Using AR technologies in cultural heritage and in medical visualization

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ABSTRACT

Augmented reality enables real-time interaction between the user, real objects and virtual objects. With this possibility we can increase user-experience, performance and raise the quality of services in many areas, such as museum exhibition, architecture and surgery.

Proposed solutions helps visualize data that don't exist or hidden in easy way. For cultural heritage it's visualization of reconstructed objects in the way where user
doctors easily prepare for surgery and see where internal structures are located during procedure, which makes it less invasive and improve rehabilitation time.

Keywords: 3D reconstruction, Cultural Heritage, Augmented Reality, heart 3d model, MRI data preccesing, Microsoft HoloLens, 3D visualization of anatomical structures, 3D printing.

1. 3D VISUALIZATION OF RECONSTRUCTED ARCHAEOLOGICAL FINDS

1.1. Developing of exibition

This exibition was made for the Great Menshikov Palace in Oranienbaum(Saint-Petersburg, Russia) and assumed of re-creation archaeological objects on the basis of the archaeological finds with help of three-dimensional graphics and animation. The project included 10 historical objects which needed to be modeled, showing the connection between original objects and the historical interiors were it was located. As an example, we can mention a fragment of a Dutch smoking pipe of the XVIII century(Fig.1.), found during archaeological excavations in the palace grounds. The visitor of the exposition has the opportunity to restore the history of this fragment, first having studied the remaining fragments of the tube. Then tracing the process of their reunion and formation of the original object and view the visualization fragment where the virtual smoking accessory is completely restored and is in the hands of a man of the eighteenth century, depicted on an art canvas.

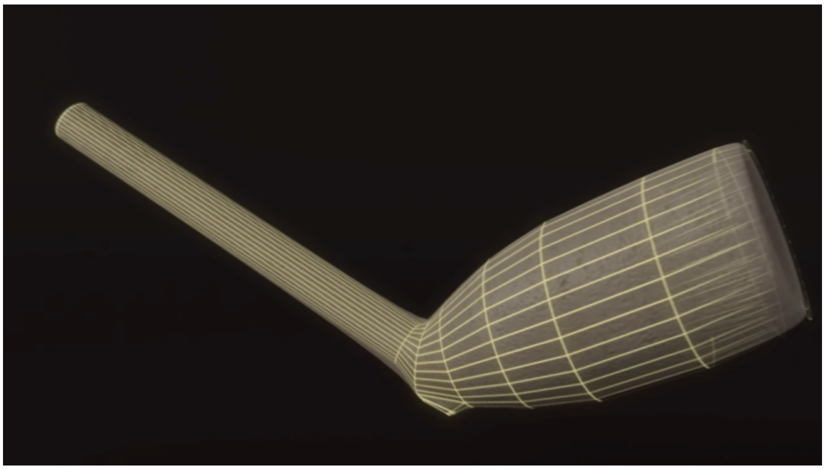

Figure 1. smoking pipe of the XVIII century

Figure 2. AR-code on a postcard

1.2.Applying AR codes.

For better demonstration of the reconstructed objects we created postcard with embeded AR-code(Fig.2.) This cards was made for mobile devices where user can see three-dimensional model of reconstructed object on top postcard right on smarphone screen or laptop. Also, the owner of the device has the ability to perform simple manipulations with a virtual reconstructed object - rotate and move it within the virtual space (Fig.3.). The realistic visualization of the object and the speed of response made it possible to bring the sensation from manipulating the object like real interaction.

