THE MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION

ST. PETERSBURG NATIONAL RESEARCH UNIVERSITY
OF INFORMATION TECHNOLOGIES, MECHANICS AND OPTICS

XX International Joint Conference
"Internet and Modern Society" (IMS-2017)

EVA 2017 SAINT PETERSBURG
Electronic Imaging & the Visual Arts

INTERNATIONAL CONFERENCE

St. PETERSBURG, JUNE 22nd-23rd, 2017

Conference Proceedings

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МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

САНКТ-ПЕТЕРБУРГСКИЙ НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ, МЕХАНИКИ И ОПТИКИ

УНИВЕРСИТЕТ ИТМО

XX Международная объединенная конференция «Интернет и современное общество» (IMS-2017)

EVA 2017 SAINT PETERSBURG

Electronic Imaging & the Visual Arts

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ, САНКТ-ПЕТЕРБУРГ, 22-23 ИЮНЯ, 2017

Труды конференции

Санкт-Петербург
2017

УДК 004.9

Revirwed by: I. B. Gotskaya, Herzen State Pedagogical University
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XX International Joint Conference “Internet and Modern Society” (IMS-2017).

EVA 2017 SAINT PETERSBURG. Electronic Imaging & the Visual Arts
INTERNATIONAL CONFERENCE, St. PETERSBURG, JUNE 22-th – 23rd, 2017
Conference Proceedings.Vol.1. – SPb ITMO University, 2017. – 118 p.

ISSN 2587-8565
ISBN 978-5-7577-0561-3

The Proceedings include articles and reports presented to EVA 2017 SAINT PETERSBURG International Conference.

XX Международная объединенная научная конференция «Интернет и современное общество» (IMS-2017) проведена при поддержке Российского фонда фундаментальных исследований (проект №17-03-14128).

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Университет ИТМО — ведущий вуз России в области информационных и фотонных технологий, один из немногих российских вузов, получивших в 2009 году статус национального исследовательского университета. С 2013 года Университет ИТМО — участник программы повышения конкурентоспособности российских университетов среди ведущих мировых научно-образовательных центров, известной как проект «5 в 100». Цель Университета ИТМО — становление исследовательского университета мирового уровня, предпринимательского по типу, ориентированного на интернационализацию всех направлений деятельности.

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CONTENTS

Section 1. Technologies of Virtual and Augmented Reality in Culture and Art

Section 2. Digital Resources of Museums and Museum Communications

Section 3. Culture, Art and Education

Section 4. 3D Reconstructions and Mixed Reality

Section 5. Optical Technologies

Section 1.
Technologies of Virtual and Augmented Reality in Culture and Art

AUGMENTED REALITY IN CULTURAL CONTEXT – FROM A LIVING BOOK AND HIMBA BRACELETS TO PLAYING VIRTUAL MUSICAL INSTRUMENTS

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Abstract

Since the dawn of the Web, the relation between data and objects has changed radically. The Web is no longer a system for sharing information and documents on objects. Since the beginning of the 21st century, computers are more and more able to understand the real world by the informational structure of meta-data. We are living in an Augmented or a Mixed Reality and we are continuously changing the real world as well as the Virtual, Augmented and Mixed Reality by living in it. Hence, the rather traditional distinction between culture and technology has become obsolete. Mixed Reality is a challenge as well for the computer industry and for cultural workers.

This paper will discuss different approaches to create AR and VR applications as well as best practice AR and VR examples in a cultural context. We will describe several technical aspects of mobile devices, sensor networks, context sensitive services in information systems for museums developed at the INKA research group at the HTW Berlin, and at the NUST Windhoek. We will examine key features of technologies, show multiple methods of concealment using information systems and sensor networks as well as several Augmented and Virtual Reality best practice applications.

INTRODUCTION

The development of information and communication technology during the past 50 years is characterised through the continued technical development. These technical developments raise the possibility of new applications and application areas. It is important for the acceptance of new technologies, that new applications create additional value, use the advantages of basic technologies and are adapted to the needs of the user.By combining the advantages of established technologies with new approaches, and further-more adapting those criteria to the different user needs and application scenarios, we are able to extend existing applications with new components and services and conceal the ICT.

This paper will discuss different approaches to create AR and VR applications as well as best practice AR and VR examples in a cultural context. We will describe several technical aspects of mobile devices, sensor networks, context-sensitive services in information systems for museums developed at the INKA research group at the HTW Berlin, and at the NUST Windhoek.

RELATED WORK

Since the first version of the Oculus Rift was successfully crowd funded in 2012, the topic of virtual reality (VR) has suddenly gained a lot of attention despite not being a new concept. Ivan Sutherland developed the first head-mounted displayin1968. However, the huge success of the Oculus Rift might be the cause for the variety of VR capable Head Mounted Devices (HMDs) developed by different companies that have been released in the past years. A side effect of the increasing popularity is the availability of mass produced, inexpensive VR devices, i.e. we can now buy the Google Cardboard for less than 3 € and the Samsung Gear for less than 200€, but have to add an smartphone.

Particularly in recent years it can be observed that VR and AR applications have been extended to many fields. One reason is that display technologies such as HMDs have changed from professional and expensive equipment to consumer electronics. Display devices such as the Oculus Rift, the Samsung Gear VR, Google Cardboard or AR Glasses bring these technologies to many areas. AR has a lot of potential for teaching, learning and entertaining in culture and art. AR applications are used for interactive entertainment, games, interactive story telling, visual and sound art installations as well as interactive opera, architecture or digital archives. Spatial augmentationfor example allows completely new opera experiences; a famous exampleis Mozart's "Zauberflöte" at the KomischeOper Berlin. A further best-practice example for a mobile AR application is Pokémon GO, which attracts millions of users.

We can also find many additional examples of Augmented und Virtual Reality installations in museums. Well-known examples are "Jurascope" in the Naturkundemuseum Berlin, "Speaking Cubes" and "Magic Mirror" in the Pergamonmuseum Berlin or the AR guide in the British Museum.

To present content only in the form of artefacts with texts, films and stories no longer matches the requirements of the audience. The visitors of a museumwant, in addition to the pure presentation of artefacts, information presented with modern technologies like Virtual and Augmented Reality, 3D visualisation as well as games and interactive approaches. Many users do not want to consume only, they want to participate, communicate and interact with the exhibition and the staff behind the exhibition.

BEST PRACTICE EXAMPLES

In this chapter wewill discuss different approaches to create AR and VR applications as well as best practice examples for each. We will describe several technical aspects of mobile devices, sensor networks, context sensitive services in information systems for museums, developed at the INKA research groupat the HTW Berlin, andat the NUST Windhoek. We will examine key features of technologies and show multiple concepts using information systems as well as several Augmented and Virtual Reality best practice applications.

The Best Practice examples demonstrate the integrating methods of design, interaction and development that is appropriate to mobile applications in the area of Augmented Reality. The examples will expose a wide range of mobile technologies available through mobile devices. It focuses on technologies such as wireless networks, communication, sensor systems, frameworks for software development, interaction design and the tools as well as Augmented and Virtual Reality.

Augmented Reality for Marketing Flyers:

The main focus of this project is to add digital content to standard paper leaflets. The selected field of application was Namibia's Wildlife Resorts (NWR). NWR is a Namibian state-owned company that has ownership of more than 20 travel and luxury resorts throughout Namibia. The actual situation is that the brochures in which the resorts are advertised do not fully showcase the features of the resort. As a digital extension it would be great to enhance the viewing of the brochure through AR utilisation. The NWR brochures come in soft and hard copy; they are usually distributed to travel information centres as well as on online travel sites. Given the issue with the brochures mentioned above, AR will be able to create an enhanced viewing experience. This experience includes viewing 3D models, movies and little games of what is shown in the brochure, for example if the brochure shows an elephant you will be able to view an enhanced version of that elephant or an animal race as a digital game.

Augmented Reality book KishiKishi:

The AR book KishiKishi is a mobile app using Augmented Reality technology to add digital content such as animations and audio to the physical book (KishiKishi: The Bad Monster by HelviItengeWheeler). This will enhance the reading experiencefor children.

The basic idea is to open the app on the user's mobile phone and point the camera to any specific page in the book. The app will detect the current page and augment digital content specific to that page. Depending on the specific page the digital information is a digital extension of the printed scene, i.e. with animations, audio and video sequences and interactive elements. The AR application was developed using Android Studio, Vuforia and Unity.

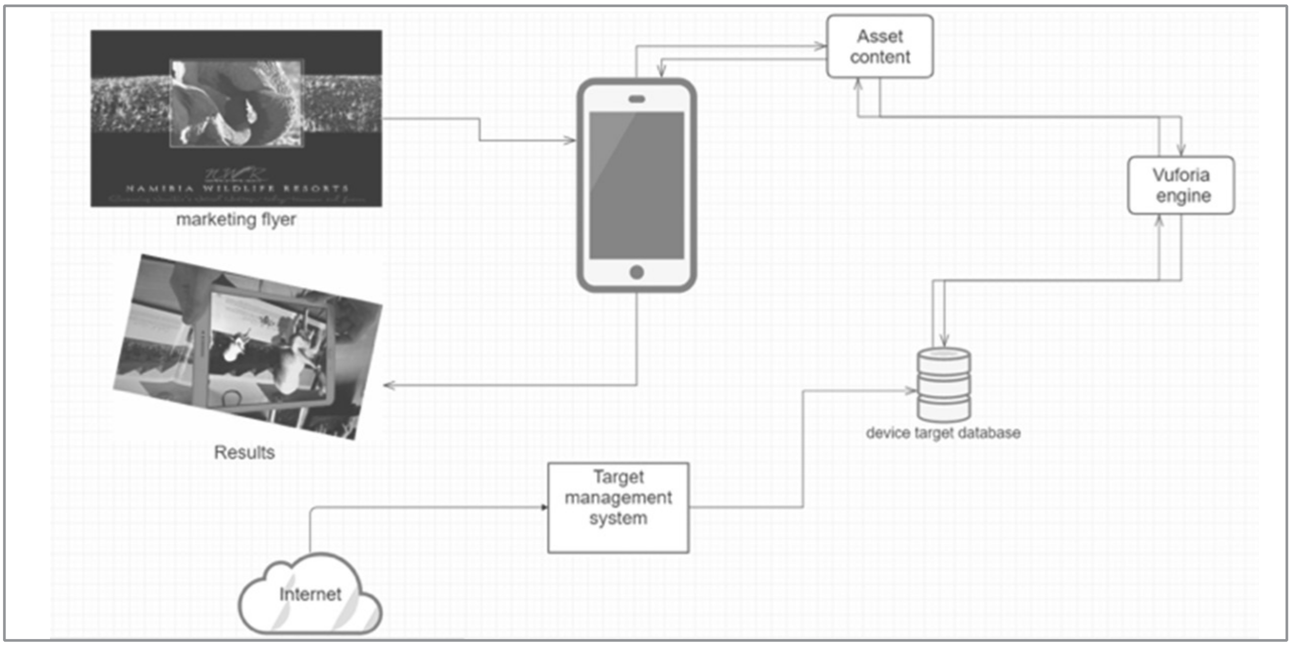

Figure 1. Marketing Flyers' System Architecture

Figure 2. Marketing Paper Flyers and Corresponding AR Content

AR for Himba Bracelets:

Cultures and traditions have always been part of human history. Located in the southern part of Africa, the Himba people emanate from an immense civilisation and still live their distinct traditional lifestyle.Their traditional arts illustrate and express the presence of their existence through bracelet, sculpture, dance and much more. The Himba bracelets are handcrafted, creative sculptures, not just jewellery, comprising multiple patterns and designs, illustrating their historical views, ideas, events and objects.

Today, the proliferation of computer technology allows us to show the culture and information behind the Himba bracelets. The key purpose of this project is to identify patterns on the bracelets and enhance them for example with an augmented object telling the story relative to each bracelet.

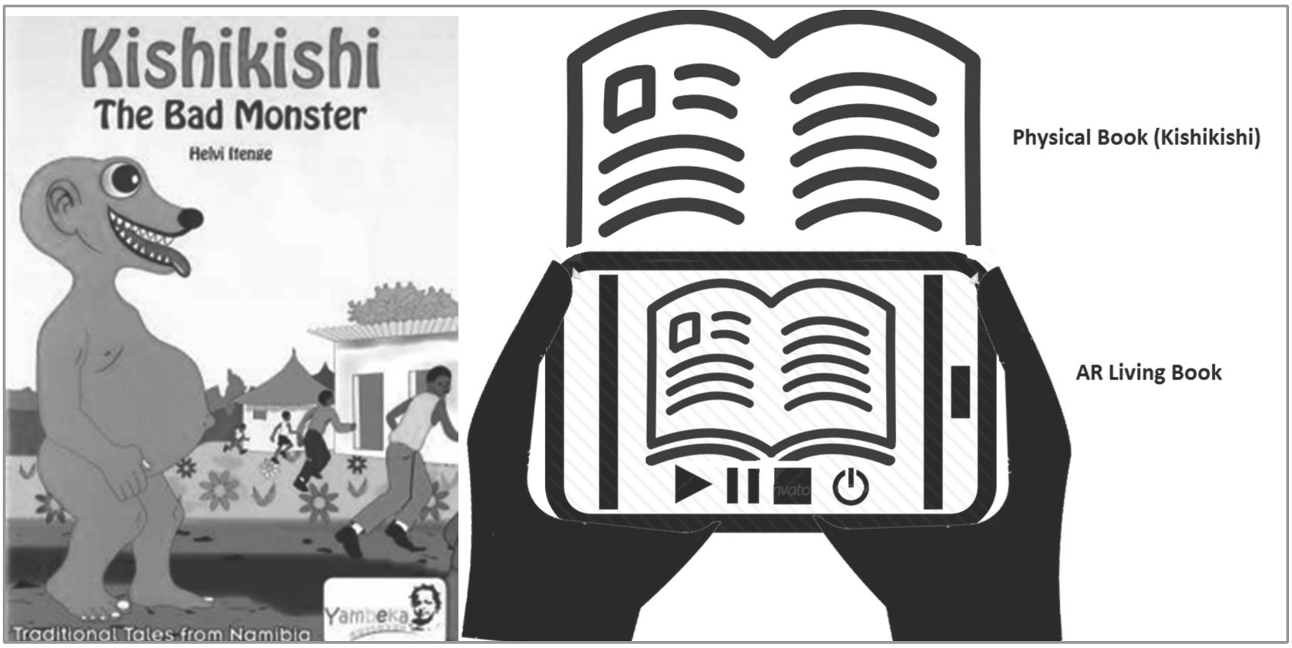

Figure 3. Kishikishi Book and the Attached Living Book Idea

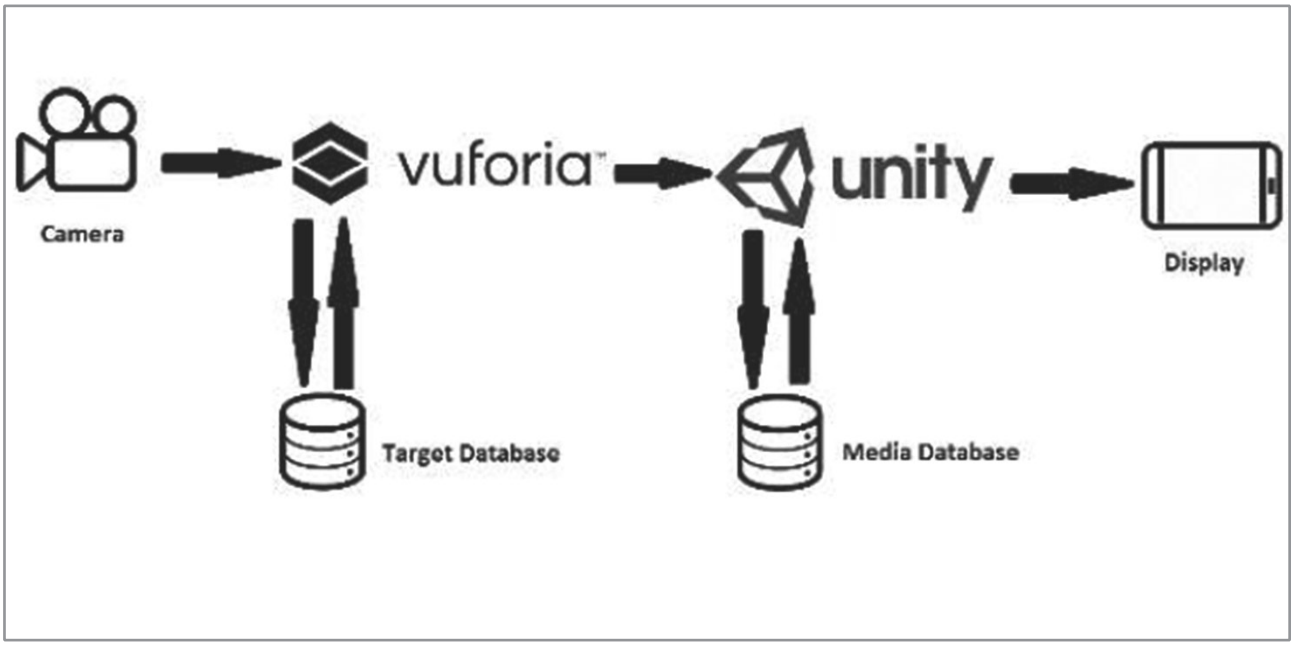

Figure 4. Kishikishi System Architecture

Holographic Display:

The focus of this Holographic Display project is to design and implement a 3D holographic display built with low-cost, recyclable material, using an electronic device (mobile phone, tablet or laptop) for projection. The display is controllable from iOS and Android applications.

The display is controlled by a mobile application running on Android or iOS. The device projecting video to the physical display can be any device with Wi-Fi capability and a Web browser – for example laptops, tablets or smartphones.

Figure 5. Kishikishi Book – Production Process in Unity

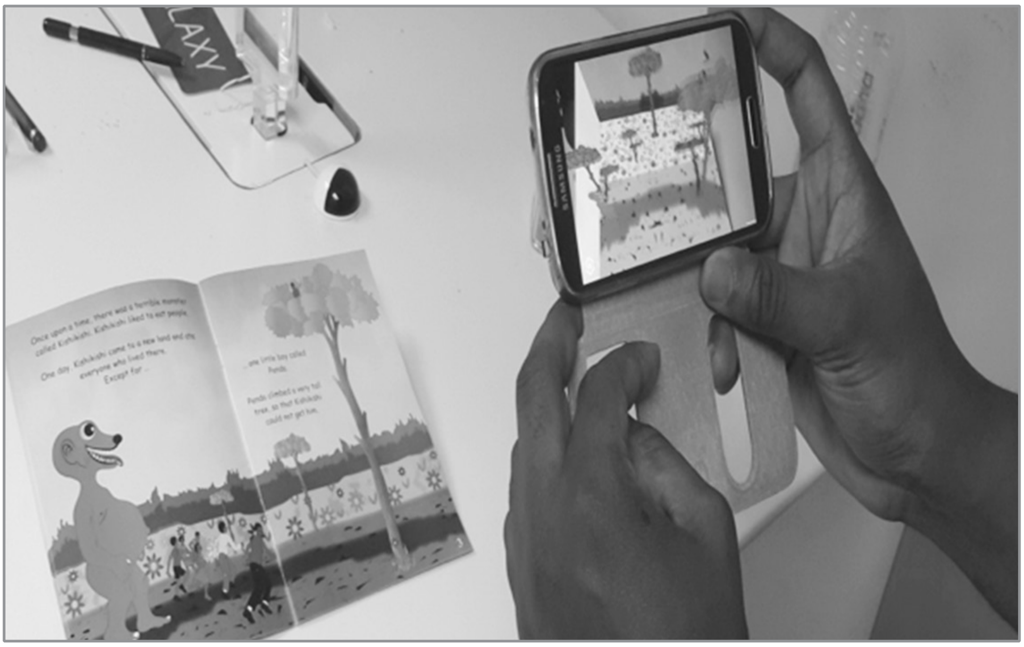

Figure 6. The Kishikishi Book – Testing the App

Magic Mirror Application:

The Magic Mirror system is an interactive game application for the Konzerthaus Berlin, developed using computer vision, pattern recognition and the Unity game engine. The game starts as soon asa player stands in front of the video camera. The main concept of the game is to listen to a piece of classical music and imitate gestures of playing a musical instrument. At certain moments a musician with a specific musical instrument is displayed on screen. The player of the game has to make the matching gesture to play this instrument (up to 10 seconds). The game uses a machine learning technology running on aKinect device to detect the poses and gestures.

Figure 7. Himba Bracelets Pattern Recognition, Bracelet Identification and Augmentation

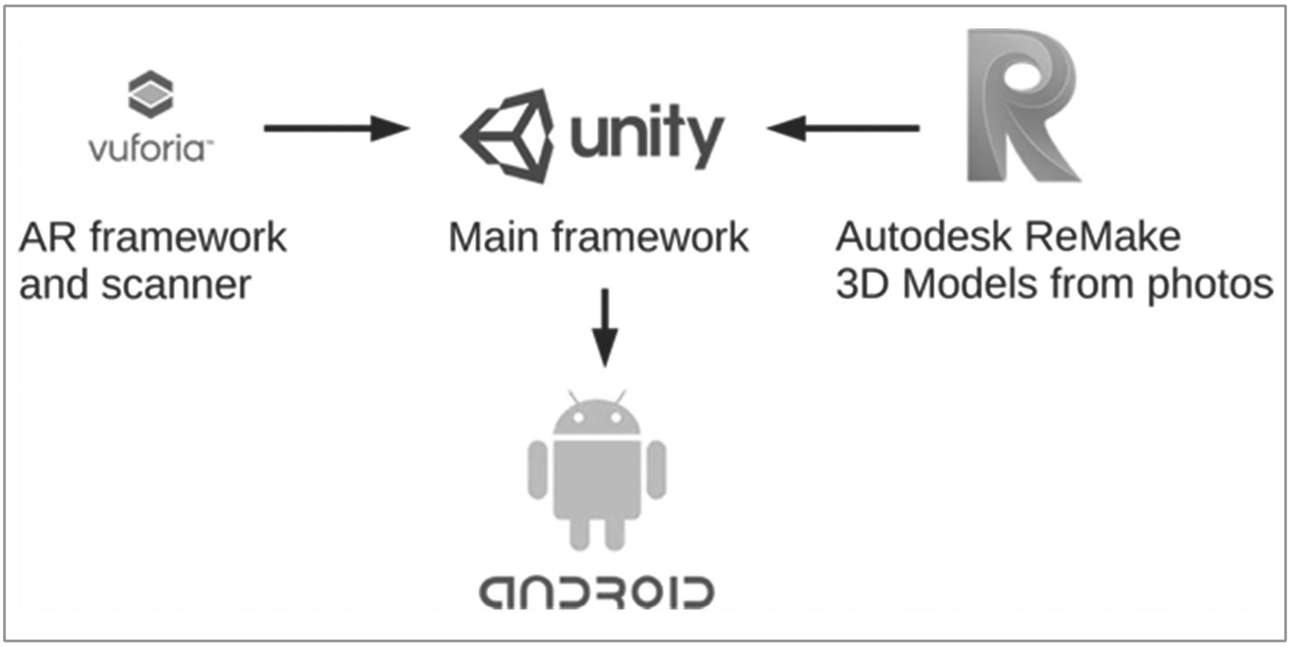

Figure 8. Himba Bracelets – System Architecture

If the player imitates successfully, a sound clip of the specific instrument will be played, otherwise a terrible off-key sound of the instrument will be generated. For each correctly recognised gesture and pose the player receives points. At the end of the game, the total score will be displayed.

