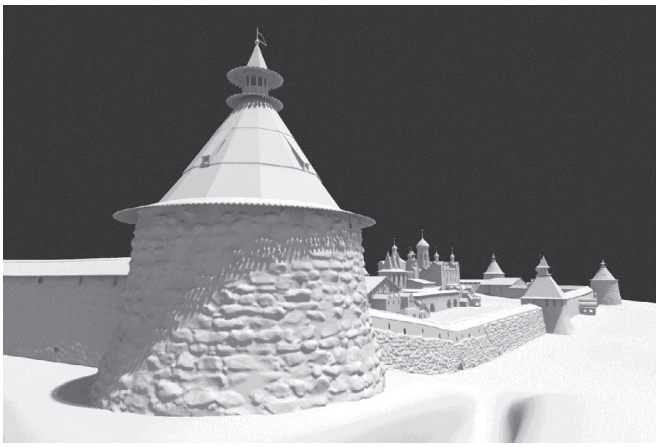

Fig. 10. Photogrammetry used for the modeling of the Solovetsky church complex

Using the blueprints, we created the 3D reference models of the turrets and the curtain walls between them. One of the challenges was the discrepancy between the data from the blueprints that were made by various restoration teams at various times.

For some of the objects, high-resolution texture maps (ca. 35,000 pixels for the long sides of the curtain walls) were assembled by hand, to be used as the textures for the models and thus to ensure detailed representation of the masonry. To optimize the process, we created reduced copies of the textures (16K, 8K, 4K) to be used at the distances that do not require very high resolution.

The modeled buildings were positioned within a landscape that was created using the topological plan and the existing sectional views of the entire Monastery's territory. While modeling, we took into account the changes in the relief that might have occurred after the 16-17th centuries.

Another challenge was to use the height maps for "bumping" the details with Displacement algorithm. To deal with this problem for all the objects based on texture mapping, we created additional masks that, being mixed with the pre-designed height maps, eliminated the respective defects.

The use of photogrammetry technologies resulted in successful design of highly lifelike 3D models, both in the sense of geometry and texture maps; they render faithful information about the shapes of the actual objects of the Solovetsky church complex (Fig. 11, 12).

Fig.11. Virtual 3D reconstruction of the church complex (XVI-XVIIth Centuries)

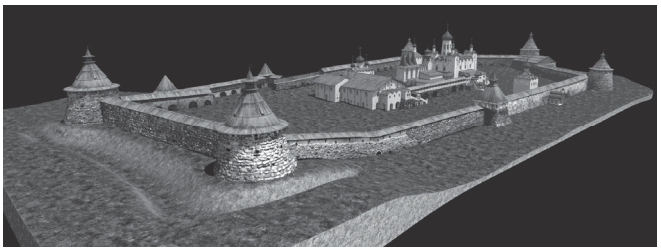

Fig. 12. Virtual 3D reconstruction of Solovetsky Monastery (XVI-XVIIth cents.)

IV. Interactive Map of the Solovetsky Church Complex

The main interactive element of this multimedia information system is an interactive map located at the homepage of solovky.ifmo.ru. The map is the chart of the Solovetsky Monastery in XVI-XVIIth centuries, and currently it features 15 hotspots, the so-called "presence spots."

To design the interactive map, we have created a software module that enables the site editor to add new presence spots and edit the relevant data. Both a block of information and media elements in various formats can be attached to each spot. In the current version of the site, the options of 360 Video representation and 3D scenes visualization are available. Other media formats can be published as well.

It's noteworthy that the media elements are separate entities of the database, which makes a difference for various aggregators. The interactive map is formed in software, on the basis of the respective database query.

The interactive map is a virtual interactive 4D tour of the Solovetsky Monastery; it mainly concentrates on the architectural highlights of the Monastery's ensemble.

The interactive part is the choice of the presence spot, as well as the choice of one of three (in the current version) information components for each spot (Fig. 13).