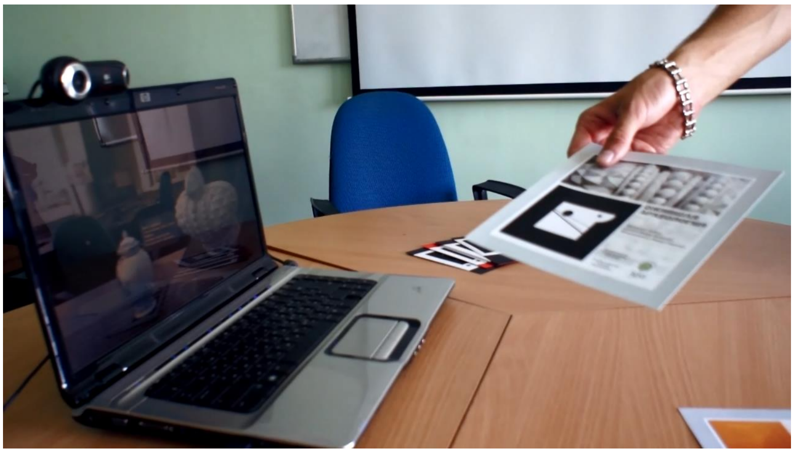

Figure 3. Interaction with virtual object

2. HEART 3D VISUALIZATION FOR SELECTED PATIENT

1.1. Modeling patient's heart

The main principle used in the study is based on the creation of highly detailed master model of a healthy heart with all internal structures and textures based on the analysis of different sets of MRI data. This model will be used as a basis for further creation of detailed patients hearts models with a variety of defects. Depending on the type of defects later in the master model is adjusted specific to pathology.

At the first stage we created an abstract model of the heart, which is based on the anatomical atlases. This model was made by digital artists together with doctors to obtain precise form with all the details of the surface and internal structures, such as valves and trabecular, which can not be fully reconstructed from MRI data. Next, artists created texture that was reconstructed using actual photographs of hearts. The result is a model of the heart, which will be used as a basis. At this stage, the base model is a form that has all the anatomical structure of the heart.

MRI data often contain partial data, they are noisy and have low spatial resolution. To improve the image usually used various noise removal algorithms, but in most cases, this approach does not solve the problem. Thus, it is necessary to borrow the missing parts from another source, which is the master model that was made earlier.

To implement this we used projection method to fill the missing pieces that are not presented in the MRI data and at the same time preserve data of patient's outer and inner contours of the heart and the ventricles. Final model of the patient's heart represented at Figure 4.

2.2. Using AR technology for improving doctor-to-patient communication

The above solution allows an affordable and quick way to get a three-dimensional model, analyze it and 3d print it out and give to the patient if necessary. Furthermore the model can be represented with help of augmented reality technology (AR-technologies) [1], which provides the ability to store all the information about the three-dimensional model corresponding to AR-code. Using augmented reality technology is possible to make intuitive interface and is uses for communication between the specialist (doctor) and consumer services (the patient). The basic principle of this technology — a combination of virtual reality and information, as which, in our case, will be the three-dimensional heart patient. The idea lies in the fact that the AR-code is printed on the medical treatment record then patient reveal it to the webcam and on the screen he can see 3d model of his heart. By changing the position of the card and turning it, he can see the heart from different angles (Figure 5).