CONCLUSION

Many visitors to cultural institutions do not only want to consume, they want to participate, communicate and interact with the objects in the exhibition, the staff behind the exhibition and with the exhibition itself. AR, MR, 3D and new interaction methods can help to solve the problem. Augmented and Mixed Reality is a challenge for the

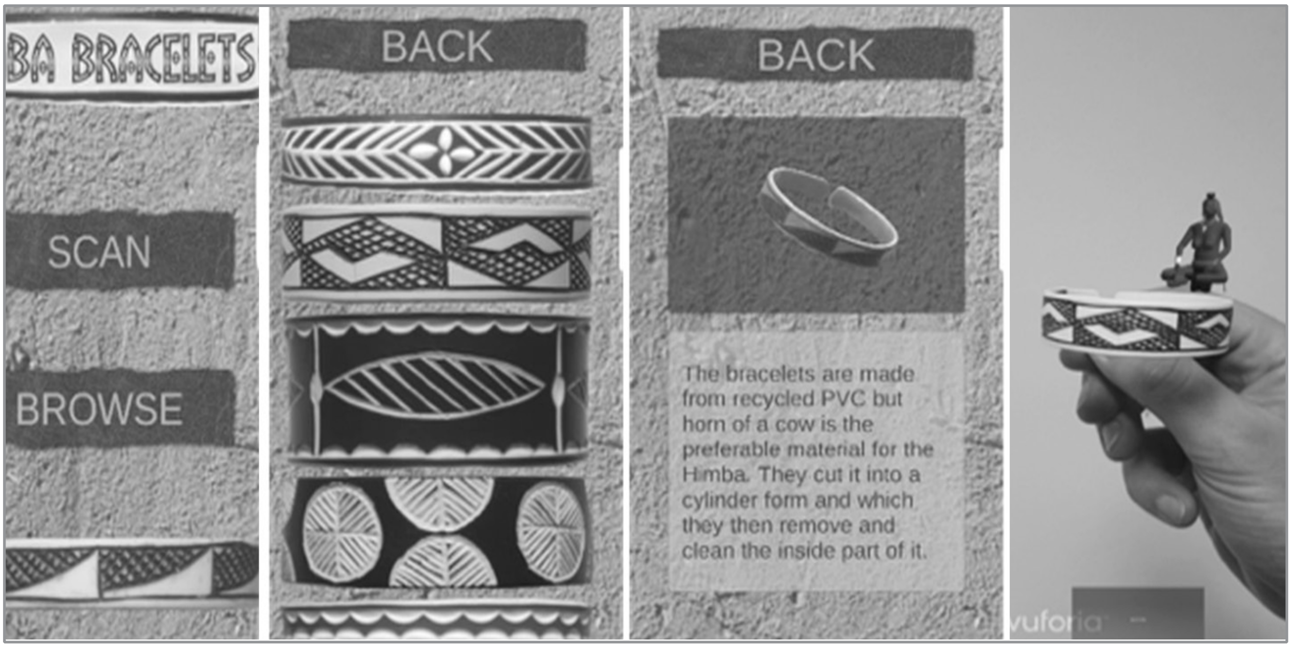

Figure 9. Himba Bracelets –Use of the App

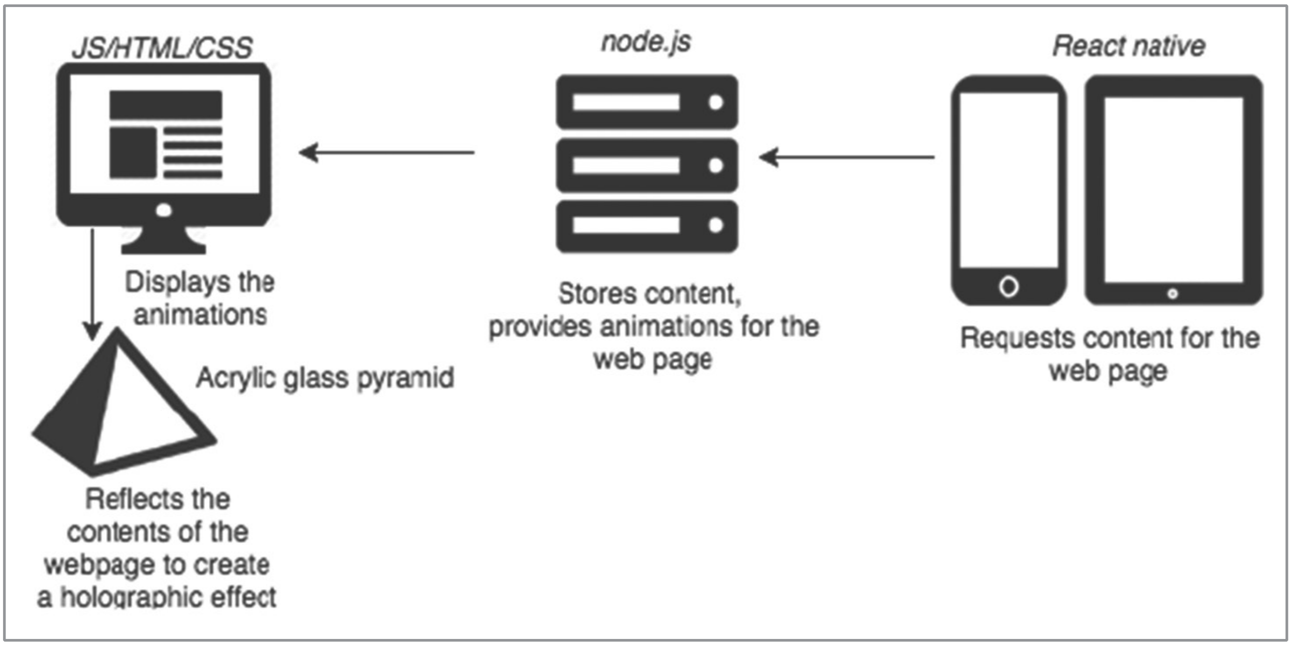

Figure 10. Holographic Display – System Architecture

computer industry as well as for cultural workers.The new technologies and algorithms for recognising objects, context and locationsmust be reliable, stable and with a very shortresponse time. It is also possible to develop AR and MR applications for all relevant operating systems in a short time. The process to integrate AR and MR in cultural institutions has commenced but there are still many fields of applications waiting for further best practice examples.

ACKNOWLEDGEMENT

This paper describes the work undertaken in the context of the project APOLLO hosted by the research group Information and Communication Systems INKA and the Konzerthaus Berlin that is generously funded by the European Regional Development Fund (ERDF).

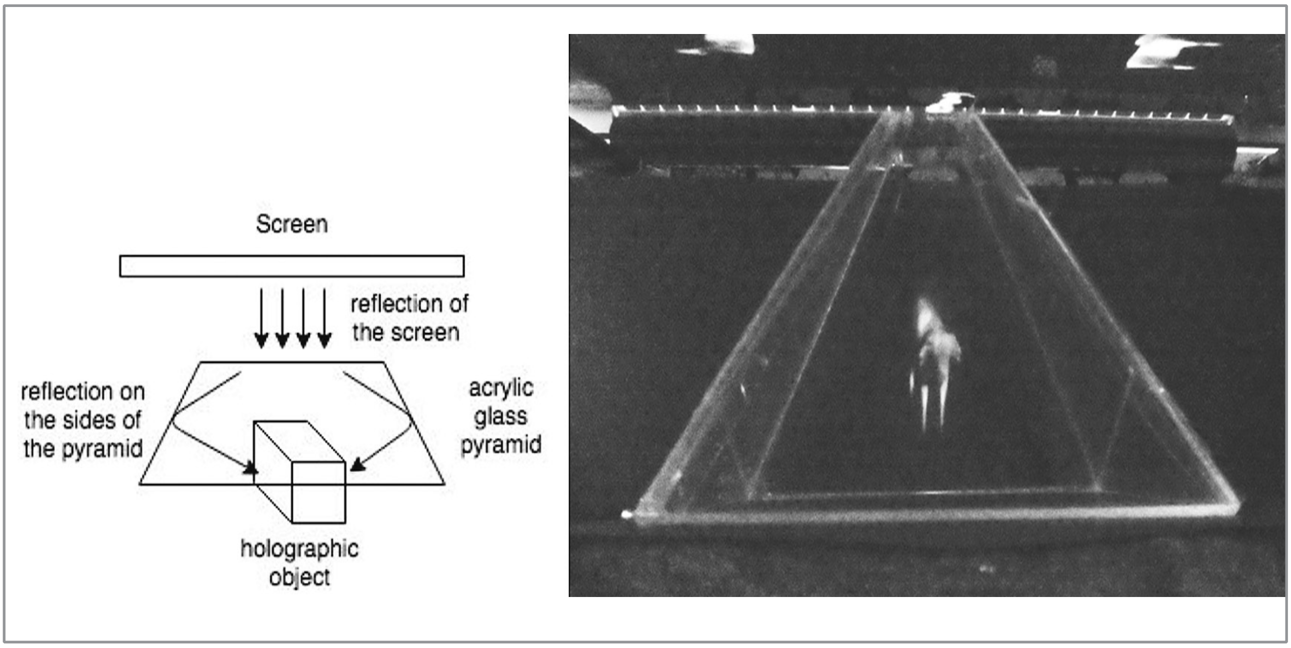

Figure 11. Functionality of the Holographic Display System

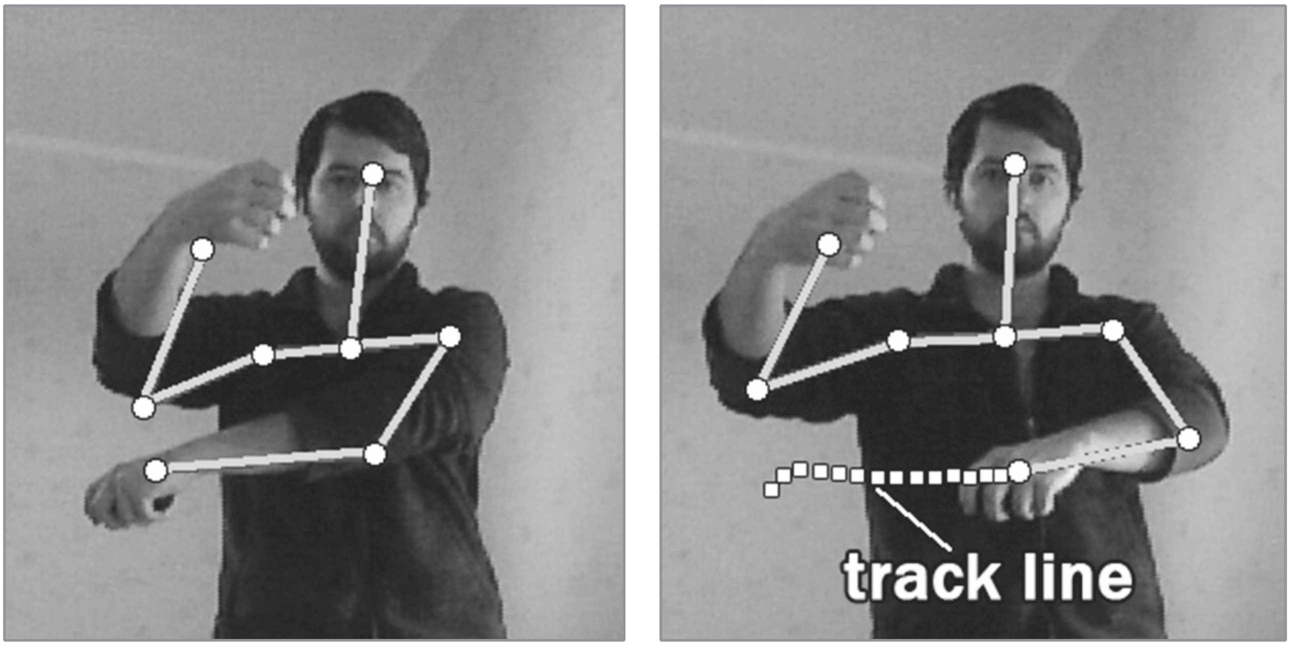

Figure 12. Recognition of Gestures and Poses of Playing a Virtual Music Instrument

References

[ABBF 01] Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., &MacIntyre, B. (2001). Recent advances in augmented reality. Computer Graphics and Applications, IEEE, 21(6), 34–47. http://doi.org/10.1109/38.963459

[Azum 97] Azuma, R. (1997). A Survey of Augmented Reality. Presence Teleoperators and Virtual Environments, 6(4), 355–385. http://doi.org/10.1162/pres.1997.6.4.355

[Bern16] Berthaut, F., Hachet, M.: Spatial Interfaces and Interactive 3D Environments for Immersive Musical Performances. In IEEE Computer Graphics and Applications, Vol. 36, No. 5, P. 82–87, 2016.

Figure 13. Magic Mirror Game in Action

[BPG 09] Barandiaran, I., Paloc, C., &Graña, M. (2009). Real-time optical markerless tracking for augmented reality applications. Journal of Real-Time Image Processing, 5(2), 129–138. http://doi.org/10.1007/s11554-009-0140-2.

[Kank12] Kanke, H., Takegawa, Y., Terada, T., and Tsukamoto, M.: Airstic drum: a drumstick for integration of real and virtual drums. In Advances in Computer Entertainment, P. 57–69.Springer, 2012.

[Kova14] Kovalenko, M., Sieck, J., Anotshchuk, S.: Real-time hand tracking and gesture recognition using a semantic-probabilistic network. 16th International Conference on Computer Modelling and Simulation, Cambridge, P. 269–274, IEEE 2014.

[Kova16] Kovalenko, M., Sieck, J., Anotshchuk, S.: Markerless Augmented Reality Approach Based on Hand Posture and Gesture Recognition. In: Kultur und Informatik: Augmented Reality, P. 171–182, 2016.

[KS 13] Kao, T. W., & Shih, H. C. (2013). A study on the markerless augmented reality for picture books. IEEE International Symposium on Consumer Electronics (ISCE), 197–198. http://doi.org/10.1109/ISCE.2013.6570182.

[Liu15] Liu, W., Fan, Y., Li, Z., and Zhang, Z.: Rgbd video based human hand trajectory tracking and gesture recognition system. Mathematical Problems in Engineering, 2015.

[Lage15] Lages, W., Nabiyouni, M., Tibau, J., and Bowman, D. A.: Interval player: Designing virtual musical instrument using in-air gestures. In 3D User Interfaces (3DUI), 2015 IEEE.

[LSD 15] Li, J., Slembrouck, M., &Deboeverie, F. (2015).A hybrid pose tracking approach for handheld augmented reality.Proceedings of the 9th International Conference on Distributed Smart Camera – ICDSC '15. http://doi.org/10.1145/2789116.2789128

[Opni17] Open-source SDK for 3D sensors – OpenNI, Retrieved January 18, 2017, from http://www.openni.ru/

[Opcv17] Open Computer Vision Library, Retrieved January, 17, 2017, from http://opencv.org/.

[Pere 11] Perey, C. (2011). Print and publishing and the future of Augmented Reality. Inf. Services and Use, 31(1-2), 31–38. http://doi.org/10.3233/ISU-2011-0625.

[PYNO 06] Pang, Y., Yuan, M. L., Nee, A. Y. C., Ong, S.-K., &Youcef-Toumi, K. (2006). A markerless registration method for augmented reality based on affine properties. Proceedings of the 7th Australasian User Interface Conference, 50. http://doi.org/10.1145/1151758.1151760.

[Sara15] Sarang, P., More, A., Gaikwad, A., and Varma, T.: Air drum using Kinect and Arduino. International Journal of Computer Science and Information Technologies, Vol.6 (2), P. 1153–1155, 2015.

[Sera16] Serafin, S., Erkut, C., Kojs, J., Nilsson, N. C. and Nordahl, R.: Virtual Reality Musical Instruments: State of the Art, Design Principles, and Future Directions. In Computer Music Journal, Vol. 40, No. 3, P. 22–40, 2016.

[Suth 68] Sutherland, I. E. (1968). A head-mounted three dimensional display (pp. 757–764). Presented at the Proceedings of the December 9-11, 1968, fall joint computer conference, part I on – AFIPS '68 (Fall, part I), New York, New York, USA: ACM Press. http://doi.org/10.1145/1476589.1476686.

EXPERIMENTAL MULTIFUNCTIONAL NETWORK OF SIMULATORS BASED ON TECHNOLOGIES OF VIRTUAL AND MIXED REALITIES

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Abstract

Analysis of the possibilities for the development of applications based on Unity3D for a network of simulators for scientific and technological centers and museums.

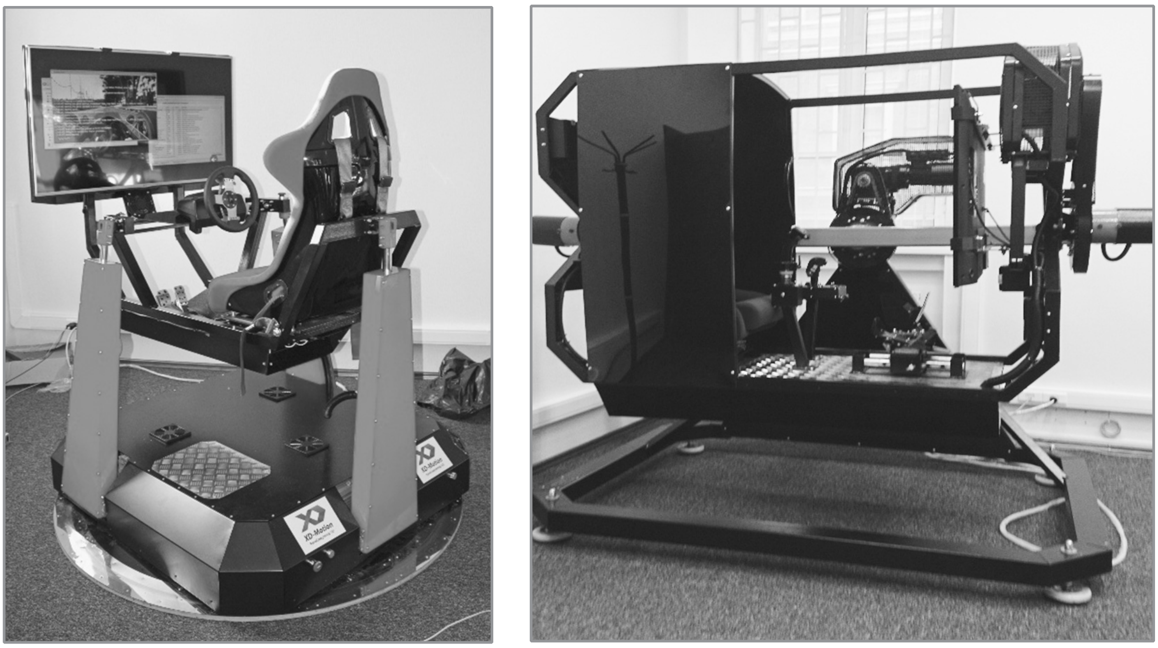
INTRODUCTION

The development of science and technology centers and museums is a relevant worldwide trend. Major and minor scientific centers and museums have been created in cities of Europe, America and Asia. These include the City of Sciences in Paris, the Science Museum in London, the Exploratorium in San Francisco, the Nemo center in Amsterdam, the Finnish Science Centre "Heureka" in Helsinki, the Science Center Spectrum in Berlin, the Science Museum in Osaka, the AXAA-center in Tartu,the Science Museum "CosmoCaixa" in Barcelona and others.

Such centers and museums are meant not only to familiarize its visitors with the world's scientific and technological heritage, but also to help the youth to make a decision about the direction of their future career, as well as to increase their interest in science and technology.

In the development of museum applications, it's recommended to take into account the effectiveness of various ways of perception and memorization of material by visitors and the involvement of all its senses in the cultural experience. Studies have shown that visitors remember [1]: 10% of what they hear, 30% - read, 50% - see, 90% - do.

Vehicle simulators and 5D-cinemas play an important role in such scientific centers, as they are popular among visitors, but such machines usually have low educational potential due to the fact that they commonly run on proprietary software, which limits possibilities for the independent development.



a) XD-Motion b) Fly-Motion

Figure 1. XD-Motion driving simulator

Figure 2. 5D-Motion

NETWORK OF SIMULATORS

The team of SUAI's Laboratory of Computer Graphics, Virtual and Mixed realities has a lot of experience in the development of interactive immersion projects in a variety of different fields, such as scientific, industrial, historical and medical centers and museums [2]. At the current moment the development is focused on creating of an experimental multifunctional network of simulators based on XD-Motion, Fly-Motion and 5D-Motion [3] using technologies of the interactive 3D-modelling, virtual and mixed realities.

The XD-Motion driving simulator is a mobile platform with an integrated driver's seat, a TV screen and a steering wheel with two pedals. Such device lets the driver feel the accelerations of a vehicle (fig. 1, a).

a) b)

Figure 3. Examples of applications based on Unity3D engine

a) b)

Figure 4. “History of the Yam Fortress” project

The FLY-Motion flying simulator consists of a fixed base, on which a mobile cockpit with a seat, a TV screen and the HOTAS control system is mounted (fig. 1, b).

The cockpit rotates around its axes 360 degrees in four directions: forward, backward, left and right. This allows the user to perform various flight maneuvers.

The 5D-Motion cinema consists of a hydraulic platform with four seats for visitors, a screen, a control panel, a video projector system, a special effects generator, an acoustic system and a set of stereoscopic glasses (fig. 2). The system’s main purpose is to let visitors watch interactive films.

All the simulators operate under Windows 7 operating system. Each simulator comes with a few proprietary applications, as well as with a common SDK, which makes creation and modifications of the possible content.

A set of applications based on Unity3D engine was developed in order to allow students to study the hardware and software, as well as to create their own projects. Each software application includes environment and vehicle 3D models with programmed behavior (a car, a plane/drone, a trolley), settings for the correct operation of the controllers of the simulators and the communication code with the mechanics (the examples in fig. 3, a and b).