The first component is a short tour in Video 360 format: a professional guide speaks about the architectural significance of the site of the Monastery located at the respective presence spot (Fig. 14).

Fig. 13. Interactive map of the Solovetsky church complex (fragment)

Fig. 14. Tour of the church complex of the Solovetsky Monastery in Video 360 format

Video 360 technology has certain advantages over the standard video, because the user can look around while listening to the guide; this enhances the participatory effect of the virtual tour [10]. Besides, apart from watching the video in this format on the screen, the user can watch the Video 360 through a virtual reality headset, which will further enhance the immersion effect.

To create this virtual interactive tour of the architectural ensemble of the Solovetsky Monastery, we filmed local tours of 15 sites within the Monastery grounds, using the Video 360 technology.

The second element is the 3D visualization of the view of the Solovetsky Monastery from the respective presence point, based on the digital reconstruction of the monastery of XVI-XVIIth centuries, with the option of a 360-degree survey. Thus the concept of a 4D tour is implemented: from one and the same location the user can "visit" two different time strata, our days and XVI-XVIIth centuries.

The third element offers the historical background, in textual format, with photos highlighting the special architectural features of the sites of the Solovetsky Monastery at this particular presence spot.

V. Conclusion

The advancement of firmware and multimedia technologies, of virtual reality technologies and their use in designing the virtual interactive representations of cultural heritage objects gives the users access to high-quality information and lets them experience the faithful, emotionally enhanced immersion into the environment of these objects.

An example of hi-end approach to the online representation of the cultural heritage objects is the multimedia information system Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity (XVI-XVIIth Centuries) [6], that offers a full-fledged introduction to this unique object through the use of various interactive and multimedia elements.

Moreover, our Multimedia information system is highly instrumental in showing the uniqueness of this historic and cultural site; this will definitely help to attract further attention of the potential visitors and, as the result, add to the increase of domestic travel in Russia.

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References

[1] Multimedia information system Architectural Ensemble of the Solovetsky Monastery in the Period of Its Highest Prosperity (XVI-XVIIth Centuries), Web: http://nwfortress.ifmo.ru/

[2] The Aurora Cruiser – the Legend Is Back, Web: http://крейсераврора.рф/

[3] F. Pfeiffer, J. Reinhardt, K. Remes, S. Schobinger, J. Sieck, M. Thiele-Maas "Combining Virtual and Audgmented Reality Approaches for a Project with the Konzerthaus Berlin", XIV. Culture and Computer Science. Augmented Reality, May 26th–27th, Berlin, Germany, 2016. pp. 29-41

[4] Virtuelles Konzerthaus, Web: http://demo.inka.f4.htw-berlin.de/~konzerthaus/index.html

[5] Open Karelia Network, Web: http://openkarelia.org/

[6] E. Balandina, S. Balandin, Y. Koucheryavy, and M. Zaslavskiy, "Role of Mobile OS and LBS Platform in Design of e-Tourism Smart Services" in Proc. UBICOMM 2016, The Tenth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, IARIA, 2016. pp. 172-177.

[7] Geo2Tag, Web: http://www.geo2tag.com/

[8] A.A. Malyshev, D.I. Zherebyatyev, S.V. Koroleva, V.V. Moor, Antropogenic Landscapes in the Abrau Peninsula in Antiquity, M.: MAKS Press, 2016, 56 p.

[9] Multimedia information system «Architectural Ensemble of the Solovetsky Monastery in the period of its highest prosperity (XVI-XVII centuries)» Web: http://solovky.ifmo.ru/

[10] N.V. Borisov, A.A. Smolin, D.A. Stolyarov, "Multimedia 360° - New Technology for Arts and Culture", EVA 2015 Saint Petersburg. Electronic Imaging & the Visual Arts International Conference, St. Petersburg, SPb, ITMO University, 2015, pp. 18-30.