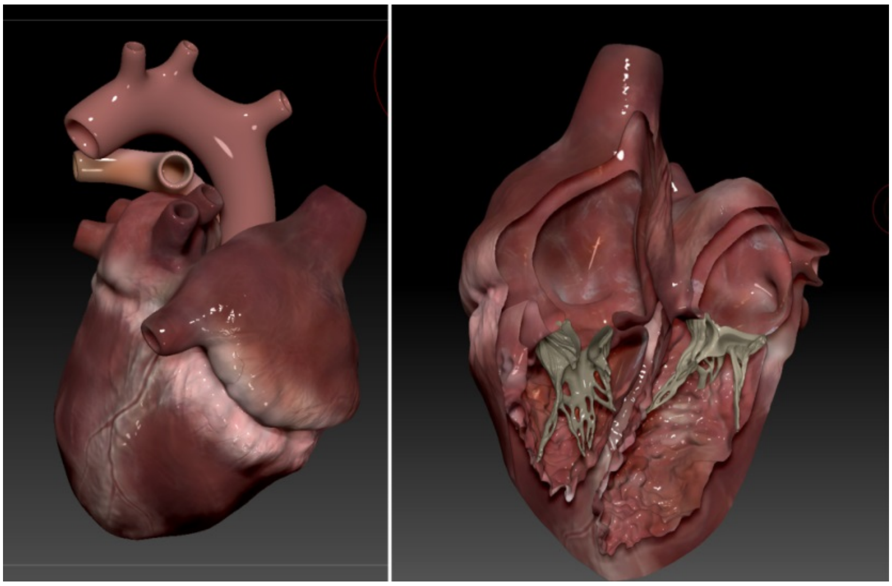

Figure 4. Generated patient model with the internal structure and texture

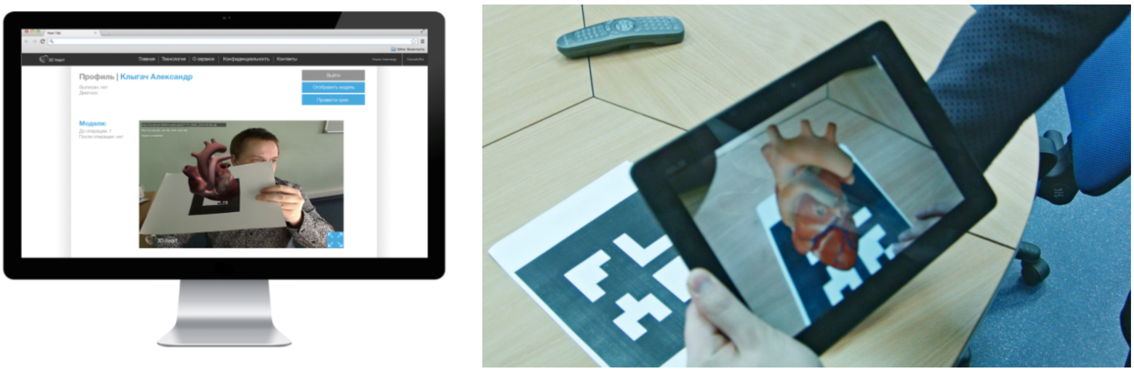

Figure 5. *Representation of the heart model in augmented reality on computer (left) and on a mobile device (right).*

3. MAPPING ANATOMICAL STRUCTURES WITH AR-GLASSES

2.1. Medical case

For the first use-case we took the patient, which has a small hollow cluster of cells that has grouped together – cyst in left nasal sinus, which was recommended for removal. It has also complex and uneven shape. So, to help physician for better understanding where it is located during the planning and operating, we developed a visualization approach with mapping an anatomical structures on top of what the doctor sees.

3.2.Workflow

Augmented reality presents information in a correct real world context. In order to do this, the system needs to know where the user is and what the user is looking at. Normally, the user explores the environment through a display that portrays the image of the camera together with augmented information. Thus in practice, the system needs to determine the location and orientation of the camera relative to object [2]. In case of HoloLens it is almost the same. For this, a separate built-in camera is used, and as a display there are two holographic projectors.

In AR technology to map display and camera uses tracking markers – AR-codes, which helps to align 3d model with user viewpoint. In our task when the object should be considered from different sides we used a special marker called cuboid where on each side is unique AR-code. HoloLens camera has limited resolution – 720p and low dynamic range in comparison to modern cameras. These cause problems with accurate tracking. To improve this we added irregular organic pattern which gives extra features for tracking process.
In addition to the problem of aligning object relative to camera our case is complicated by the fact that the marker needs to be fixed on the person's head. Strictly with certain position and certain orientation. For this task we extracted head 3d model from CT-data using Materialize Mimics medical software [3]. Then we marked areas on which the alignment will occur and marker fixation. Based on the selected areas, was build 3D model-shell with a platform for attaching the marker. Shell was made in such way where it could be easily put on in the right position (Fig.6).Finally it was 3d printed (Fig.7) and marker was attached on predefined place.

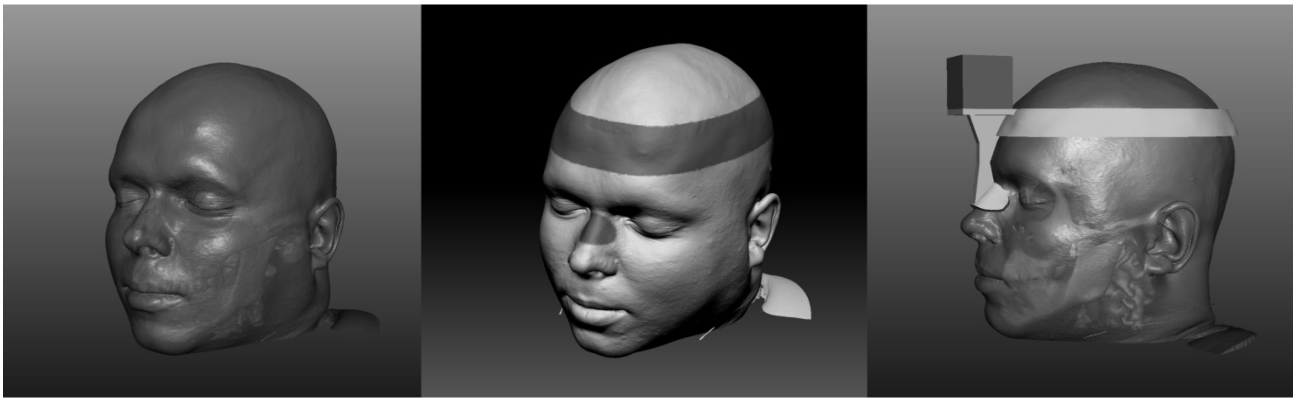

Figure 6. *Left image – Extracted face and skull models form CT; middle – marked areas, right – shell model with cuboid maker on top.*