These applications can run in either offline or online mode. It's possible to connect all the simulators in a single 3D-space using the online mode. To allow users to develop and to integrate their own models, a set of user guides was created and tested.

Furthermore, to increase the emotional involvement of a visitor, a set of virtual tours was imported from the "History of the Yam Fortress" project, which was aimed to preserve and popularize the historical information about that cultural heritage object [4]. Those virtual tours were made using a recording from a camera, which was moving within "Yam-Yamburg" fortresses 3D models during varying historical epochs along a predefined walk or fly mode. The virtual tours demonstrates three versions of the fortresses – from XIV, XV and XVIII centuries. Some overlay images, a voiceover and some background music were added onto these recordings(fig. 4, a and b).

The following projects are ready for implementations:

- Expansion of virtual 3D-visualisation capabilities by adding virtual reality helmets, such as HTC Vive and Oculus Rift.
- Embedding online video into 3D applications using augmented virtuality technology.
- The study and maintenance of simulators based on augmented reality technology using MS Hololens.

CONCLUSIONS

The development of the user guides and offline and online example projects for the simulators using Unity3D resulted in creation of an open environment for those users, who are willing to create their own projects in such fields as education, entertainment, transportation, ergonomics, industry, etc.

The possibility to connect all the simulators into a single network allows the usage of the system in a science and technology center that is being designed within the framework of the inter-university cooperation.

References

[1] Five Principles for Successful and Sustainable Heritage Tourism. National Trust for Historic Preservation. http://www.preservationnation.org/information-center/economics-of-revitalization/heritage-tourism/basics/the-five-principles.html#Quality .

[2] The site of the Laboratory of Computer Graphics, Virtual and Mixed realities of SUAI.
http://guap.ru/labvr .

[3] The site of the company "SEMZ-Vympel"http://xd-attraction.ru/

[4] A.A. Nikitin, A.V. Nikitin, A.A. Nikitina, N.N. Reshetnikova, Computer reconstruction of the fortress Yam-Yamburg based on the technology of interactive immersion // The Second International Conference on Virtual Archeology. - The State Hermitage Museum, St. Petersburg,2015.P. 199-207.

Section 2.
Digital Resources of Museums and Museum Communications

DIGITALLY TRANSFORMED MUSEUM COMMUNICATION: CONVOLUTION OF THE FUNCTIONS

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Abstract

The modern paradigm of the museum mission requires the innovative methods and tools for scientific investigations and applied informatics in museum work. The digital and communication technologies result in change in ordinary museum functioning. The museums try to apply some successful marketing solutions for their profitable growth, like VR for attractive dissemination. Museum profitable growth has not strong correlation with number of visitors; even this number is taken as a coefficient of effective work. While the official feedback channel exists on the museum Web-page, the personalized notes in virtual space are possible only in social media. The internal museum communication is not enough for the system analysis. Authors offer some data on marketing strategy and business planning as an example of digitally modified business.

Commercial approach to the customer experience study differs from the humanitarian one. The applications taking in account only the cognitive component of museum function are useless. The reasons of satisfaction in a museum depend of the expectations of a visitor, of emotions caused by museum communication. They are more complicated than a simple purchase in e-market. Digitalisation of some business processes inside of museum requires various additional services not linked directly with museum functions. There is a danger, that such structures and new digital business become dominant, or distort the initial business process of a museum.

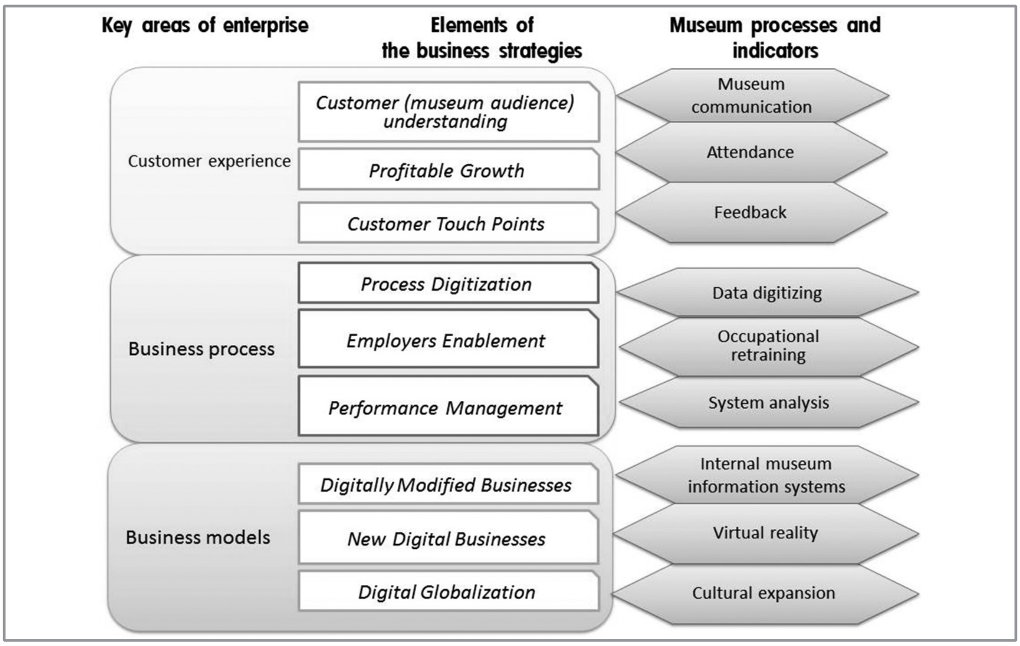

Figure 1. Digital transformation in museum processes.

INTRODUCTION

In accordance with the UNESCO Convention on the Protection and Promotion of the Diversity of Cultural Expressions, “the protection, promotion and maintenance of cultural diversity are an essential requirement for sustainable development”. The same idea was fixed in Strategy of Innovative Development of the Russian Federation until 2020 (http://mkrf.ru/upload/mkrf/mkdocs2016/09_03_2016_01.pdf). The modern paradigm of the museum mission requires the innovative methods and tools for scientific investigations and applied informatics in museum work. The open access electronic resources turn to be storage of useful data on cultural heritage, national history and cultural relations. [1] The focus has shifted from artefacts to individuals. We started to speak about researchers, scientists and personalities referring to a museum object. Aiming at being innovative and effective the museums need scientific cooperation with various institutions. The continuous museum social research has revealed them to be the place where people try to avoid social cataclysm and any crisis, financial or psychological – museum attendance increases at the time of economic or political instability. Museums are associated with traditional values which are closely linked with social stability. They give people a feeling of safety, a hope for the future.

At the same time, the digital and communication technologies result in changes in ordinary museum functioning. Digital transformation [2] is a popular term in marketing. It has penetrated from business and describes how the ICT change our traditional functional processes. Evidently, the businessmen are playing words in order to increase attractiveness of a product.

1. Digital transformation and museum communication

Leaders of the business companies define 3 main directions of digital transformation: customer experience, business processes and business models. [3] Every direction comprises also 3 components having influence to the changes (Fig.1). We tried to appreciate the impact of them to the digital transformation in museums. The effectiveness of domestic cultural institutions estimated by a set of coefficients is not able to present an actual level of digital transformation. Strictly speaking, the leaders make a choice between the directions and their components, which results in partial digital maturity (https://digitalmaturitycheck.ey.com/). In 2015 in Paris, just a year ago, at the SITEM expo the experts have spoken a lot about scenarios of museum exhibitions. That’s right for design and production, but customer’s point of view is completely different. Commercial sector has digital and soft skills to collect users’ opinions, to calculate visitors, “likes” and other signs of satisfaction. The museum visitors arrive for special type of communication – museum communication, based on both a cognitive component and the positive emotions. Museum space is not a Disneyland, the positive emotions have other origin than simple distraction. So, the specialised software must be adaptive in very specific meaning. [4]

2. Customer experience in a museum

The effect provided by digital transformation comprises the museum audience understanding, museum profitable growth and audience touch points.

Museum audience understanding provides the effectiveness of the ICT application. Traditional museum studies form such experience in case if a special department works in the museum or a certain professional company was engaged. A standard questionnaire form gives answers only in frame of an investigation, while social media offer people more free conditions for expression of opinion and estimations. This way many companies and museums as well begin to study customer experience in social media. Optimum of the feedback can be obtained in case of the system of web-sites and different societies in social media reflecting various focus groups. The study of their needs allows the museum to prepare a product relevant to a special audience, or a service according to the requirements. Collecting of the customer experience is based on the data from the questionnaire forms and on computerized processing with the analytical methods.

The specialists from Victoria&Albert Museum in London recommended to reveal one goal according to the investigation of virtual museum audience, then to try to balance with the museum stuff targets. Clear understanding of the aim helps to create only one information product but successful. Probably, museum needs some products with various aims, but they must in correspondence with museum visitors' experience.

Museum profitable growth has not strong correlation with number of visitors, even this number is taken as a coefficient of effective work. Digital strategy defines the way to get some result with the help of digitals technologies. That would be perfect when you have serious financial support helping to provide all necessary improvements. If not, your "best in the world" strategy is useless. For example, actually nearly all foundations are not able to support museum studies and technical projects. The lucky exception - Vladimir Potanin Foundation support cultural and educational programs. The middle and small state museums have very small budgets. ICT are too expensive for them. The State Hermitage is exception because there other possibilities: endowment, special foundation helping its activity and Hermitage Museum Friend's Club program. Finally, even if you have financial support, the anti-corruption laws leave you no chance to get the equipment you need, casuistic case. A reasonable solution was found in scientific collaboration, cooperation between museums and universities. Museums possess informative content and creative ideas, universities have equipment and modern technologies. Their mutual activity creates positive atmosphere for education of new generation of specialists who could be attracted in future for cultural heritage preservation.

That solution gives the feelings of comfort and satisfaction to a visitor and results in profit from sale of the souvenirs and books in museum-shop. The e-shops have clear aim of increasing pure profit, as for the museum web-sites – they are not an objective tool for the feedback study. Sometimes, they look like a barrier between audience and museum specialists. So-called, "special functions" for museum sites – "my collection" or "share" – came from marketing, where they suppose a "market basket". For museum it looks strange. Nobody proposes planning of the museum visit according to the user choice, because in reality there too much constraints and conditions.

Audience touch points are revealed on different levels, which results in a complex estimation. At the State Hermitage museum the very first contact is a result of booking or purchase of the e-tickets, planning season tickets or crossing the turnstiles. Second contact with a museum happens during the visit, when there the possibility to comment the impressions is provided by a sensor kiosk in the exit zone. The official feedback channel exists on the museum Web-page. But the personalized notes in virtual space are possible only in social media. The internal museum communication is not enough for the system analysis.

The digital services of a museum can be various: e-tickets, e-shops with books and souvenirs. The most part of "digital tours" presents typical e-catalogues. Smart apps designed instead of audio-guides are useful in open space, where the distance between described objects exceeds several meters. The requirements consider AR based on GPS location. The panoramic views of the museums are popular less than it was predicted. The new technologies are applied mostly in the cultural centers and the technical or natural history museums, e.g. the list of the modern museums of Canada (http://www.ngxinteractive.com/#work). The historical monuments and art museums use innovation more rare in order to keep attention on the aim of visit. World experience of the social media profiles use for the individual tours compiling is not accepted by the domestic developers. [4]

The only one museum web-page based on the principles of life communication is Brookline museum's one. The study at the State Hermitage Museum has revealed the communication with virtual visitors forming the permanent museum audience during autumn and winter, after the high-touristic season – regular patron. E.g., General Staff Building is visited daily by young women with families and friends or managers of the big private companies (Y-generation), and evenings – employers of budget institutions (X-generation). Of course their preferences are different, and emotional reactions on exhibitions and museum atmosphere vary. Addressing the concrete audience, a project manager requires the data on its specifics. [5] If one suppose generation Y (1984-2000) to be stakeholder of video for Youtube-channel, we should take in account creative style of communication, pragmatism and video thinking.

Commercial sector has digital and soft skills to collect users' opinions, to calculate visitors, "likes" and other signs of satisfaction. In my opinion, we are mistaken expecting benefit from the interaction with computer. Being a means of human communication, museum communication requires more complex system than simple human-computer interaction. A "signal" we transmit from a person to another person is an emotion.

[6] There are different ways to fix the emotional state but it is not the same as engineers do for simulators in education and training. Today we are not ready to offer suitable AR or VR equipment helping people enjoy a museum, as well as we propose them certain simulacres instead of virtual museums. The museum visitors arrive for special type of communication – museum communication, based on both a cognitive component and positive emotions.

While the interactive and mobile applications are based on cognitive approach, museum audience prefers emotional component in any museum space, virtual or real. Thus, a loop control in virtual museum space requires a tool for emotional balance control. All researchers, the museologists and engineers together are only in the beginning of mutual way. [4]

3. Museum business process

Evidently the main benefit of the museum consists in improved business processes, the fact with which every commercial institution starts. [7] This internal process includes museum processes digitalization, employers enablement and performance management.

Museum process digitization is defined by strategy of the museum, describing the main problems: keeping, management, conservation, restoration and demonstration of the museum collections. According to the actual laws collection management is based on the electronic database aiming legal protection and state control of the museum objects. The data input to this database became the priority objective, but no formal automatization can increase productivity. All terms depend of human resources. New functions of the museums aiming digital heritage design and archiving appear. In commercial company time saved from the repeatable operations allows employers to concentrate on investigations and creativity, the state-of-art of digitalization in museums is completely different. Instead of expectable vacant employers we fix necessity in additional stuff: photographers, computer operators, data control managers etc. In addition, the quality of images varies for publications in art books, for restoration needs and for museum documentation. Guided tours could be followed by tablet presentations, or mobile applications for individuals, but they result in new specialists. Sometimes new technologies enter our everyday life so fast that we think they are designed only for pleasure. We do not realise them being not only entertainment, but labour-intensive work. We completely forget numerous designers and engineers developing them for us. For example, virtual reality looks nice only on pictures and in films. Virtual space possesses its own rules, modes of interaction and even limits. That means we have a span between scopes of museum visit and being in virtual space even a lot of financial or material efforts were applied. The expenses of a museum grow up, and its budget must take in account new equipment, supplies and refresher training.

Employers enablement, revealed in commercial field, is not evident in the museums. The museum specialists need new skills and knowledge, because they have to be relevant to the modern challenges. In former time the programmers composed algorithms and translated them into a computer code. The engineers supported an interaction with computer, who returned back results in order to find mistakes in the algorithm. Thus, we had time to evaluate all parts of an information system. Now nearly everybody feel himself a Creator, even a Designer and does not realise the functionality of the system, which he tries to break the deadlock. Many operations became automatized, not appreciable and nobody is responsible for mistakes. [8] Museum curators try to design content for the virtual excursions as they did it in exhibitions hall and ignore the principle of virtual space, the rules of a “computer game”, of course the result is very bad. The only possible decision exists. We are able to invite VR-specialist in museum team in order to get the necessary skills. No new job profiles in museums, perhaps the old jobs require new competence of use modern facilities. Network and common use services allows employers to contact in chart anywhere they are, and get access to any data. Such possibility is very comfortable for supplementary services of a museum, while the main museum functions cannot be provided online. The museum collections description, restoration and conservation, transporting, mounting of exposition require presence of curator. Thus the question is in effective tools and applications providing the functionality, preferably free or with one license per the institution.

Any change in a museum is always painful, but even so conservative institution realize new competences as requirement influenced by time and external factors, as telephone and electricity in the beginning of last century. The main problem is not in electron device instead of human but in relevant combined team for the project using ICT. [9] Work within ad hoc teams under time is a real challenge for the domestic museums.

Performance management particularly takes in account attendance of a museum and not a communication result. Museum communication, from the museum visitor’s point of view realise the information exchange in museum space resulting in the visitors reactions. Part of reactions could be found in visitors’ book, because it fixes mostly audience composition and binary estimation “like-dislike”. Field research in museum space with the help of social psychological methods offers possibility to get data on real visitors. These data result in visitors’ feedback analysis and require fast processing.

The basic charge of those, who are responsible for ‘museum performance’ management (in the meaning of productive capacity, not art), to do the statistical reports, and they do not manage proposals on strategy or recommendations for middle managers. The strategic solutions on museum development need definition of the critical factors related with positive impression from exhibition projects and museum atmosphere. That means there is necessity in investigation of real and virtual audience of a museum in comparison with main competitors.

4. Museum business models

Digital transformation involves both operation business processes and interaction between various services. For this reason there are digitally modified business, new digital business and finally, digital globalization.

All types of geolocation based on Wi-Fi and Bluetooth, digital marks, security systems – all these technologies are helpful, but they solve only supplementary problems. Anyway all of these innovations, especially maintenance of them, are very expensive and require extra money from the museum. Museum queues as a result of muss media activity, aiming to increase profitable growth, turned to the museum a catastrophe. Reasonable number of visitors per a museum depends of numerous factors (limited places in cloakroom and checkroom, throughput rate of ticket offices, available number of caretakers and security in the entrance zone), and not well thought out advertising is very risky.

Strictly speaking, digitally modified business leads yet to the increment of electronic document flow following by enormous paper consumption. Although there are special methods, now so new but leading to the positive results, e.g. SWOT-analysis [7] or PERT-charts. The correct management and leadership are also important but not as a successful aspect, only as second level provision of the project.

The new digital businesses for museums suppose electronic ticketing, online shops and also absolutely new activity as a virtual museum. The term appeared in 1991 with an object of computer-art and then it was transformed to the marketing ploy. The entity of term consists not in a digitized form of an existing object, but in a specific virtual environment, which level of immersion can be estimated. In addition to the technical parameters of immersion the feedback should take in account psychological evaluation of the emotional reactions of human. Museum is not a simulator for training; it is companion for whom the individuality of real or virtual visitor is very important.

The digital globalization of activity allows museum transferring from local level to the regional or even national. According to the Strategy of the State Cultural Policy (http:// http://mkrf.ru/upload/mkrf/mkdocs2016/09_03_2016_01.pdf) the state museums of the Federal level are in need to create their regional branches and therefore to take in account the local specifics and possible risks.[10] Coordination of the work of branches requires new professional skills: some troubles in one point will cause troubles in other one. In such case about century the engineers use to apply Henri Gantt's charts and Program Evaluation Review Technique (PERT). That is even one of requirements for the international project submission, e.g. Horizon2020 - the EU Framework Programme for Research and Innovation (http://ec.europa.eu/programmes/horizon2020/).

CONCLUSIONS

Museum business process is continuous. The physical analogue of the process can be presented as short-time impulse influences to a periodic signal, e.g. sinusoid. Imagine, you have your ordinary, traditional everyday functionality but a weather-forecast says you must adapt your business to the new climate conditions, like an impulse. The changes in business and in museum activity will be the convolution of functions: typical, continuous and a new one, influenced by innovative technologies, helping your stakeholders and you too, to get more benefits from your activity. That means a digitally transformed museum, who achieved digital maturity in marketing terms, must have properties of commutativity, associativity, distributivity, linearity and multiplicative identity, and differentiation rule and property of Fourier transform can be applied too. Regarding to these properties, the museum functions will have following characteristics:

- The order of decision of small problems composing a complex problem does not influence to the final result, if all of them must be finalised;
- Spectrum of functions of a cultural institutions is the same, while the ICT are implemented in the main or supplementary business processes;
- The scale of a museum does not affect the digital transformation and its functioning. Velocity of changes in convolution of the functions is defined by velocity of changes in every function separately.

No one of analysed foreign business companies did not take in account all 9 directions of business strategy. Domestic companies first of all try to optimize business processes; they are not so interested in customer. The review on experience of ICT use describe the positive examples and do not discuss the reasons of the unsuccessful cases. It should be mentioned, that relationship with clients, internal processes and competitive offers depend firstly of competently and structural management/ that is why the museums have to pay attention to the mistakes in marketing and investigate their own clients – museum audience – before any change in their activity.

References

[1] D.Yu. Hookk “Illusion of attendance and accessibility: technological innovations in museum”, Heritage & Museography, 15, pp.68-71, 2015.

[2] R.Grossman “The Industries That Are Being Disrupted the Most by Digital”, Harward Business Review. 2016. Retrieved March 1, 2017, from https://hbr.org/2016/03/the-industries-that-are-being-disrupted-the-most-by-digital.

[3] G.Westerman, D.Bonnet & A.McAfee “The Nine Elements of Digital Transformation”, MIT Sloan Management Review, January 07. 2014. Retrieved March 1, 2017, from http://sloanreview.mit.edu/article/the-nine-elements-of-digital-transformation/.

[4] D.Hookk, T.Kharitonova, A.Nikitin & S.Hermon “Loop control control of emotional balance in a museum reality-virtuality continuum. Problem definition and proposed approach”, EVA 2016 Saint Petersburg. Electronic Imaging & the Visual Arts International Conference, St. Petersburg, June 23rd–24th, 2016. Conference Proceedings. SPb; SPb ITMO University, pp.131-136, 2016.

[5] «Исследование Сбербанка: 30 фактов о современной молодёжи». AdIndex, March. 2017. Retrieved January 1, 2016, from https://adindex.ru/files2/news/2017_03/158487_youth_presentation.pdf.

[6] J. P. Chaplin Dictionary of psychology (rev. ed.). New York: Dell, 1975.

[7] A.S.Humphrey “SWOT Analysis for Management Consulting”, SRI Alumni Association Newsletter, December, pp. 7-8, 2005.

[8] R.Holler “Five myths of agile development”. Versionone, pp.1-5, 2010.

[9] G.C.Kane, D.Palmer, A.N.Phillips, D.Kiron & N.Buckley “Strategy, not Technology, Drives Digital Transformation”, MIT Sloan Management Review, 2015. Retrieved January 1, 2016, from http://sloanreview.mit.edu/projects/strategy-drives-digital-transformation/.

[10] А.А. Первозванский, Т.Н. Первозванская. Финансовый рынок: Расчет и Риск. Инфа-М, 1994 год.

BLENDED COURCE AS A TOOL OF CORPORATE AND OPEN RESOURCES INTERACTION

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Abstract

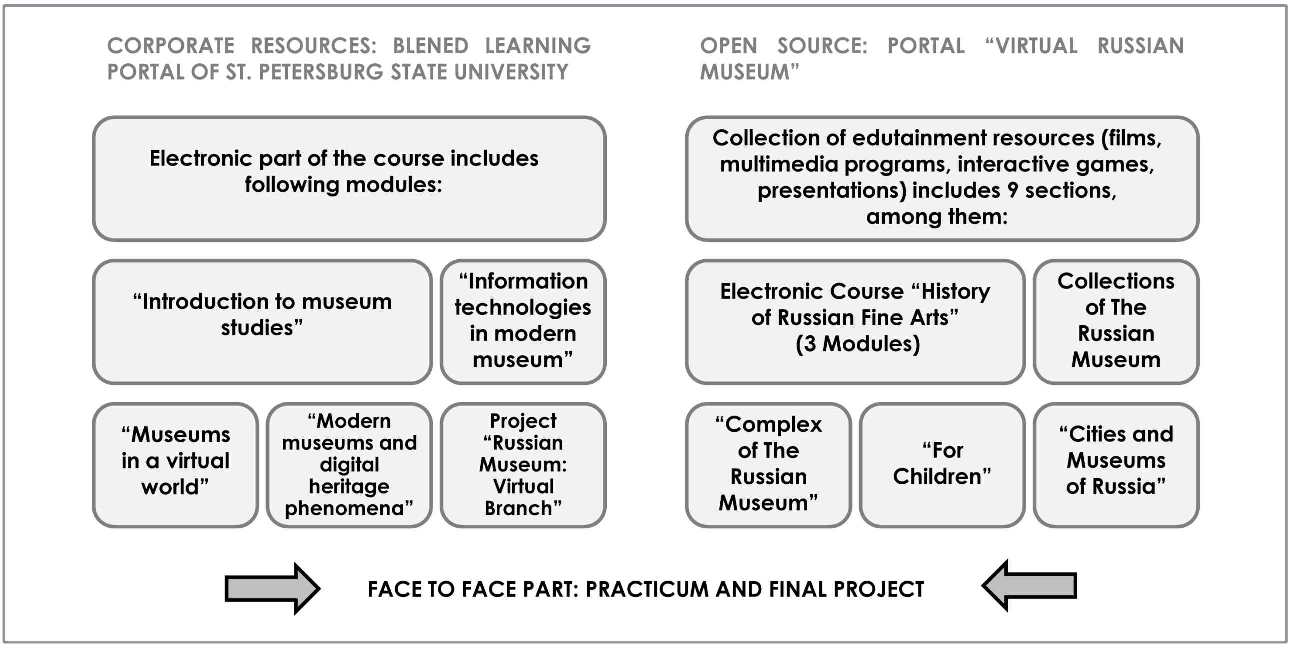
The article is devoted to collaboration between classical university and fine arts museum in education of professionals in information technology in the arts and humanity. Authors develop a live issue of students' inclusion into expert team as a way of increasing the higher education efficiency and show that Internet open sources can be applied for this purpose. Blended course concern as the "gate" into the virtual community of professionals.

INTRODUCTION

Information technologies development has changed not only social institutes, but also anthropological characteristics of people. Education is area where crossing of these vectors is very noticeable; therefore, researches in the field of use of pedagogical potential of virtual space are in the center of attention of the modern scientific countries, which are in a segment of information society [1].

In the Russian Federation one of the main directions of the pedagogical theory and practice is research of eLearning possibilities for increasing of high education efficiency and implementation of the received results in educational process of educational institutions [2, 3]. St. Petersburg State University, being one of the oldest universities of Russia, is at the same time one of leaders of the higher education of the country and the initiator of the advanced developments in a wide range of scientific knowledge fields. Pedagogics is among them and the university provides experts and students with opportunity to use the portal as a tool for modernization of Face-to-Face learning process to Blended learning practice.

It is obvious, that technological platform is insufficiently condition for implementation of a learning process. Learning Management System should maintain wide range of diverse resources and electronic segments of the blended courses are among them. Pedagogical design of such resources is based on interaction of three components: area of scientific knowledge of the course, pedagogical approaches and technological decisions.



Scheme 1. Structure of Blended Learning Course "Information System for Museums". Saint-Petersburg State Museum, Faculty of Arts. Fall terms of 2015/16, 2016/17, 2017/18 years

PEDAGOGICAL THEORY

Theoretical basis of the research is following concepts Blended Learning [4], Social Constructivism [5,6], Web Environmental Learning [7]. The theory of web environmental learning is developed by expert team led by Tatyana Noskova, Institute of Information Technologies in Education of Russian State Pedagogical University named after A. Herzen. It is a system of knowledge about specifics of educational process in information society. The theory benchmark is a priority of personal development of future specialist as a condition of his (her) successful professional implementation. Internet is considered as space for professional interactions among experts, therefore students should be taught special competences, for example, presentation of their research, evaluation of reliability electronic materials, participations in professional discussions etc. Application of these theory is presented in collaboration of Saint Petersburg State University and Russian State Museum [8,9].

It is a challenge for students and teachers. Students, as digital natives, do not understand that Facebook and Web of Science expect different styles of communication from their audiences. Pedagogues, as digital immigrants, sometimes are shocked by style of forums where their students are in one's element. Presumably, the most convenient place for their communication are universities portals of blended learning. At the same time open web sources are extremely important for future professionals and in reality learning process takes place in two segments of Internet: "corporate gulf" and "open sea". In this case, teachers face two problems: (1) the design of resources are based on synergy of capacities of the "gulf" and "sea"; and (2) organization of educational process, aims to successful free floating of students in their professional future.

A sample of a forementioned resource is electronic part of blended learning course "Information Systems for Museums" is a required course on basic educational program Applied Informatics for Arts and Humanities (the direction 09.03.03 the Bachelor's level) at St. Petersburg State University, Faculty of Arts.

CORPORATE RESOURCE IS BLENDED COURSE OF CLASSICAL UNIVERSITY

The Course aims:

- to train of highly skilled, widely educated and professionally competent experts in a field of modern information technologies in museums of different profiles to give to students the necessary volume of knowledge on history of development of a museum as a specific sociocultural institute from antiquity to the present time;
- to acquaint students with variety of types of the museum; to show multilateral interrelation of the museum with various scientific disciplines and culture phenomena, esthetic and social characteristic of different eras;
- to show the specifics of development of the museum in information society and such trends as presentation of museums' collections in the virtual world, application of information technologies in museum space and participation of museums in creation of Digital Heritage phenomena.

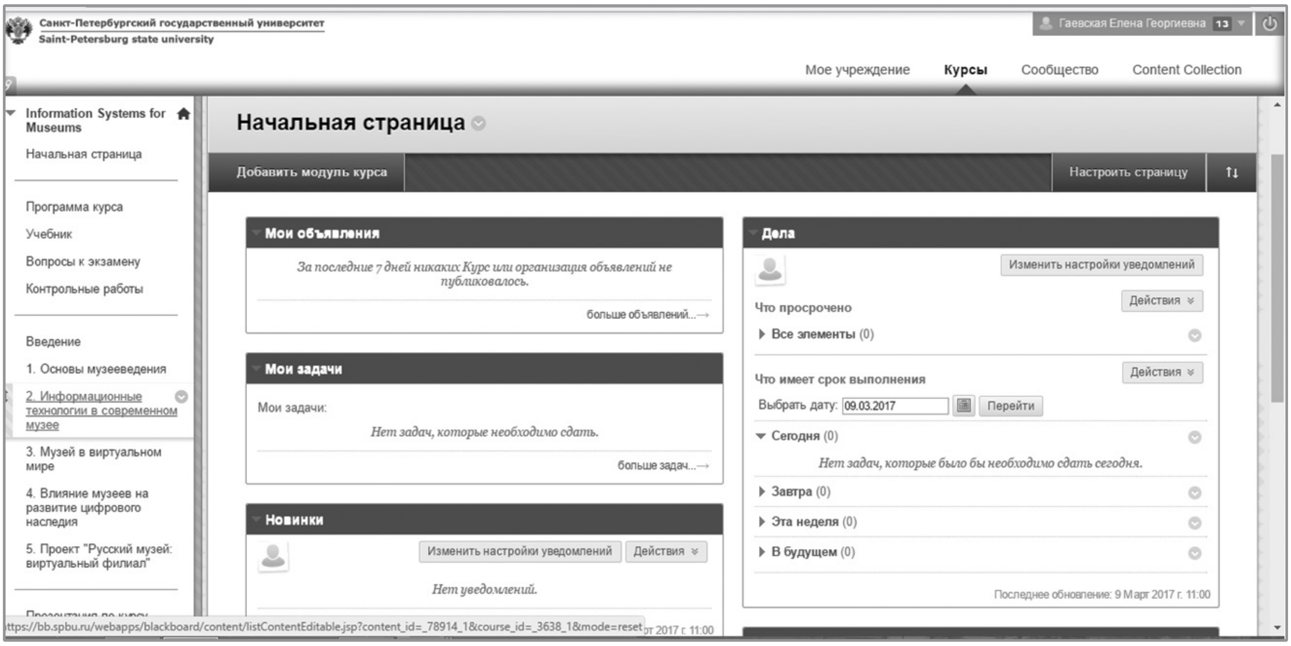


Figure 1. Start Page of Blended Learning Course “Information System for Museums”, Blended Learning portal of Saint-Petersburg State University

The Course Content and Structure

The coursecontent includes internal and external resources (Scheme 1) and is divided into following sections:

Unit 1.Introduction to museum studies;

Unit 2. Information technologies in modern museum;

Unit 3. Museum is in a virtual world;

Unit 4. Impact of modern museums on development of digital heritage phenomena;

Unit 5. Project “Russian Museum: Virtual Branch” is a unique museum institution of information society.

Internal resources are modules of the Course are published in the Blended Learning Portal of Saint Petersburg State University (Picture 1), and [10], and External Resources are Open Sources of Museums, Electronic Copies of Fine Arts Treasure Repositories and Massive Open Online Courses.

The Course Methodology

Experts more and more actively use such tools of communication as social networks, blogs, discuss of professional issues via videoconference, publish articles in electronic journals, etc. In this connection, development of such competences as delivering results of researches in articles, oral presentations, participation in discussions, papers reviewing, etc. in virtual and face to face formats is very relevant in context of modern requirements to professional trainings. Consequently, the course methodology is based on combinations of these approaches.

Virtual Format: creation of the course thesaurus (service “wiki”), publication students’ projects on the course forum, test on the main issues of the course modules, and blind review of the essays (service “Assignment”).

Classroom format: Lectures, meetings with experts, visits to museums, consultation, discussion of projects.

A stable trend of nowadays is creation of technical possibilities for professional interaction at the institutional and individual level in the virtual space through Web2.0 technologies by different organizations. Many institutions of science and culture place on their portals services that provide possibilities to develop the network community of the organization, and pay great attention to their successful functioning. There are portals of museums and virtual collections of fine arts electronic copies among them. Studying these resources is important part of the course methodology; in particular, the students’ final projects are focuses on creation presentations of one of them.

The outcome of the students’ work is implementation of final projects, within they must demonstrate level of the competences mastered in the course of studying the materials of the preceding modules of the course. The project includes following stages (1) creation of presentation of a museum, an exhibition or exhibit, (2) publication the product on the course forum, (3) discussion the presentation with classmates in virtual and audience formats, (4) publication presentations in social networks, (5) external review and (6) defense of the project at the closing session.

The Course Learning Management System

The course is presented on Blended Learning portal of the St. Petersburg State University, which functions based on services Black Board LMS. This software provides with a set of services for students and teachers. The LMS allows the teacher to create conditions for the development of future professionals through the alignment of an educational path through gradual complication of learning tasks, based on the individual characteristics of students and to motivate them for personal development. It gives to students possibilities for comfortable interaction with internal and external learning environment.

OPEN SOURCE IS PORTAL OF RUSSIAN STATE MUSEUM "Virtual Russian Museum"

One of the most successful examples of activities in this direction is the portal "Virtual Russian Museum". An unquestionable advantage of this resource is orientation to community of Russian Museum: Virtual Branch Project. The portal designers take into account the diverse needs of the network which includes international organizations of arts, culture, charity, science, and education. At the same time educational organizations cover a wide range of participants from secondary schools to universities.

News feed, archives of online lectures and video broadcasts records, social networks pages allow the portal to realize its functions of technological and resource base of a like-minded team, which join more than one hundred organizations from almost 20 countries. Each institution - participant of the project is provided with a personal cabinet, for presentation in the expert network, information about events taking place in the organization, or participation in joint projects.

At the same time, the portal has a significant pedagogical potential, consists in providing open access to multimedia publications, grouped in the following cycles:

- Complex of The Russian Museum: twenty films and multimedia programs about the Mikhailovsky Palace and the Mikhailovsky Castle, the Marble Palace, the Stroganov Palace, Peter the Great's Cottage, Guardhouse, the Summer Garden and the Summer Palace of Peter the Great;
- Collections of the Russian Museum: more than one hundred computer, multimedia, and video films and interactive programs devoted to various aspects of the history of Russian fine arts; systematized by headings: Artists, Art and Religion, Funds, Technology, Theme in Arts, Folk Art, Associations, Styles, Collectors;
- The history of one masterpiece: more than twenty computer and video films;
- Cities and museums of Russia: more than twenty interactive programs, multimedia and video films;
- For Children: more than twenty interactive programs, multimedia and video films;
- Electronic course of the history of Russian Fine Arts: three modules "Art of the end of the XIX - early XX century", "Russian avant-garde", "Gardens of the Russian Museum";
- The Cycle of films "Century of Russian Fine Arts": Sixty three films about the history of Russian Fine Arts and museum work;
- Programs in foreign languages: twenty game computer programs, interactive programs, video films;
- For Branches: Eight video presentations and interactive programs.

CONCLUSION

Long-term cooperation of the university and the museum meets modern trends of education development. It allows students to receive high quality multimedia resources for learning sessions which conduct in classroom and virtual space, and also to be included in communication with team of experts at an early stage of professional training. Sometimes it is possible to establish a network communication between students and professionals, for example, in the case of reviewing the students' projects.

At the same time, practice shows that in the process of university - museum cooperation occur challenges are related to the specifics of the partnership participants. In this case, the issues lie in the fact that the university and the museum have specific goals in the field of pedagogical activity: museum field of activity is edutainment, but university area is professional education. In this connection university have to make Pedagogical adaptation for the resources are created by the museum and then include them to educational process of university. The adaptation usually is development of some exercises, questions, tests accompanying film or multimedia program. The museum addresses to academic capacity of the university in such projects as seminars, conferences, competitions, and we will have opportunities to master new directions of common activity.

ACKNOWLEDGEMENTS

The authors are grateful to the Saint Petersburg State University administration and the State Russian Museum direction for the possibilities are provided for long term cooperation in frame of the Project "Russian Museum: Virtual Branch" and personally Vito Cappellini for interest to the project and opportunity to present it in the international conference EVA Firenze 2017.

References

[1] Marc Prensky (October 2001). “Digital Natives, Digital Immigrants”. OntheHorizon (PDF). 9. MCBUniversityPress. RetrievedMarch 1, 2015.

[2] Федеральный закон “Об образовании в Российской Федерации” от 29.12.2012 N 273-Ф (статьи 15,16,18,97,98) http://www.consultant.ru/document/cons_doc_LAW_140174/

[3] Федеральные государственные образовательные стандарты высшего профессионального образования http://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=LAW&n=142304&fld=134&dst=1000000001,0&rnd=0.7492467292665748#1 (ст. 11.3)

[4] Bersin, Josh (2004). “How Did We Get Here? The History of Blended Learning”. The Blended Learning Book: Best Practices, Proven Methodologies, and Lessons Learned (PDF). Wiley. ISBN 978-0-7879-7296-7.

[5] Vygotsky, L. (1978). Mind in Society. London: Harvard University Press.

[6] Mark McMahon, Social Constructivism and the World Wide Web - A Paradigm for Learning, ASCILITE 1997

[7] Носкова Т. Педагогика общества знания. Noskova T. Pedagogics of Knowledge Society. St. Petersburg2015 Носкова Т.Н. Педагогика общества знаний: - Монография СПб.: Изд-во РГПУ им. А.И. Герцена, 2015 – 236 с. ISBN 978-5-8064-2168-6

[8] Babina O., Gaevskaya E. Virtual Branch of Russian Museum at Saint Petersburg State University: First Decade of Cooperation. EVA 2016 Saint Petersburg. Electronic Imaging and Visual Arts. Intenational Conference, St. Petersburg, June 23-24, 2016. Conference Proceedings – SPb ITMO University, 2016 – 144 p. ISBN 978-5-7577-0535-4

[9] Портал “Виртуальный Русский музей” http://rusmuseumvrm.ru/

[10] Blended Learning portal of Saint-Petersburg State University, Course “Information System for Museums. Access:https://bb.spbu.ru/webapps/blackboard/execute/modulepage/view?course_id=_3638_1&cmp_tab_id=_14316_1&editMode=true&mode=cpview

FACE TO FACE – CLOSE RANGE INSPECTION OF HEAD VASES

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Abstract

Several hundred attic head vases are known worldwide and stored in museums and collections. In 1929 Beazley has categorized twenty groups (A-W) based on stylistic properties and historic methodology. Head vases are assembled in several steps, most important for our comparison is the molding of the head area. While the other parts of head vases like the size of the handle and the painting can look quite different, one can notice similarities in the head shape of the same group. Since molds were used to shape the heads, our initial hypothesis was to perform a quantitative comparison of head shapes based on digital scan data. Comparison of scan data is straightforward and is very similar to quality control and inspection work done for industrial parts. Nonetheless, quality control of approximately 2500-year-old artefacts that are distributed among several different places is not straight forward. Initial analysis was performed on older scan data. A high-resolution fringe projection scanner was employed to scan further head vases in additional museums in Germany and Italy. Scan resolution and accuracy of approximately 0.1 mm in all dimensions were required to reveal differences below 1 mm. All new scans were performed with an AICON Smart-Scan-HE C8. This scanner captures not only shape, but at the same time records color textures which can be employed for presentation or future analyses. Shape analysis results of the head areas do not only confirm that it is likely that the same mold was used for shaping some of the head vases, but also that it is not unlikely that a first generation of larger head vases was used to prepare molds for consecutive generations of head vases that are slightly smaller by 10-15%. This volume loss resembles closely the volume loss observed after oven-burning of pottery. Scanning will continue to increase the data set for further analyses.

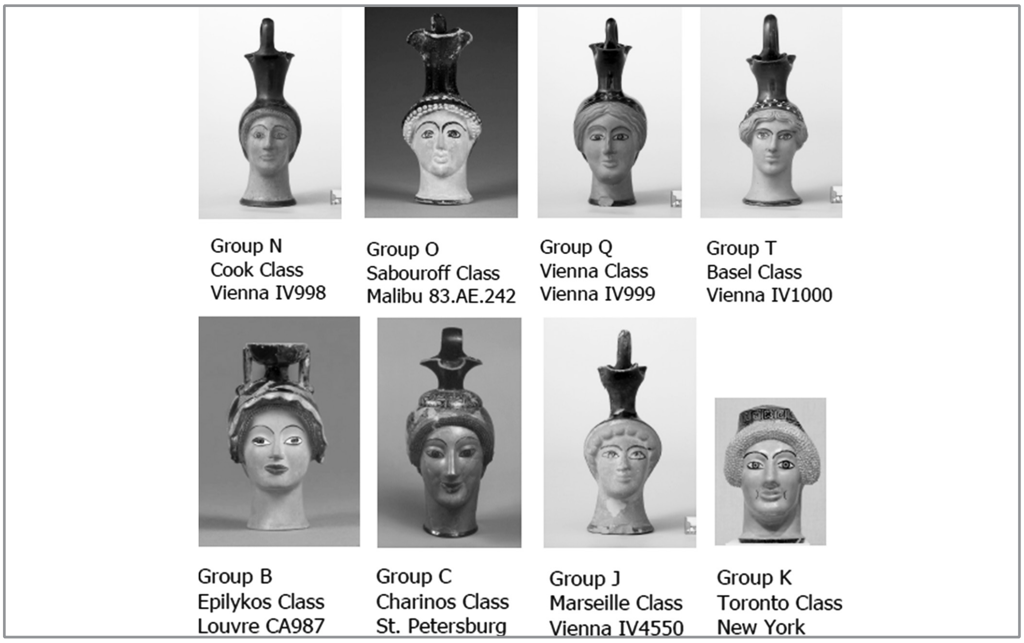

Figure 1. Attic head vases of different groups.

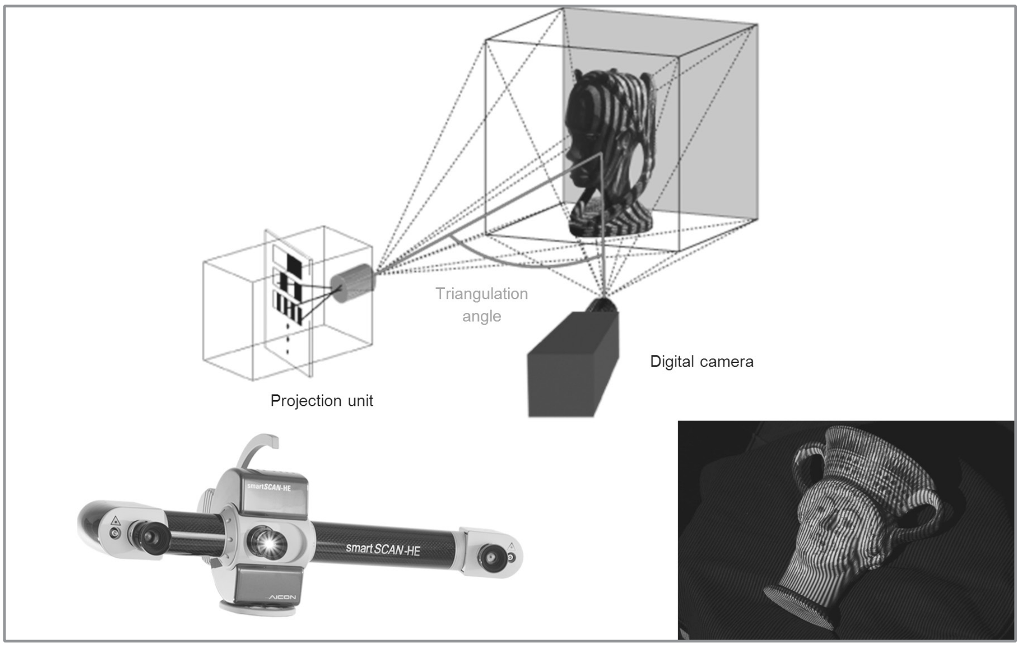

Figure 2. Principle of fringe projection system (above). Fringe projection scanning process on attic head vase (lower right, Antikensammlung Berlin).SmartScan-HE C8 stereo camera fringe projection scanner (lower left).