Figure 7. *3d printed shell.*

After that, using same CT-dataset we extracted skull model and cyst of patient using Mimics. In the case of a cyst, it was marked on CT by a doctor layer-by-layer, such structures are clearly not readable in CT and the program cannot allocate them automatically. These two models was exported to Unity for further development for HoloLens[4] (Figure 8).

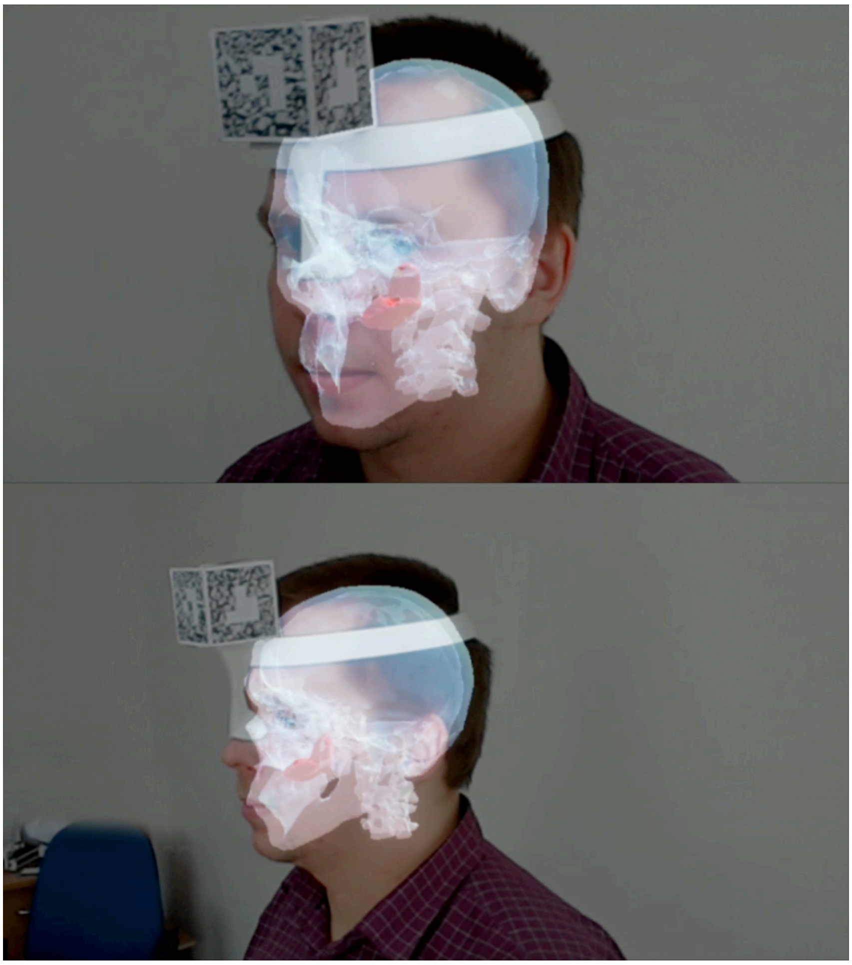

Figure 8. *View of skull thought Microsoft HoloLens.*

9. REFERENCES

[1] R. Azuma, **A Survey of Augmented Reality**, in press.

[2] A. Baradeswaran., L. Joshua Selvakumar, R. Padma Priya, "Reconstruction of Images into 3D Models using CAD Techniques", **European Journal of Applied Engineering and Scientific Research**, No. 3, 2014, p. 4.

[3] T. Chih-Hsiao, Y. Jung-Chuan, "The Augmented Reality Application of Multimedia Technology in Aquatic Organisms Instruction", **Journal of Software Engineering and Applications**, No. 7, 2014, pp. 745-755

[4]. R. Krause, T. Thompson, R. Young, ”Working with Hololens and Unity", **Iowa State Univercity Holomon project**, 2017, p. 19-25.