INTRODUCTION

It is an ancient practice to shape a vase in human or animal form. It dates back to the early Mediterranean cultures and lasts until the modern times. In this contribution, we focus on Attic productions of pouring vases (oinochoai) of late archaic and early classical times which bodies are shaped as a human head, mostly female heads (Figure 1). We owe their classification to the fundamental paper of Sir John Beazley, written in 1929 [1]. Since then numerous vessels have been published, but Beazley's groups are still relevant. Beazley categorized the vases in the form of human heads in twenty groups (Group A-W) and a miscellaneous list, according to the depicted figure and the stylistic development of the face, based on an art historic methodology. This classification grounds on a comprehensive knowledge of stylistic development and

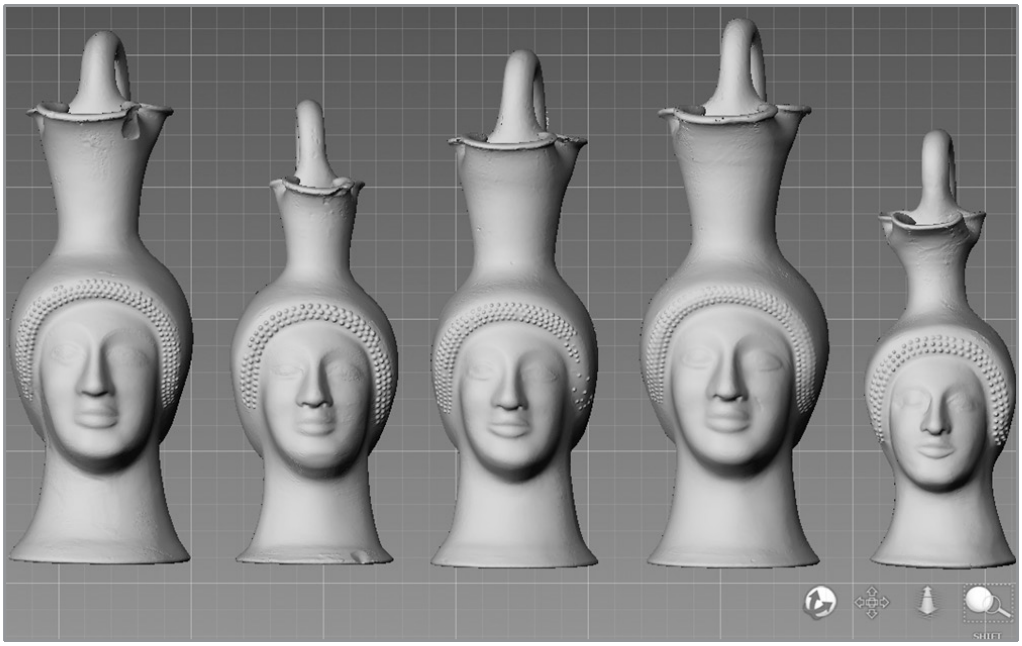

Figure 3. Head vases from Antikensammlung Berlin; F2191, F2192, F2193, F2194, F2195

Figure 4. Head vases from Kunstmuseum Wien (1038 and 997). Red areas were selected manually to define regions of interest for alignment.

was criticized in the recent decades because of its subjectivity and lack of transparency. We focus on Beazley's groups N and Q. The largest group of all, the Cook Class (group N), comprisesmore than 225 known vases worldwide with various human heads in which women's heads are commonest. The small group of the Vienna Class (group Q) includesapproximately 14 samples, so far all of them are female heads. The clear majority of the Attic pottery is thrown by the potter´s wheel. Concerning the head vases the potters used the same technique only for the upper part of the vessel whereas the head of the head part of the vase was made by two molds, one for the face and a second for the rear; finally some facial details, like eyes and eyebrows, are painted by hand. The process of production interconnects head vases and terracotta figurines.

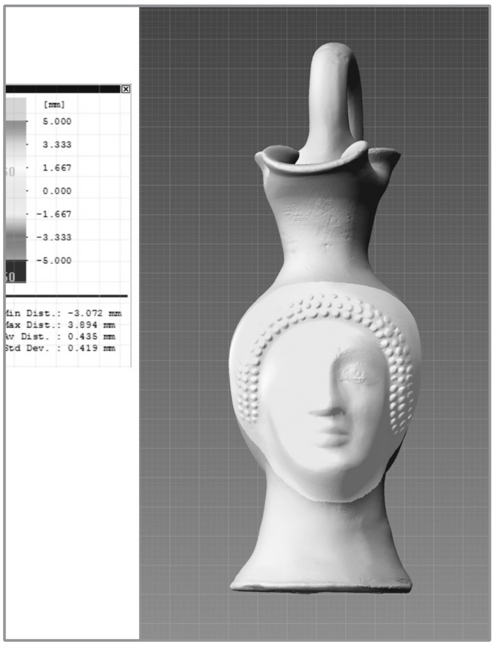

Figure 5. Comparing two head vases from Antikensammlung Berlin (F2195) and Antikensammlung München (SH2745) revealed differences of less than 1 mm in most of the face area and less than 2 mm of the whole area that was compared.

MATERIALS AND METHODS

3D scan models of several vases were selected for comparison. Data was available in PLY and OBJ format and was imported in OptoCat 3D scanning and analysis software [2]. From Kunstmuseum Wien, some older scans were available in OBJ format. These scans were captured-more than five years ago with a Konica Minolta triangulation laser scanner. Additional scans were captured in Antikensammlung Berlin, Antikensammlungen München and recently in Museo Archeologico Bologna with an AICON SmartScan-HE C8 with 450 mm field of view and resolution of 0.1 mm (Figure 2).

Feature accuracy of the system is better than 0.030 mm. The field of view covered the whole vase at a resolution necessary for comparison at the mm to sub-mm level. The accuracy of the system ensured that data acquired at different locations can be compared to each other. Most head vases show very dark and shiny areas in combination with light paintings. This range of material properties (contrast, shininess, etc.) is not straight forward for scanning and required high- dynamic range scanning mode and careful scanner positioning as well as data processing to avoid artefacts in the resulting models. Working with color cameras in the scanner allowed capturing shape and color texture at the same time. In the software OptoCat 3D color textures may be switched on or off. For shape analysis color textures are not useful. For presentation and artistic interpretation color textures can be switched on.

Placing 3D models next to each other allows for a quick comparison of the 3D data (Figure 3). Please note that only 3D models were used for the geometric comparison and that no texture data was used. We are convinced that Beazley's groups are principally correct. Nevertheless, recent computer technology and visualization systems can help to further refine and consolidate the original groups, in respect to chronology and production process. Conventional archaeological methods are inappropriate for these three-dimensional comparisons.

Shape comparison was performed in AICON´s OptoCat software (AICON, 2017). Two candidates were roughly aligned manually and the region of interest that was molded was selected by hand (Figure 4). A fine alignment of the selected areas was performed in OptoCat software which uses an implementation of the iterative closest point algorithm for alignment. After the alignment, the distance between two models was calculated for all vertices and was plotted.

Placing several head vases of different sizes next to each other, they appear like scaled models of each other. Applying a liner scale factor of 10 to 15% in x, y, z direction, the digital models were adjusted in size and compared to each other as before.

RESULTS AND DISCUSSION

Differences of ±1mm were assumed to indicate a close correlation between head vases. For several vases deviations were small enough to assume that they originate from the same mold (Figure 5).

Comparison of scaled models also revealed small offsets. This variation maybe due to shrinking during oven-burning for vases originating from the same mold or may indicate that additional molds were taken from finished vases to produce a set of smaller vases (Figure 6, 7).

CONCLUSIONS

Quantitative analysis of digital scans allows for comparison of 2,500 year old attic head vases. Several vases appear to originate from the same mold. In addition, scaled versions indicate that series or generations of vases exist.

Working with a digital data sets allows for testing many hypotheses in a fast way, even for large regions. Traditional methods would have to rely on a small number of tactile manual measurements. The current results add to the qualitative analysis performed almost 90 years ago by Beazley as well as observations by archaeologists that formulated similar hypotheses for a long time based on thorough observation. With the help of three-dimensional models, these hypothesis can be tested today.

Figure 6. Head vases from Antikensammlung Berlin from left to right: F2191, F2192 scaled to 110%, F2192 in original size.

ACKNOWLEDGEMENTS

Weacknowledge support by Kunsthistorisches Museum Wien, Staatliche Antikensammlungen München, Antikensammlung Berlin. The project is also supported by the Fritz Thyssen Stiftung.

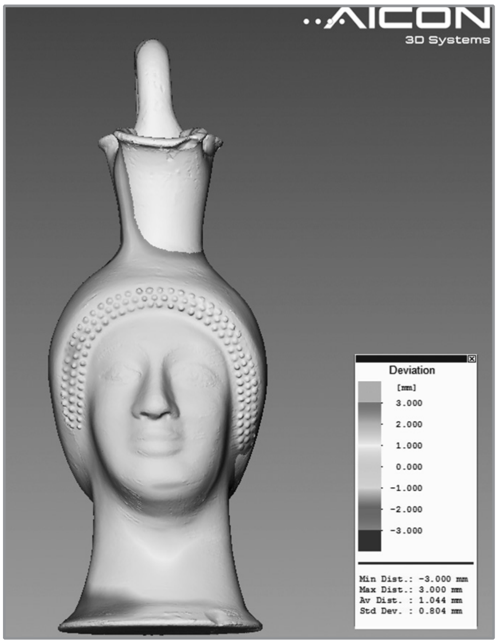

Figure 7. Comparison of Antikensammlung Berlin F2191 and F2192 scaled to 110%. Only the head region was used for alignment.

References

[1] Beazley, J. D. “Charinos”, JHS 49, pp. 38-78, 1929.

[2] AICON 3D Systems.” OptoCat User Manual”, 163p., 2017.

BRAINWORK: A PILOT BRAIN COMPUTER INTERFACE STUDY ON THE RELATIONSHIP BETWEEN CREATIVITY, PERSONALITY AND IMAGINATION

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Abstract

The aims of this work is to identify possible biomarkers (EEG) related to the creative process in specific tasks, exploring it in a real-time ecological setting, investigating the relation between explicit and implicit mechanisms, between creativity and personality trait, the semantic memory and to validate a tool to study creativeness.

The pilot study reveals the presence of significant relations between personality components, EEG indices and creative processes, suggesting that the use of a self-echo setting may be applied also to boost creativity in people with specific thinking styles and personality traits, to empower creativity in a tailored fashion.

INTRODUCTION

Thanks to the increasing availability of new neuroscientific methodologies, the topic of creativity has received considerable interest in cognitive psychology and neuroscience, with the production of numerous studies investigating the brain activity during different creativity tasks [3]. However, the study of creativity is complex by many points of view. First of all, we may find many definitions of creativity and probably we should consider it an aggregated concept made by different aspects and phases. Thus, it is not directly clear what kind of creativity neuroscientific studies address. Secondly, neuroscientific settings are often artificial and poorly "creativity-friendly". Consequently,

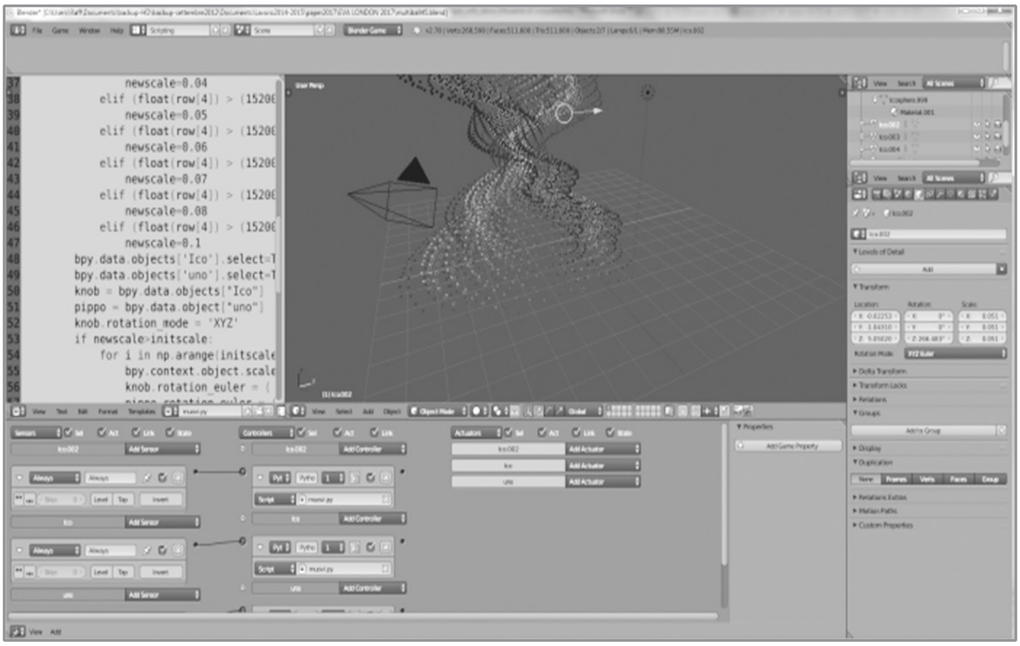

Figure 1. The Blender platform used to develop graphical and audio object of the performance

few previous studies explored the topic of creativity by modulating, or reinforcing, some capacities that are thought to be related to creative processes and generally they did not provide consistent results [2]. In the present study, we opted to use a complex setting by the use of a Brain-Computer Interface (BCI). The BCI was proposed during the creative process. In fact, BCI furnishes portable and easy-to-use solutions to explore such issues in a more ecological setting [4, 5]. Also, thanks to EEG technique, it permits to monitor the cognitive and emotional processes related to creativity in real-time, within milliseconds. Together with EEG recording, Electrodermal Activity (EDA) may be used in a way to identify emotion-related implicit processes. Participants were asked to interact with a computer, thanks to an audio-visual stimulation, by only using their mind, in a way to create an audio-visual artefact based on their brainwaves. In this way, we elicited cognitive processes and at the same time participant were asked to interact (by the BCI) a computer to change the graphical and acoustic production in a real-time application. In this way, since subject where involved in a cognitive process implying both imagination and verbal thinking (thus loading their working memory) the brain-computer interaction took place as a result of a mix implicit-explicit processes not completely under the conscious control. Moreover, the graphical and acoustic brain-guided stimulation acted as a complex neurofeedback activating a mind-brain-computer loop. Actually, the present pilot study is focused on the role of the creative process in shaping human experience, thus situating the mind within its environment. In fact, our paradigm allowed the self-revealing to the mind/environment dynamics through the brain-computer interface. Indeed, the disclosure of something implicit (as the process through one's own mind connect with the world) can be considered a powerful phenomenon, which could perturb both self-consciousness and the creative process. We can refer to this effect ad "self-echo".

The task included 5 conditions to explore different "thematic domains" related to creativity, together with verbal and non-verbal components. Creative and imaginative capabilities were also assessed, together with other personality traits, in a way to explore a possible relation between all these different levels.

Thus, the aims of the present work were to identify possible biomarkers (EEG) related to the creative process in specific tasks; to explore the creative process in a real-time ecological setting; to investigate the relation between explicit and implicit mechanisms during creative processes; to explore the relation between creativity and personality trait, semantic memory; to validate a useful tool to study creativeness.

MATERIALS AND METHODS

Participants

In this pilot study, nine university students (pilot sample), 7 females and 2 males (Mage=23; SD=2), with no neurological diseases participated in the experiment. All subjects were right-handed with normal or corrected-to-normal visual acuity. They gave informed written consent for participating in the study and the experiment was conducted in accordance with the Declaration of Helsinki. No payment was provided for subjects' participation.

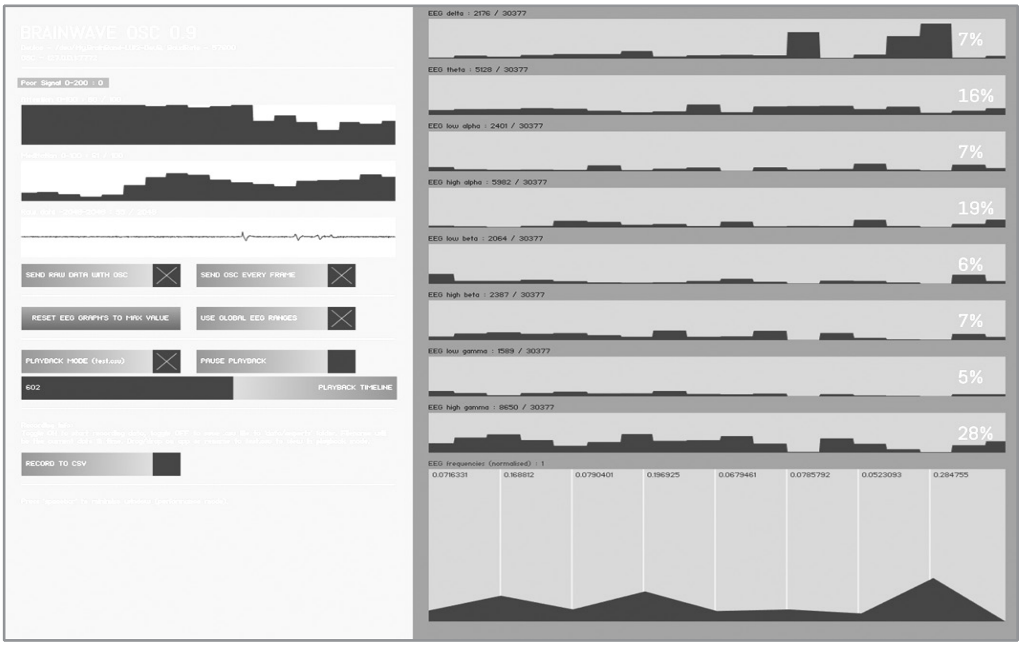

Figure 2. The BrainWaveOSC interface

Brain-Computer Interface

The Neurosky Mindwave, a new version of Neurosky MindSet (http://www.neurosky.com), with defined accuracy and reliability (Grierson and Kiefer 2011) has be used. The Mindwave is composed of a passive sensor positioned in Fp1 (left frontopolar) and from a reference sensor, positioned on the earlobe, used to subtract the common ambient noise through a process known as common mode rejection. To realize the performance, a graphical and sound interface to the BCI was created by using the open source 3D graphics and animation software Blender (https://www.blender.org/) (Fig. 1).

The realized graphical and audio objects and the related animations were linked to the brain rhythm collected by the BCI in real time, using the interface library BrainWaveOSC (https://github.com/trentbrooks/BrainWaveOSC) (Fig.2). BrainWaveOSC was designed to pass EEG data from Neurosky ThinkGear-based bluetooth EEG sensors to other applications like Max-MSP and PureData via the OpenSoundControl networking protocol. The interface to BrainWaveOSC and all the code needed to link the collected EEG values to the graphical and audio output has been realised in Python.

Psychological Assessment

Big Five Inventory-10 (BFI-10). The Big Five Inventory-10 [13] consists of 10 short-phrase items, rated on a five-step scale from 1 (“disagree strongly”) to 5 (“agree strongly”) and explores the Big Five Factor Model which includes the factors Extraversion, Agreeableness or Friendliness, Conscientiousness, Emotional Stability or Neuroticism, and Intellect or Openness to Experience.

The Torrance Test of Creative Thinking. The Torrance Test of Creative Thinking is a test of creativity. Subjects are asked to draw and give a title to their drawings (pictures) or to write questions, reasons, consequences and different uses for objects (words). It has two different versions: the TTCT-Verbal and the TTCT-Figural. The TTCT-Verbal has two parallel forms, A and B, and consists of five activities: ask-and-guess, product improvement, unusual uses, unusual questions, and just suppose. The stimulus for each task includes a picture to which people respond in writing [15]. The TTCT-Figural has two parallel forms, A and B, and consists of three activities: picture construction, picture completion, and repeated figures of lines or circles.

BIS/BAS questionnaire. It has been argued that two general motivational systems underlie behaviour. A behavioural approach system (BAS) is believed to regulate appetitive motives, in which the goal is to move toward something desired. A behavioural or inhibition system (BIS) is said to regulate aversive motives, in which the goal is to move away from something unpleasant. The BIS/BAS questionnaire by Carver and White (Carver & White, 1994) includes 24 items (20 score-items and four fillers, each measured on four-point Likert scale), and two total scores for BIS and BAS. Each item of this questionnaire is a statement that a person may either agree with or disagree with, from 1 (very true for me), to 4 (very false for me). Here, BIS and BAS scores will be calculated for each subject by using the Italian version of Carver and White Questionnaire (1994) [6].

VVIQ. The Vividness of Visual Imagery Questionnaire (VVIQ) consists of 16 items in four groups of 4 items in which the participant is asked to consider the

Figure 3. The experimental setting

image formed in thinking about specific scenarios and situations and rate the vividness of the image along a 5-point scale [1].

TVIC. The Test of Visual Imagery Control (TVIC) consists of 10-items in which the participant is asked to rate his own ability to control visual images on a 5-point scale [1].

Procedure

Participants were asked to read and sign an informed written consent (1), then, they were required to complete the personality and creativity tests (2). After the montage of EEG headband (3), a resting baseline was recorded (2 min eyes closed + 2 min eyes open; step 4). After these steps, participants received instructions on the computer screen to guide the different conditions during the creative task (5). Before beginning with the 5 conditions, a 1-min free-run period was recorded. The instruction was: "Set your mind free to interact with the computer interface". After this run, the other 5 conditions were presented randomly; the instructions was: "While you're interacting with the graphical and acoustic computer interface try to imagine and focus on…": a) concrete task: "a concrete object". b) abstract task: "an abstract concept". c) color task: "a color". d) place task: "a place you know". e) Person task: "an important person for you". A 1-min pause was administered between each condition. Together with the instructions, 3 distracting words have been auditory presented to the participants following a standardized temporal pattern. The distractors were 3 examples within the semantic category. Finally, subjects were required to write a story down (step 6) by using the 5 words and the related semantic fields previously imagined during the tasks. The instruction was: "Now we ask you to take some time to write down a story by using the concepts you experienced during the 5 experimental trials (color, concrete word, abstracts concept, place and person)" (Fig. 3).

RESULTS

Data analysis

All EEG data were checked for artifacts and data higher than the 20% of the mean value were excluded from successive analyses. Then, "Loading" and "Dumping" indices were calculated as the ratio between Gamma and Beta brain rhythms, and Theta and Beta brain rhythms, respectively.

Also, questionnaires have been scored and the stories have been analyzed in their content, with respect to the number of words, nouns, adjectives, and adverbs. Then, other linguistic indices have been calculated as the ratio between nouns, adjectives, and adverbs and the total number of words.

Correlational analysis

Preliminary correlational analyses have been applied to Loading and Dumping Indices during the 5 different conditions and the baseline (both eyes closed and open), personality scores, and linguistic indices.

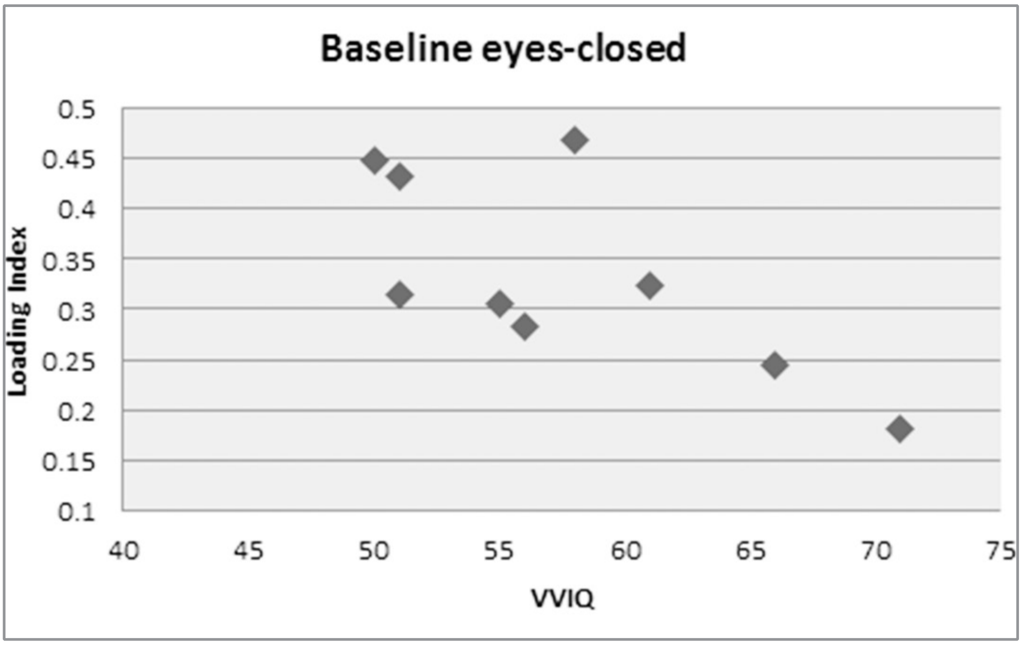

Figure 4. Correlational analyses applied to Loading and Dumping Indices

A significant negative correlation was found between VVIQ scorings and Loading index during the eyes-closed baseline ($r=-0.71$; $p<0.05$). Thus, in case of lower vividness of visual imagery, higher Loading indices emerged (Fig. 4).

Also, significant negative relations emerged between Big 5 Conscientiousness scale and Loading Index during Free ($r=-0.72$; $p<0.05$), colour ($r=-0.72$; $p<0.05$) and place ($r=-0.71$; $p<0.05$) conditions. Thus, in case of lower conscientiousness scores, higher Loading indices emerged (Fig. 5).

Moreover, significant positive relations emerged between BAS drive scorings and Dumpling index during Free ($r=0.81$; $p<0.05$) and Concrete ($r=0.84$; $p<0.05$) conditions. Thus, in case of higher attitudes in pursuing goals, higher Dumpling indices emerged.

Finally, for what concerns the story writing, the Noun index significantly correlated with TVIC ($r=0.71$; $p<0.05$), with BAS reward scale ($r=0.81$; $p<0.05$), and with the Loading index during the concrete condition ($r=0.8$; $p<0.05$) (Fig. 6). Thus, in case of higher visual imagery control, higher reward attitudes and higher Loading index during the Concrete condition, higher Noun indices were found.

DISCUSSION AND CONCLUSION

In the present work, psychophysiological biomarkers (EEG indices) related to the creative process were explored in specific ecological tasks with respect to personality trait and semantic memory. Correlational analyses revealed some interesting preliminary results: first of all, inverse relations emerged between the Loading Index and the vividness of visual imagery, as well as between the Loading Index and the Big 5 Conscientiousness scale. That is, lower conscientiousness traits and lower imaginative capacities were related to higher Loading Indices. This effect could be explained by hypothesizing higher cognitive efforts in those individuals who are less inclined to display self-discipline and less capable to manage visual images. In fact, the loading index signals an increase in higher EEG frequencies such as gamma band, which is related to a series of higher cognitive processes, such as focused attention [10], memory [8], linguistic processing [11], behavioral and perceptual functions [14], emotional states [9] and associative learning [7].

Moreover, significant positive relations emerged between BAS drive scorings and Dumpling index during Free and Concrete conditions: in fact, in case of higher attitudes in pursuing goals, higher Dumpling indices emerged. This result replicates what already found by Putman and colleagues [12] who found increased theta/beta ratio in high BAS-drive subjects. This result could be explained by considering the reward- and approach-related motivational trait and increased attentional processes, in particular when focusing on a concrete concept or object.

Finally, focusing on the story writing, the Noun index significantly correlated with TVIC, with BAS reward scale, and with the Loading index during the concrete condition. In detail, in case of higher visual imagery control, higher reward attitudes and higher Loading index during the Concrete condition, higher Noun indices were found. For what concerns TVIC, it is possible that the capacity to manage and control visual concepts could be related to a higher tendency to translate such images

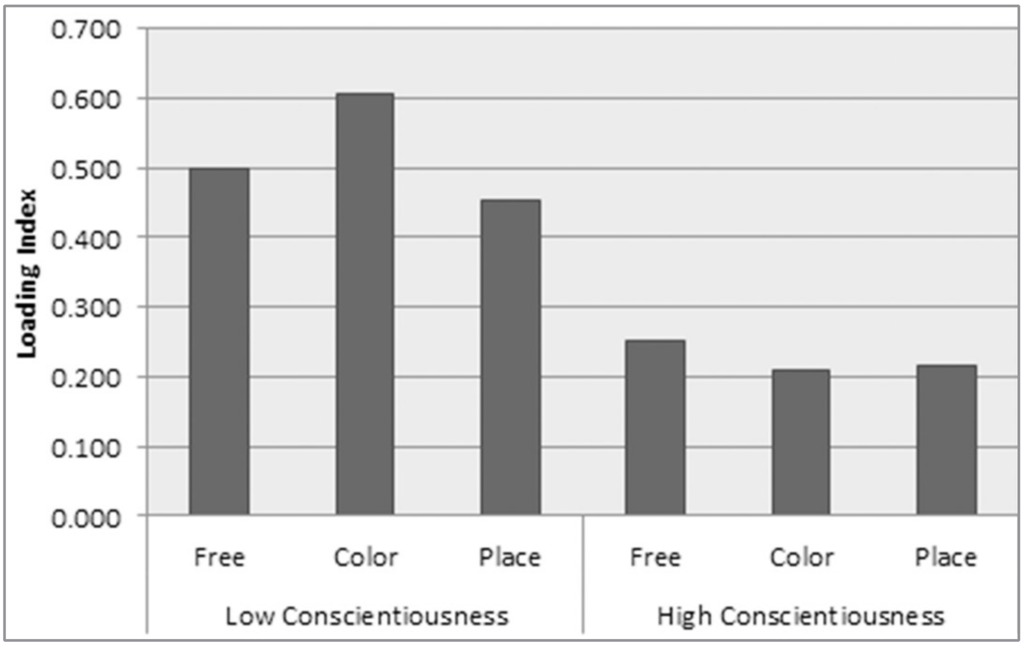

Figure 5. Relations between Big 5 Conscientiousness scale and Loading Index during Free, colour and place conditions

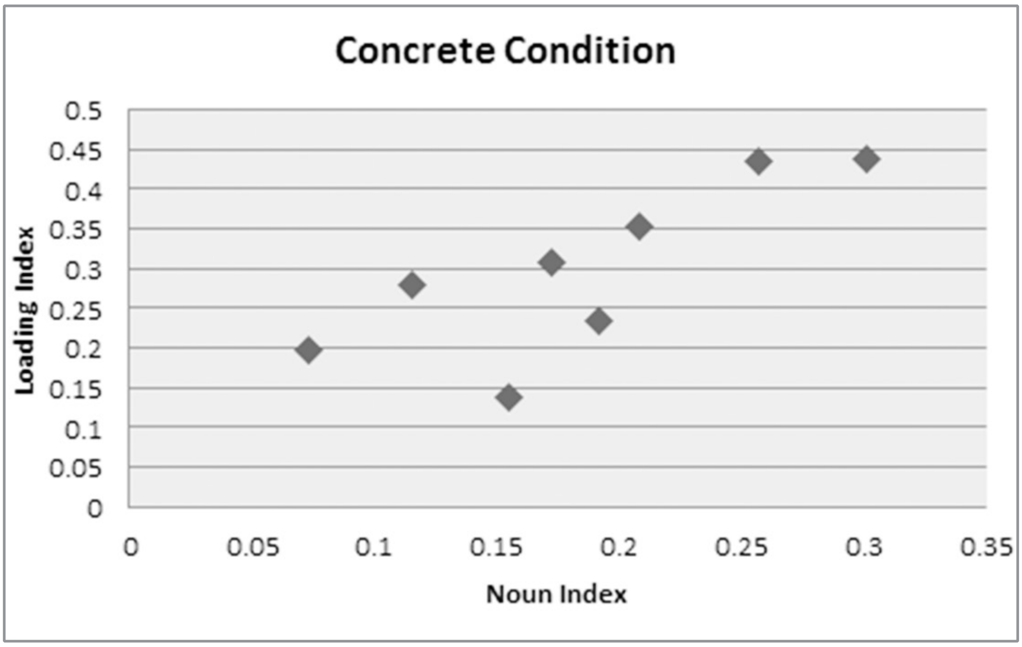

Figure 6. Noun index correlation with the Loading index during the concrete condition

into concrete scenarios. For what concerns BAS reward, instead, the effect could be ascribed to the tendency to use many real elements in the story, thus gratifying the researcher and hypothetically receiving a reward for completing the task in an original way. Considering the EEG response, the Loading Index during the Concrete Condition was related to an increased use of nouns. The increased brain activity in the concrete condition is perfectly in line with a subsequent tendency to use real scenarios.

To conclude, the present pilot study permitted to underline some preliminary data about the presence of significant relations between personality components, EEG indices and creative and imaginative processes. In particular, in future research it will be possible to analyze if the use of a self-echo setting may be applied not only to investigate statistical correlations and/or the presence of neuropsychological correlates, but also to boost creativity in people with specific thinking styles and personality traits, in a way to empower creativity in a tailored fashion. Indeed, we argue that creativity is a personal feature that should be addressed in a complex setting able to take together a number of different components. In this way, we might substitute the "creativity-pill" approach with a more effective self-adaptive boosting process.

References

[1] Antonietti, A., & Crespi, M. (1995). Analisi di tre questionari per la valutazione della vividezza dell'immagine mentale. Milano: Dipartimento di Psicologia, Università Cattolica.

[2] Dietrich, A., & Kanso, R. (2010). A review of EEG, ERP, and neuroimaging studies of creativity and insight. Psychological bulletin, 136(5), 822–848.

[3] Fink, A., & Benedek, M. (2014). EEG alpha power and creative ideation. Neuroscience and Biobehavioral Reviews, 44, 111–123. Elsevier Ltd.

[4] Folgieri, R., Lucchiari, C., & Cameli, B. (2015). A Blue Mind: A Brain Computer Interface Study on the Cognitive Effects of Text Colors. British Journal of Applied Science & Technology, 9(1), 1–11.

[5] Folgieri, R., Lucchiari, C., & Marini, D. (2013). Analysis of brain activity and response to colour stimuli during learning tasks: an EEG study. Proc. SPIE, 8652 (February), 86520I–86520I–12.

[6] Leone, L., Pierro, A., & Mannetti, L. (2002). Validità della versione italiana delle scale bis/bas di Carver e White (1994): generalizzabilità della struttura e relazioni con costrutti affini. Giornale italiano di Psicologia, 29(2), 413–434.

[7] Miltner, W. H. R., Braun, C., Arnold, M., Witte, H., & Taub, E. (1999). Coherence of gamma-band EEG activity as a basis for associative learning. Nature, 397(6718), 434–436. Nature Publishing Group.

[8] Pantev, C. (1995). Evoked and induced gamma-band activity of the human cortex. Brain topography, 7(4), 321–330. Springer.

[9] De Pascalis, V. (1999). Psychophysiological correlates of hypnosis and hypnotic susceptibility. International Journal of Clinical and Experimental Hypnosis, 47(2), 117–143. Taylor & Francis.

[10] Pulvermüller, F., Birbaumer, N., Lutzenberger, W., & Mohr, B. (1997). High-frequency brain activity: its possible role in attention, perception and language processing. Progress in neurobiology, 52(5), 427–445. Elsevier.

[11] Pulvermüller, F., Lutzenberger, W., Preil, H., & Birbaumer, N. (1995). Spectral responses in the gamma-band: physiological signs of higher cognitive processes? Neuroreport, 6(15), 2059–2064.

[12] Putman, P., van Peer, J., Maimari, I., & van der Werff, S. (2010). EEG theta/beta ratio in relation to fear-modulated response-inhibition, attentional control, and affective traits. Biological psychology, 83(2), 73–78. Elsevier.

[13] Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. Journal of research in Personality, 41(1), 203-212.

[14] Rodriguez, E., George, N., Lachaux, J.-P., Martinerie, J., Renault, B., & Varela, F. J. (1999). Perception's shadow: long-distance synchronization of human brain activity. Nature, 397(6718), 430–433. Nature Publishing Group.

[15] Torrance, E. P. (1989). Test di pensiero creativo (Torrance tests of creative thinking). In G. Sprini & S. Tomasello (Eds.), Firenze: Organizzazioni Speciali.

THE SOURCES OF ORNAMENTAL PATTERNS FOR INPUTTING OF MONGOLIAN ORNAMENTS INTO DATABASE[1]

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Abstract.

The "Source" is one of the classification parameters, according to which the data is entered into the Database of Mongolian ornament (DBO). Since by "Mongolian ornament" we mean the ornaments of the Mongols and the Buryats together, we consider published books in Russia and Mongolia. Russian books are few. In Mongolia, many books with patterns of ornaments have been published in recent years, but they are also hard to find in Russia. Therefore, digitization and the patterns input into DBO will help to overcome the lack of printed publications and will allow many people to learn the Mongolian ornament.

[1] This work was partially supported by the RFBR project 15-47-04328

INTRODUCTION

The work on the BDO creation has been held for more than 20 years, and all these years we collecting a library of books with patterns of ornaments. Buryat and Mongolian scientists from the 1920s redrawn samples of folk ornament, accumulated ancient clothes and household items. In later years some artists created their own patterns of ornaments. Only a small part of this rich heritage has been studied and published. Now, we have only about 20 books and albums on Buryat and Mongolian ornaments, the illustrations of which have been scanned. The images quality is various, mostly not good. Descriptions of ornaments are absent in almost all books, especially in the Buryat patterns. The literature contains the names only of the most frequently used motifs. The goal of this work is to review the sources and identify the problems of their processing.

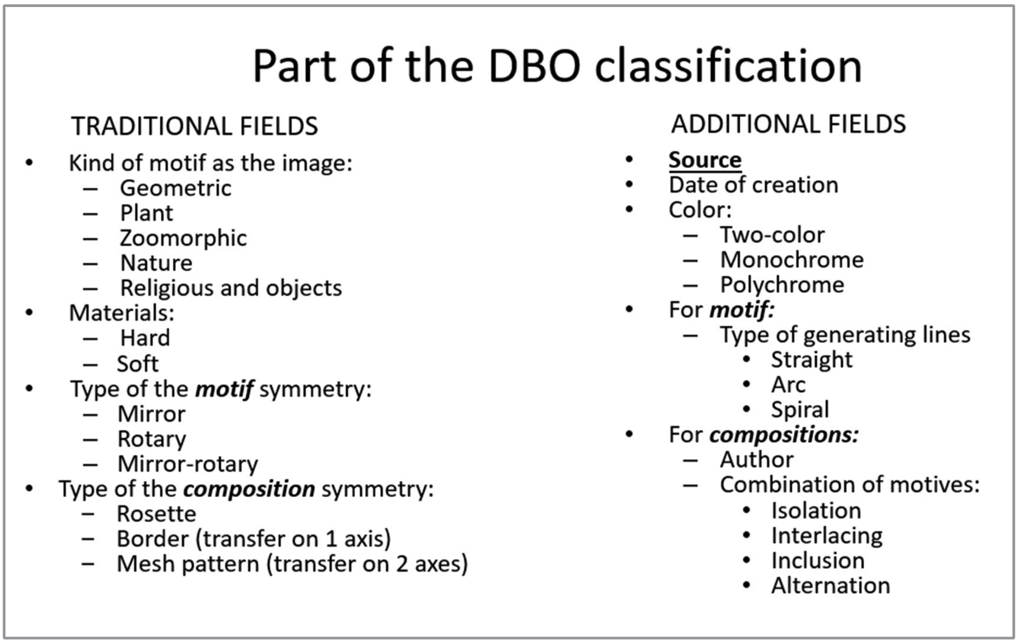

Figure 1. The some part of the ornament classification

CLASSIFICATION OF ORNAMENTS

Uniform classification of patterns has not yet been worked out, either in Russia or in other countries. Specialists are using different classification systems, depending on the purposes of the work usually. Expanded multi-faceted classification [1] has been created by us to inputting the DBO. Ornamental motifs and compositions are described by about twenty parameters, which have a different number of values, so the classification characteristics of the motifs and compositions are displayed in more than 50 fields (77 fields for the motifs, 51 – for the compositions). The parameter "Source" is indicated necessarily for both motifs and compositions (Fig. 1). The value is entered in the text field and represents the name of the printed publication from which the sample is taken.

SOURCES OF SAMPLES OF THE BURYAT ORNAMENT

In addition to the traditional collections of paintings, decorative and applied arts, sculptures, many museums are justly proud of their ornamental collections. In the Buryat Republican Art Museum there are collections of ornaments in the performance of the artist Ts. Sampilov (the museum is named after him now). The Center for Oriental Manuscripts and Xylographs of the Institute of Mongolology, Buddhology and Tibetology of the Siberian Branch of the Russian Academy of Sciences (COMX IMBT SB RAS) has a set of ornaments of the master Budzar Budayev and the other collection accumulated in the early 20-ies of the XX century by ethnographer P.P. Khoroshikh. No one, except for narrow specialists and guardians of funds, has seen these and many other priceless collections. Museum staffs do not have enough time, energy and desire to study these collections, however, access for outside interested persons is often not provided.

The books about the Buryat folk ornament are published very rarely. Most of them were printed in Soviet times, 20-70 years of the last century. This is the article by B.E. Petri (1884-1937), published on the basis of his expeditions to the Baikal region in 1912-1916 [2]. It has detailed the traditional Buryat ornament, the samples of which were preserved in those times without experiencing Russian or Lamaism influences. He considers the objects separately, depending on the patterning technique: 1) carpentry, which includes shaman boxes and singly – chests used in everyday life (abdar); 2) blacksmith's works – quivers, covers-for-bows (naluchnik), belts, etc. and 3) sewn work – coves for boxes in which the arrows is stored and which were used in wedding ceremonies (strelohranilische) and carpets. 93 figures illustrate this article – the photographs and redraws, i.e. exact copies of ornaments. All motifs B.E. Petri subdivides into I – “the sun and the moon”, II – “ram horns” and III – “geometric ornament”.The signatures to the patterns contain: the name of the motifs, manufacturing technique, the remoteness of making and dimensions (in proportions).

Archaeologist, historian and ethnographer, pupil and follower of Professor B.E. Petri, P.P. Khoroshikh (1890-1977) in the 1920s continued the work of the teacher to study the life of the Buryats, and published several articles about the ornaments. In work [3], 1926 edition, 11 samples of knitting wool stockings are presented. Angular forms of motifs are due to the drawing of facial loops, which were knited from different colors yarns. In the captions to the figures are indicated the name of the settlements of the Olkhon Island on the Lake Baikal, where the pattern is detected, and the remoteness of the origin of the ornament, which ranges 60-90 years (i.e., all the samples belong to the XIX century).Samples are presented in natural size, are about 10x15 cm, images are black-and-white, and their quality allows to consider the patterns well.

The next work [4], 1927 edition, describes ornaments of the same northern Buryats from the Olkhon Island, only made with embroidery technique. Here are 27 pictures. 10 of them demonstrate embroidery for the strelohranilische, 4 patterns are for fancywork of mittens, 7 - for high fur boots (unts), 3 - for embroidery of the upper dress, and only one sample for decorating the pocket of the gown, purse and saddle cloth. Illustrations are black-and-white. Clichés for printing were made by artists N. Nikolayev, K. Modzalevsky and P.F. Trebukhovsky. In the figure caption states: emblazoned subject name, ubiety, size, remoteness of making and sometimes – thread and the background colors and embroidery technologies – chain stitch or satin stitch.

After a long break, posthumously, an article [5] was published. It is relatively small, and is illustrated with images of all eight patterns for strelohranilische, only one of which is different from those presented in the article [4].

The most complete publication of ornaments from the collections accumulated by P.P. Khoroshikh, took place in 1974 [6]. An employee of the Buryat department of the Siberian Branch of Academy Sciencesof the USSR E.B. Batotsyrenova compiled this book. 157 black-and-white and color drawings of various patterns presented here over 50 pages. Some of decorations are grouped, and descriptions for 111 samples are given where it is indicated for what subject the pattern is designed, its ubiety, size, date and inventory number of storage. The names of the motifs are not given here.

Currently, the full archive of P.P. Khoroshikh is contained in COMX IMBT SB RAS. In 890 folders are stored priceless historical materials, including original drawings of ornaments, which the author has collected in the 20-30s of the XX century.We have the preliminary agreement with COMX IMBT SB RAS about the joint study of art collections from the fund of P.P. Khoroshikhand other authors.Our plan is to make scanned images of originals fordata input into the DBO, since the quality of printing is not the best in the reviewed publications.

After almost 100 years it is not completely clear how early researchers – B.E. Petri and P.P. Khoroshikh have identified the motifs. For example, they wrote that on the strelokhranilishche, the most different variations of the motif “ram horns” were used a lot. In our opinion, most of these patterns are more similar to the image of the pointed arrowhead and barb of the arrow, which is also logical for decorating these items. Undoubtedly, an additional study of the entire collection of P.P. Khoroshikh is required at a new level of knowledge and modern technical capabilities.

The next source is an album compiled by F.I. Baldaev (1909-1982) [7]. Here are composed the samples of patterns stored in the Museum of Art named Ts. Sampilov, Ulan-Ude.In the post-revolutionary years, Buryat artists traveled to the regions of Buryatia and redrawn ornamental samples from various items – chests, clothes, shoes. One of the first professional artists of Buryatia, Tsirenzhap Sampilov (1893-1953) created, in addition, his own patterns of ornaments, including signs of a new life in ornament – a hammer and sickle, a red star, Red Army men. From the more than 600 samples of the ornaments created by Ts. Sampilov kept in the museum, also the artist, and at that time the museum director F.I. Baldaev, compiled his own selection of Buryat folk ornaments, including in it more than 90 drawing of patterns and several sheets with images of female jewelry ornaments, a male set with a knife, a saddle. There are no descriptions of ornaments in this album. Despite this, colorful samples have served and serve as a desktop tool for many Buryat artists, folk artists and decorators, working in different techniques and with different materials.

Unfortunately, when working on the re-issue [8], we did not find many original sheets with ornaments. In the new book sketches of ornamental objects made by F.I. Baldaev were added. This is a knife and scabbard, a pouch, a tube, a cane, vases, a bowl and cutlery, a headrest (dere). In total, the book presents 94 samples. A short description has been added, including the kind of ornamental composition (border, rosette, panel), enumeration of the motifs names forming the pattern, their kind (geometric, vegetative, zoomorphic, natural) and types of symmetry.

Almost 20 years later, an album was published dedicated to the work of People's Artist of Buryatia Lubsan-Dorzhiev (1918-2011) [9]. During his great creative life, the artist formed many ornamental pictures in the style of Old Buryat painting and designed a lot of own ornaments. 100 of them are included in this album. In the description, there is information about the name of the ornamented item, the year of creation, the materials of manufacture and the size. All ornaments are made tempera on cardboard with a size of 40x50 cm. Unluckily, the quality of printing and paper does not convey all the beauty of the work, and the originals are currently inaccessible. Therefore, to input these samples in DBO, their scanning and careful processing are required.

Containing only 19 samples of patterns the small coloring book has been published the following [10]. In it and in the next work of the author [11], several ornaments from the private collection of the family of prof. S.O. Nikiforov, storing ornamental stencils, with which the unknown master from Zakamensky district of Buryatia worked. Also in the coloring book were used samples from the album of F.I. Baldaev [7]. The name of the main motif of the pattern in Russian and Buryat languages was given. These patterns were redraw in a graphical editor in the form of contours and presented in good quality.

In 2007, E.A. Batorova publishes her monograph, which as a whole summarizes the works of her predecessors on the study of the Buryat ornament [12]. The monograph contains more than 60 color and black-and-white illustrations from the collections of the art museum, mainly also with the works of P.P. Khoroshikh and TS. Sampilov, given a great theoretical and practical material. There are also works by other authors who studied the Buryat folk ornament - this is S.V. Ivanov, N.V. Kocheshkov, I.I. Soktoyeva, A.V. Tumahani, etc. We take into account their theoretical development, but we do not use image sources yet.

SOURCES OF MONGOLIAN ORNAMENT SAMPLES

The colorful album of the People's Artist of Mongolia Manibadar, published under the editorship of prof. Rinchen in 1974 [13] is one of the main sources of the Mongolian ornamental patterns. The album contains 92 sheets; there are more than 150 different patterns and images of several ornamented objects: unts, pouch, comb, ear protector, knife in scabbard, flint, yurt, tent. The album sheets are numbered, but there are no explanations to the patterns.

More than four hundred specimens of ornamental motifs given in the book of prof. Ts. Yadamzhav [14]. The publication is in the Mongolian language, black-and-white, print-quality is not well. The patterns are grouped by kind of motif in accordance with the above classification, where five types are distinguished: Geometric – borders and interlacing patterns; Vegetable – borders, rosettes and corners (more than 60 images of the lotus pattern); Zoomorphic designs – butterflies, birds, fish, lions; Natural motifs – mountains, clouds, stars, waves, a rainbow; Cult motifs.

In 2009, Ts. Yadamzhav reissues this book in revised form and translated into Russian [15]. The structure of the book is preserved, some black-and-white and colored ornaments have been added. It is possible to get a brief description of the patterns group, their symbolic meaning, origin are given. To input these patterns into the DBO after scanning, pre-processing is required – correction of lines and symmetry. Images of some rosettes are not complete, is ½ or ¼ from figure, so they must be redrawing to be the whole pattern.

For a long time we did not have other sources of patterns. In 2015, we purchased new books with ornaments published in the last few years in Ulan-Bator [16-21]. These more modern publications have texts in two languages – Mongolian and English, the book [21] additionally has Chinese text.

Two books by B. Bold (each 240 pages) have black-and-white illustrations. They contain classical samples of Mongolian ornament. The content is broken into chapters. There are 8 chapters in [16], five of them are devoted to five kinds of ornamental motifs, similar to the above classification. The following three chapters are devoted to: Ornament for decorating traditional clothes and footwear; Ornament for household items – teapot, pitcher, flask, silver bowls, patterns on the front side of the chests; Decorative ornament for banknotes, postage stamps, uniforms of the National Army, book graphics. The book [17] describes the decor of Mongolian architecture. There are 6 chapters in which you can see the decoration: of the Mongol ger, of Mongolian monasteries and temples, stupas, interior decoration of the Mongolian government house, architecture of modern times and decoration of the fences. At the beginning of each chapter there are brief explanations, there are no descriptions of the samples.

Ch. Bayarmaa's books are interesting in their own way. Each of them shows a distinct motif of the ornament – interlaced patterns ulzii [18], puuz, lanz and swastika motifs [19] and the flowers (lotus) [20], all books are 96 pages long. This artist has published numerous own variations of popular motifs, performed in a bright colorful manner. In the books there are short forewords, no descriptions of ornaments are offered.

In addition, the last book that we want to present to the attention of the reader is the editionby T. Jadambiin [21]. This book contains selected ornaments that have been crafted and constructed for the last years by himself, his students from Setgemj Design Institute and his daughter. 168 pages contain 402 very interesting and very complex ornamental compositions in the style of M. Escher. T. Jadambiin describes the technique and expresses the hope that readers will enrich their perception and understanding about ornaments and provide an opportunity to acquire knowledge and skills to create your own ornaments.

Thus, we have enough samples of both Buryat and Mongolian patterns, which for all their similarity have their own individual characteristics. For the patterns input in the DBO, careful selection and preparation of drawings is necessary. After scanning the page, separate ornaments must be cut out; the pictures are then displayed in a human-readable form – contrasting, without blots, with clear lines. We plan to introduce in the DBO about 3000 samples of ornaments and characteristics to them. In addition, we assume that the described sources will be enough to present on the Internet all the completeness of information about the ancient and developing ornamental art of the Mongols and Buryats. Undoubtedly, it is necessary a further study and introduction into scientific circulation patterns of ornaments that are kept in the COMX IMBT SB RAS, National Museum of the Republic of Buryatia, which now unites the Ts. Sampilov Art Museum, M. Khangalov History Museum and other divisions and in others Museums.

References

[1] T.V. Kocheva,“Electronic tool for studying and keeping collections of the folk ornaments”,Book of the All-Russian Scientific and Practical Conference "The Art of the Siberian Peoples: Past, Present, Future",pp. 94-98, Oct. 2004.

[2] B.E. Petri,“Ornament of the KudinBuryats”, Collection of the Museum of Anthropology and Ethnography named after the Great Peter at the Russian Academy of Sciences, Vol. 5, rel. 1, pp. 215–252, 1918.

[3] P.P. Khoroshikh,“Materials on ornament of the Olkhon Buryats. Woollen stockings”, pp. 6,tab. 11, 1926.

[4] P.P. Khoroshikh,“Ornament of the Northern Buryats. Issue 2. Patterns on the sewn works”, pp. 9, ill. 22, 1927.

[5] P.P. Khoroshikh, “Ornamental motifs on the quivers of the Olkhon Buryats”, Material culture and art of the Transbaikalian peoples. Collection of articles,pp. 38-41, 1982.

[6] “Buryat household ornament”, Comp. E.B. Batocyrenova, 62 p., 1974.

[7] “Buryat national ornament”, Comp. F.I. Baldaev, 64 p., 1972.

[8] “Buryat national ornament: album”,Comp. F.I. Baldaev,80 p., 2016.

[9] “Buryat Pattern in LubsanDorziev’s works”, Comp. I.S. Baldano 126 p., 1992.

[10] T.V. Kocheva,“Buryat ornament”, Issue 1, 16 p., 1995.

[11] E. Batorova and T.Kocheva, “Ornamente und Schablonenaus der Sammlung der Familie Nikiforov ”Mongolische Notizen, S. 90-94, Nr.12/2003.

[12] E.A. Batorova,“Buryat ornament in the XVIII-XX centuries”, 164 p., 2007.

[13] Rinchen,“Pearls patterns of Mongolian folk ornaments. (Album)”,92 p., 1974.

[14] Ts. Yadamjav, “Original contour of Mongolian national patterns”,96 p., 1985.

[15] Ts. Yadamjav, “Mongolian national ornament”,162 p., 2009.

[16] B. Bold,“Mongolian national ornament”, 240 p., 2011.

[17] B. Bold, “Decoration of the Mongolian Architecture”,240 p., 2014.

[18] Ch. Bayarmaa,“Mongolian national ornament. Ulzii patterns”,96 p., 2010.

[19] Ch. Bayarmaa,“Mongolian national ornament”,96 p., 2013.

[20] Ch. Bayarmaa, “The flower art”, 96 p., 2013.

[21] J. Tumurkhuyag,“Creative methods of inventing ornaments”, 164 p., 2010.

DATA VISUALIZING POPULAR SCIENCE FICTION MOVIES WITH USE OF CIRCULAR HIERARCHIAL EDGE BUNDLING

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Abstract

In this article, a specific type of data visualization method called Circular Hierarchial Edge Bundling has been utilized to investigate a subjective discussion on determining the most commonly observed themes in the popular Sci-Fi Movies. To reflect people's opinions on the subject, a website (www.dystopia-utopia.com) has been designed to invite larger communities to participate in with filling an online form to deliver their judgements. Data Visualization methods and the research results are elaborated in further details.

INTRODUCTION

With the rise of the ability to collect vast amount of data from multitude of communication resources, data visualization has been a promising field within the visualization sciencesover the past decades [1]. Used as an analytical tool to comprehend simple solutions from a set of complex structures, data visualization is an interdisciplinary field that has copious implementations including business analytics, network monitoring, complex behavior analysis, air trafficing etc. Data visualization refers to configuring computational methods to attain interpretive results from complex data sets in visually explicit forms. It is a method of information investigation and turning raw data into a well-formed information. In this respect, this field embodies research from diverse fields of interests, such as Computer Science, Visual Design, Interaction Design and Human Computer Interaction. No matter how complex the structure of the problem is, it is evident that the final effort is always to gather simplified information with use of appropriate visualization techniques. Even though the attempts to discriminate visually appealing results from the similar conclusions are challenging to qualify, some criterias are quite evident to overcome basic problems such as cluttering, congestion, ambiguity etc [2].

Use of graphs have been a common method to combine multiple entites as connected networks within a shared framework. When these graphical relations are utilized, the appropriate positioning of nodes and the methodical arrangement of graphical forms of edges plays a crucial role in determining a refined analysis. During the process of linking data graphically, according to Zhou [3], use of edges is an essential tool to structure data with the use of representative graphs, trees and nodes. However,in a large set of observations, when these relations are to be developed on a graphical representation in a limited amount of space, the final analysis is prone to be introduced with visual cluttering problems.Visual cluttering is a certain kind of aesthetic pollution that diminishes the capability of proper apprehension and results in distraction and discomfort.

To remedy this situation different methods are in use such as implementing compound graph visualization, edge routing and edge bundling [4], [5]. Abstraction of clusters, use of transparent edges are alternative solutions to overcome these visual cluttering problems, but particularly in this study to enhance the visual aesthetics a visualization method named Circular Hierarchial Edge Bundling was implemented as an interactive online content.

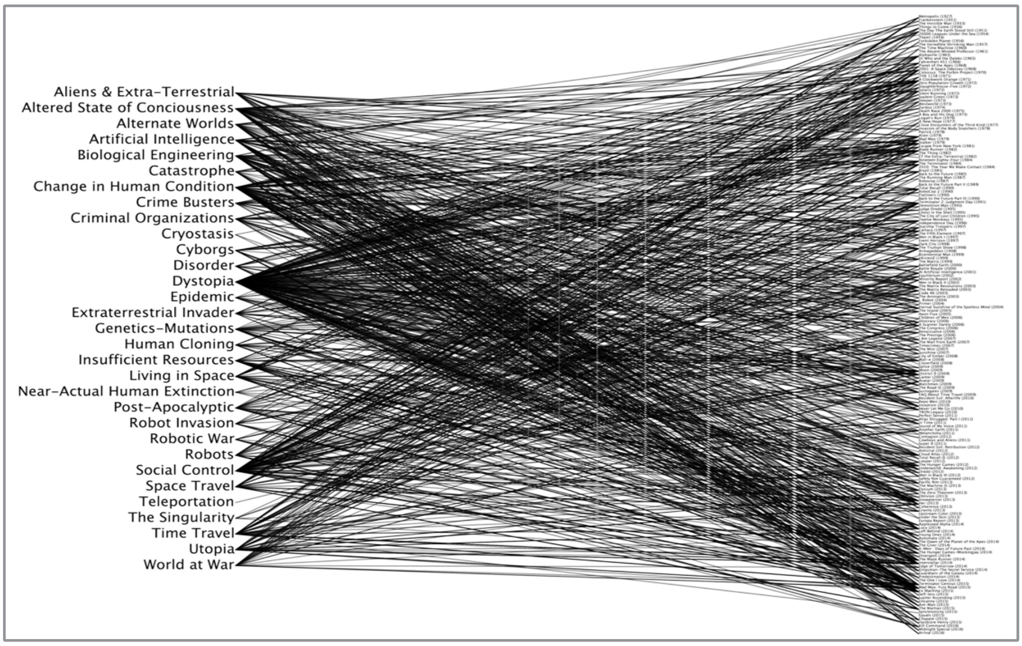

Figure 1. Visual Cluttering Problem

IMPLEMENTATION OF CIRCULAR LAYOUTS

As it is observed from the figure above, it is evident that from the set of multiple connections it is laborious to circumvent visual cluttering problems with use of Parallel Coordinates Plot. In Parallel Coordinated Plot, when the interconnected lines are graphed, altough it becomes much clearer to observe the accumulation behaviors inside the data set, yet there are problems on ambiguity and cluttering to a notable degree. Moreover, a substantial problem of inefficient use of space arises with the use of this visualization method. It becomes very difficult to list all the node names in a constrained vertical space. As an alternative option, circular layout is a much more efficient method to visualize massive amounts of data [6]. Circular layouts enable the node names to be spreaded on a circular orientation, so as a result it reduces the amount of space utilized on a single directional axis drastically. Therefore, circular orientation of the nodes prohibits the implementation of linear connections to be drawn for visualizing the relations. Thus, nonlinear bending structures such as Bezier forms are preferably considered to be used inside the circular peripheral. Bezier curves have certain parametric structures to manipulate their orientations and visual forms. The control points are regardedas quantifiers to demonstrate certain type of weight relations between the connecting node entities. Particulary in Hierarchial Edge Bundling, the adjacent edges are bundled together to lessen the visual cluttering due to the tangling of connections.

As Holten [7] states the pipeline behind the Hierarchial Edge Bundling idea follows a similar principle of grouping cables and merging them into bundles to avoid messy organizations and to ease solutions for lost track of connections between node points.

RESEARCH METHODOLOGY

It is more common to observe that in many data visualization applications a quantitative set of data is provided to the visualization process. On the contrary in this research, the main analysis involves issues of making subjective decisions on determining relations between themes and sci-fi films. In order to collect a rich data set, an open call has been announced online to deliver people's opinions on the subject matter. Volunteers may participate actively in the data collection process. With the use of a web based online form, the participants are asked to select films from a given list and match the film with a set of theme names provided. When the selection and matching process is achieved, the results are submitted to the server and recorded as an entry in a database structure. Then the visualization algorithm refers to the database to create the data visualization layout based on Hierarchial Edge Bundling methods. In order to increase the people's motivation by making the participation as easy as possible, no other further questions concerned with their identity is included. If the user would want to deliver his/her opinion on the project, they are able to fill in an empty text box to provide more information. Moreover it is observed that the users are willing to recommend new films and genres to the system.

Interaction scenarious in the visualization layout enables users to get deeper information about the included

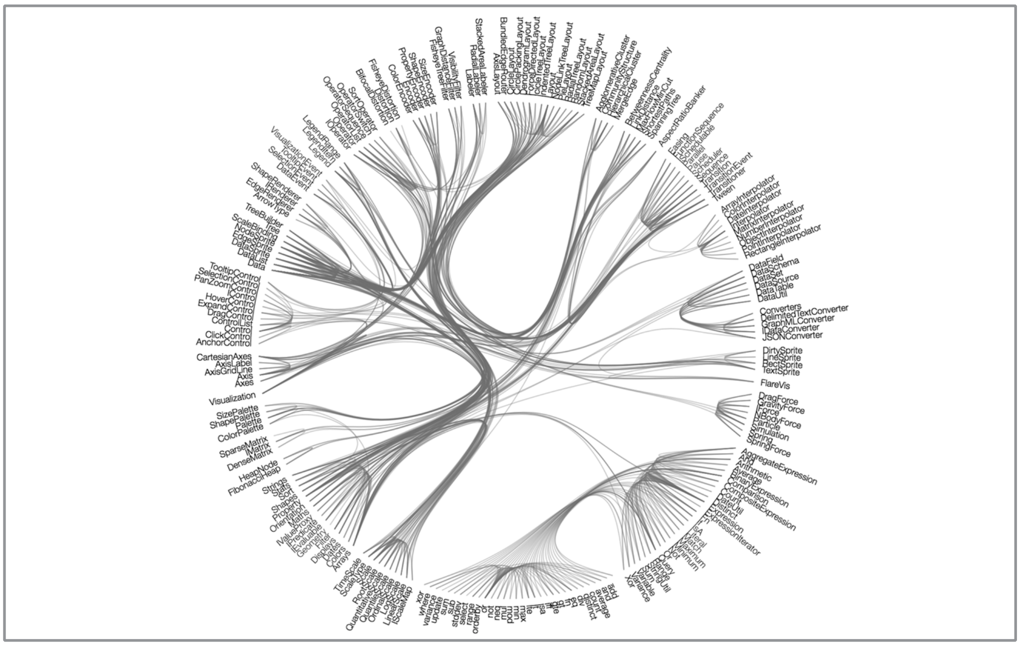

Figure 2. Circular Hierarchial Edge Bundling

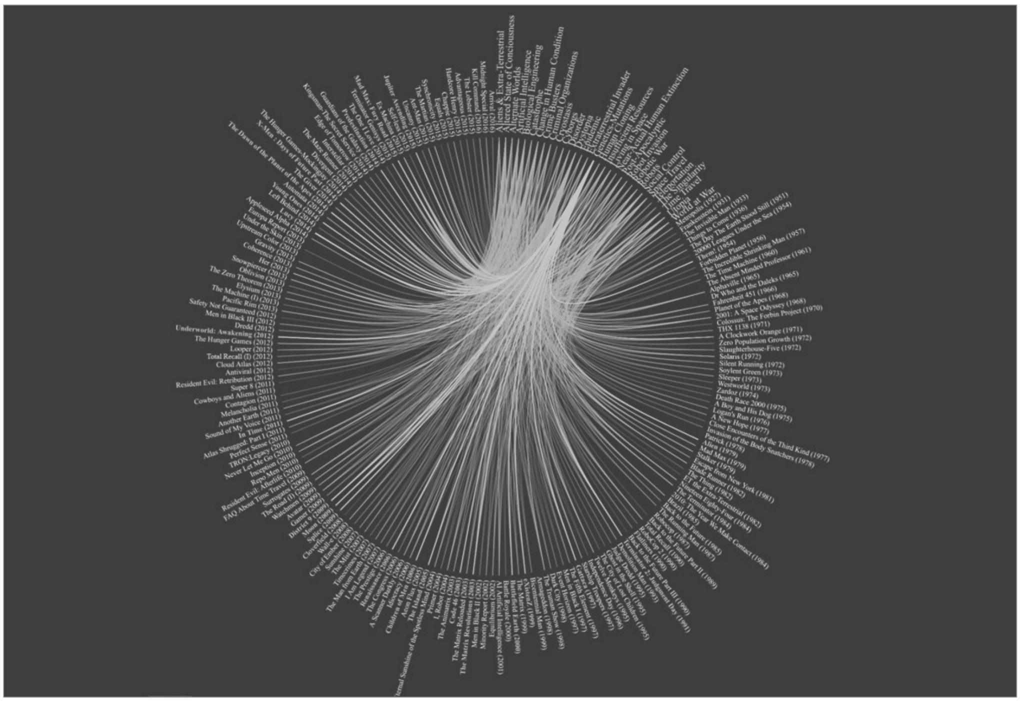

Figure 3. Interaction Scenarios

list of films. As soon as the user double clicks on a film name, a secondary browser window is triggered and a relevant IMDB website page is opened for the user to investigate more on the film with watching a trailer, or reading a synopsis etc. Alternatively as the user single clicks on a film name or a theme name, all existing relations are highlighted with the use of a different color either red or green to enhance visual apprehension.

Participant's inputs are handed over automatically to the database on the server. Until 29th of May 2017, there have been 1360 user opinions recorded as an input to the system. With the inclusion of the user's recommendations, there are 32 film theme names and 121 film names available. During the selection of the films to be included in the list, there have been certain criterias accepted. First, the films have to be tagged as Sci-Fi in IMDB website.

IMDB is one of the most popular and the richest source for movie content to be explored online. Since the analysis of this research has been focusing on asserting an opinion for popular Sci-Fi movies, IMDB stands as an conveniet resource to be considered. Second, the films chosen has to be rated as minimum 5.0 out of 10. This allows employing a certain filtering to reduce the amount of Sci-Fi films listed on IMDB website. Similar to the above discussion, since the main goal in this research is to achieve a popular point of view, the better ranked films are preferred instead of including vast amount of Science Fiction movies.

RESULTS

According to the final analysis based on the participants opinions, particular theme names are standing out compared to the total number of theme names. The theme "Dystopia" is by far regarded as the most popular theme in Science Fiction Movies. Later the theme of "Social Control" has been selected as the second most popular theme in the list. The third most popular theme has been selected as "Change in Human Condition". This analysis can easily be ascertained by looking at the Data Visualization method implemented on the data set. When analysed, one may observe a coarseness of an artery directing towards the Dystopia theme. The highest rate of votes have been provided to the movie entitled Mad Max Fury Road (2015). Nevertheless what makes a Sci-Fi popular has a lot to do with certain type of emotional and sensational elements exerted in the film. Feeling of worriedness, state of uncertainity are the main indispensablefactors for a Sci-Fi film to be delivered as enthusiastic. Similarly the audiences are dominantly interested in seeking future scenarios based in Sci-Fi movies. In that respect combined with the exposition of anxiety, "Dystopia" stands as one of the most visited themes in the popular Sci-Fi movies.

References

[1] Keahey, T. Alan. "Using visualization to understand big data." IBM Business Analytics Advanced Visualisation (2013).

[2] Luo, Sheng-Jie, et al. "Ambiguity-free edge-bundling for interactive graph visualization." IEEE Transactions on Visualization and Computer Graphics 18.5 (2012): 810-821.

[3] Zhou, Hong, et al. "Edge bundling in information visualization." Tsinghua Science and Technology 18.2 (2013): 145-156.

[4] Telea, Alexandru, and Ozan Ersoy. "Image-Based Edge Bundles: Simplified Visualization of Large Graphs." Computer Graphics Forum. Vol. 29. No. 3. Blackwell Publishing Ltd, 2010.

[5] Lambert, Antoine, Romain Bourqui, and David Auber. "3D edge bundling for geographical data visualization." Information Visualisation (IV), 2010 14th International Conference. IEEE, 2010.

[6] Gu, Zuguang, et al. "circlize implements and enhances circular visualization in R." Bioinformatics (2014): btu393.

[7] Holten, Danny. "Hierarchical edge bundles: Visualization of adjacency relations in hierarchical data." IEEE Transactions on visualization and computer graphics 12.5 (2006): 741-748.

Section 3.
Culture, Art & Education

VIRTUAL MUSEUM AS A PART OF DESIGN EDUCATION

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Abstract

The article is devoted to the idea of a virtual museum usage for the education and training of design specialties students. The idea is that separate modules or "halls" dedicated to the design of different epochs and countries are created to study the history of design development.

INTRODUCTION

Students of the Department of Graphic Technologies of ITMO University will have the opportunity to engage in design and computer technologies in their professional activities. The training program

To attract attention and sustained interest of modern students, it is important that visual material was presented in an interactive form, using the latest technology. Therefore, the format of virtual museum was chosen as an additional visual material on the history of design. It is assumed that the hall of a virtual museum can exist as WEB-site, or as a separate file that can be downloaded to a computer.

We decided to start implementation of the virtual design museum, the idea of which was discussed at the previous conference. At the same time, the process of creating the modules of the museum has become an important element of training for students working on this project. As examples of the idea's realization, the report presents two projects fulfilled by the students of Graphic Technologies Department (ITMO University). During the project, the students were required to select materials themselves and create 3-D models of exhibits, using their form analysis and computer visualization skills. This work helps to understand better the intentions of classics of design and acquire additional skills and knowledge in the computer technologies.

The article briefly describes the process of two modules of the Museum creating. The first one is a site with virtual 3-D exhibits, dedicated to the industrial design of Bauhaus School in Germany. The other room of the virtual museum is devoted to the "space" design in the USSR.

"BAUHAUS" MODULE OF THE VIRTUAL DESIGN MUSEUM

In 2019, Germany will be celebrating the centenary of the founding of the Bauhaus, together with partners all over the world. The school of design only existed for a total of 14 years. Despite this, the influence of the Bauhaus continues right down to the present day all over the world [1].

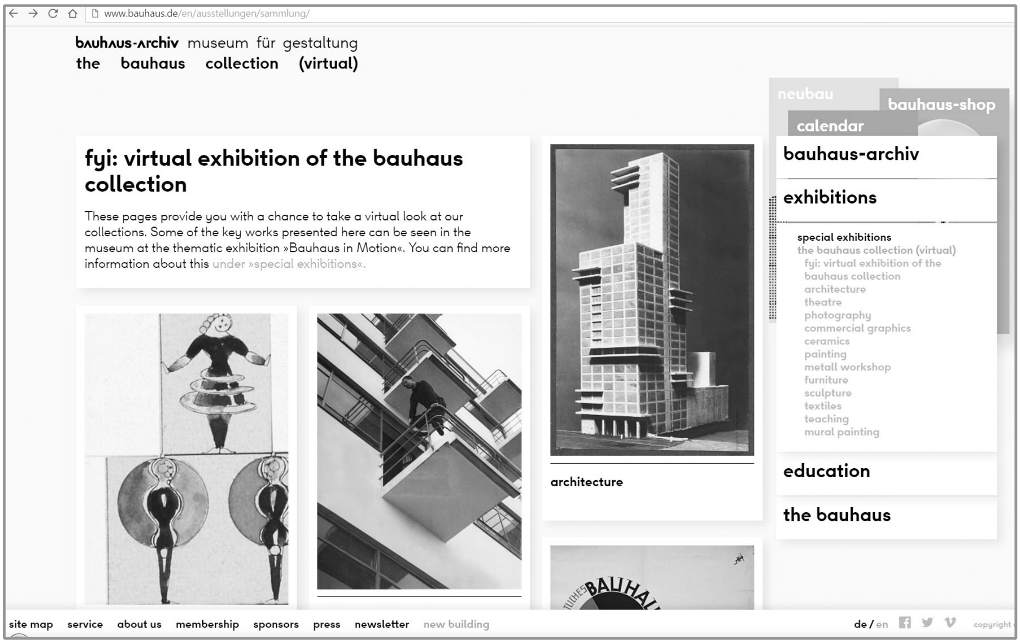

Figure 1. WEB-site *http://www.bauhaus.de* page with the exhibition catalogue

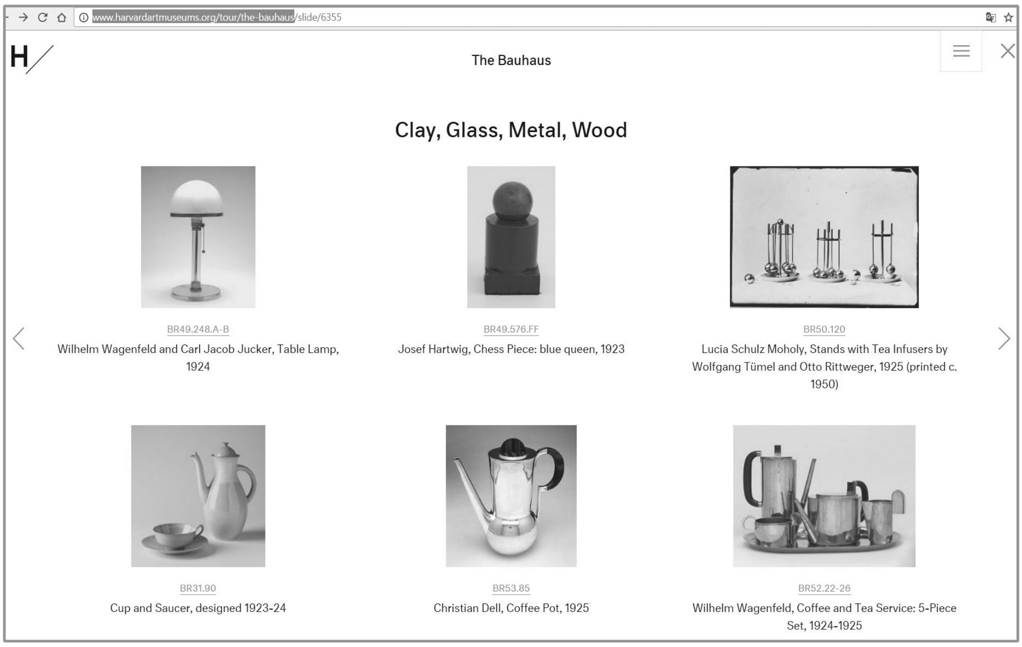

Figure 2. *http://www.harvardartmuseums.org*

We didn't find analogues of virtual museums with 3-D exhibits, dedicated to the Bauhaus, in the part of the Internet that we have studied. There is an official site of the museum and archive. But there is no way to examine the exhibits in volume, from all sides.

A lot of interesting documents and photos are presented on the http://www.harvardartmuseums.org site, but there are also no 3D exhibits.

It was decided to make the module in such a way as to immerse the viewers in the visual environment of the Bauhaus era and give an opportunity to get acquainted with the famous designers' masterpieces. We chose the format of the site for the museum, supplied not only with texts and photographs, but made the gallery in the form of a time scale and each exhibit was presented as a 3-D model. The design of the site is made in the

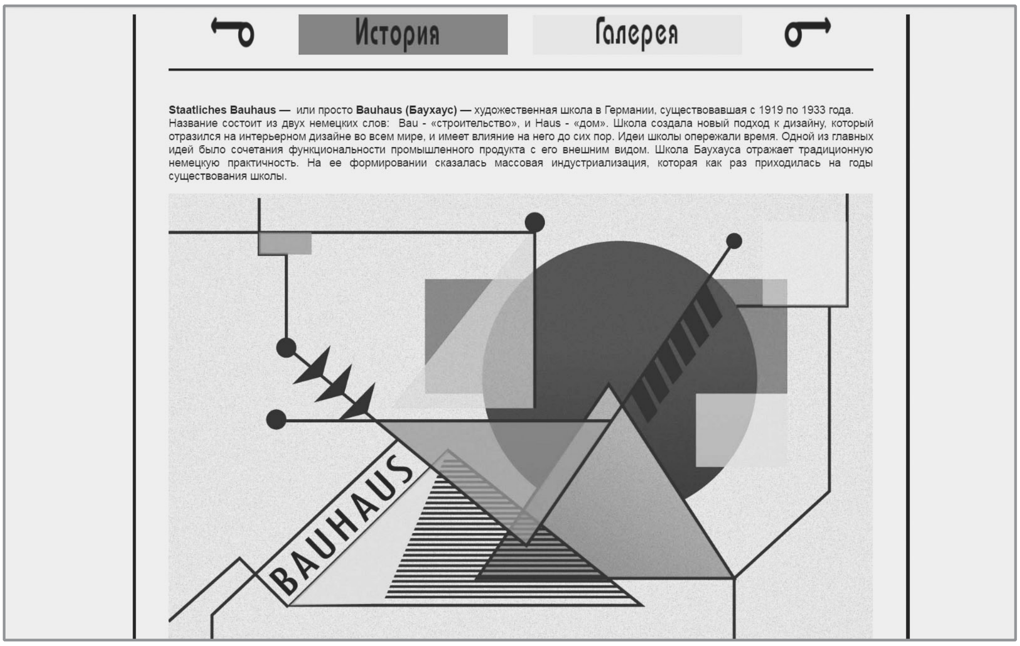

Figure 3. *bauhausmuseum.ifmo.ru* main page

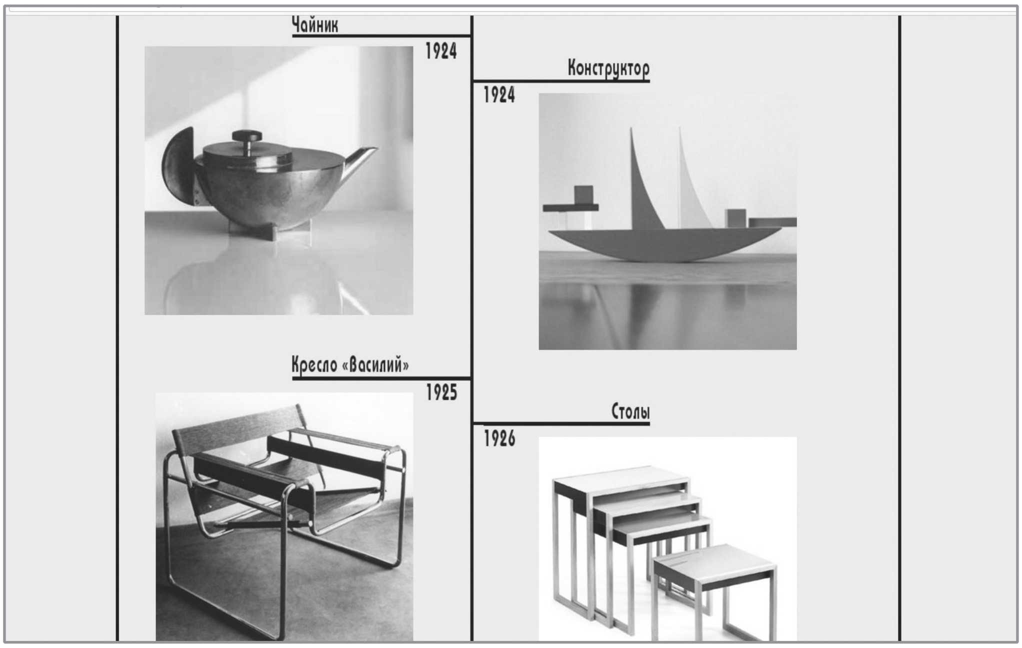

Figure 4. *bauhausmuseum.ifmo.ru* gallery page

graphic works of the Bauhaus style. Our site has the address bauhausmuseum.ifmo.ru now.

An introductory lecture on the Bauhaus history is placed on the starting page of the site with vertical scrolling. To navigate through sections, a menu is designed at the top of the pages.

The "Gallery" section - a time scale with exhibits – is following. The exhibits are arranged in the order in which they were created to show how the style changed over time. Through the gallery one can select to view any of the presented objects and move to its page. The choice of objects for the gallery based on the need to show the symbolic, epoch-defining and style things. On the exhibit page one can see the model, read information about the object and see historical photographs, as well as additional text material. The model window, allows

Figure 5. An exhibite page.Window with 3D model (top left)

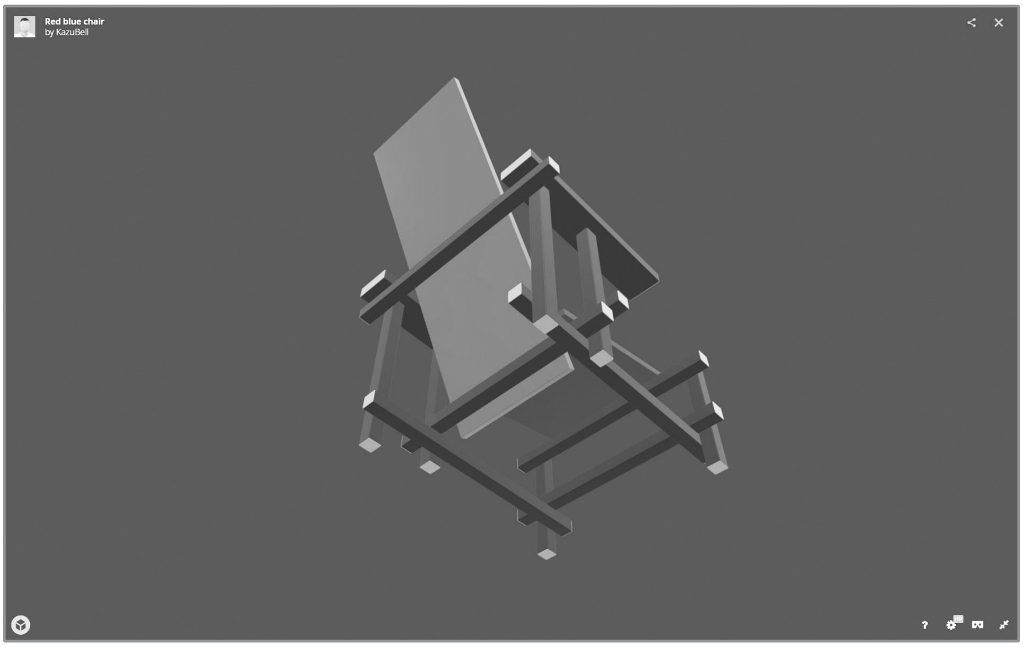

Figure 6. A model in full-screen regime

to open full screen mode and rotate the exhibit in any direction with mouse movements.

3D-models creation required a certain research work: the selection of photographs of the objects in different angles, descriptions of objects, as sources of information about the color, texture and design of objects. The models were created in 3DS max. For this, historical photographs, drawings, photos of modern replicas, descriptions of objects, were used according to the author's opinion. The basic proportions of the models were calculated from the photographs with the projection view. All three-dimensional models were downloaded to the SketchFab site, so that it's easy to get familiar with them on the web.

The site can be viewed from a desktop computer or mobile devices.

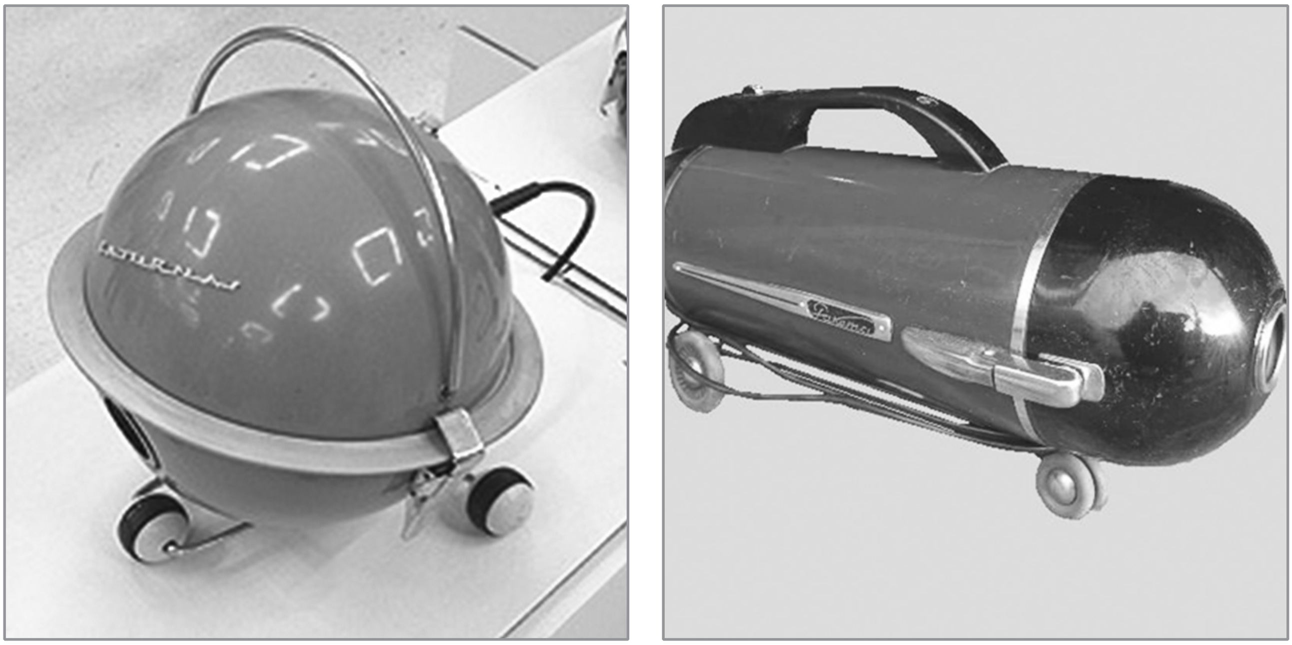

Figure 7. Vacuum cleaner “Saturn” (1962), Vacuum cleaner “Raketa”

Figure 8. Pedal car for children “Raketa”, 1950-th

"SPACE" DESIGN IN THE USSR” MODULE OF THE VIRTUAL DESIGN MUSEUM

The choice of the "space" design in the USSR” theme is associated with the interest to one of the most interesting and original periods in Russian design of the 50-70s of the 20th century. The era of the initial conquest of space and the fashion for everything "cosmic" in the USSR coincides with the emergence of industrial design as a kind of creative activity. Films about space were made, songs were composed, and space images were used in architecture, sculpture, decorative art, painting. Products of industrial production of utilitarian household purpose, but in the form of spaceships or planets, also appeared.

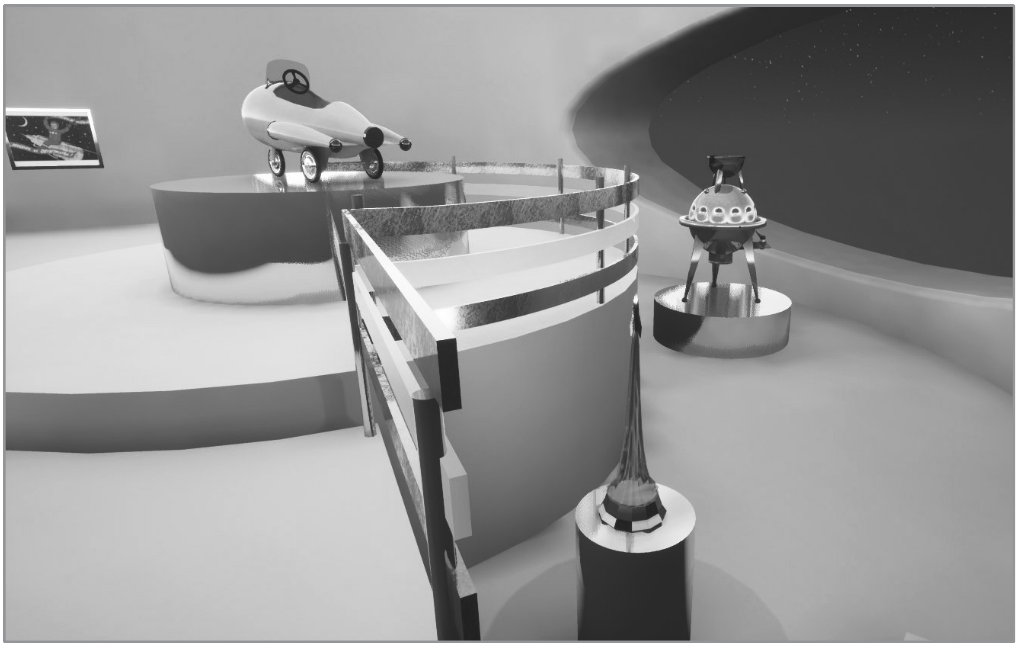

Figure 9. Virtual hall (fragment of exhibition)

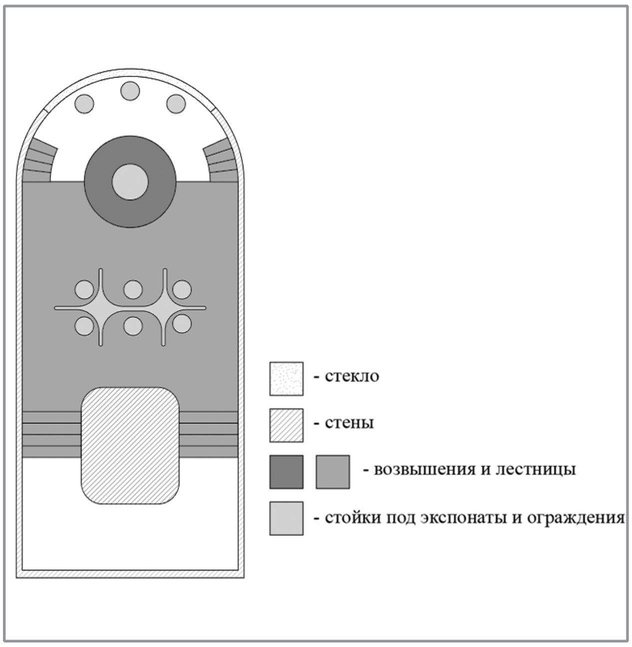

Figure 10. Plan of exhibition hall (scetch)

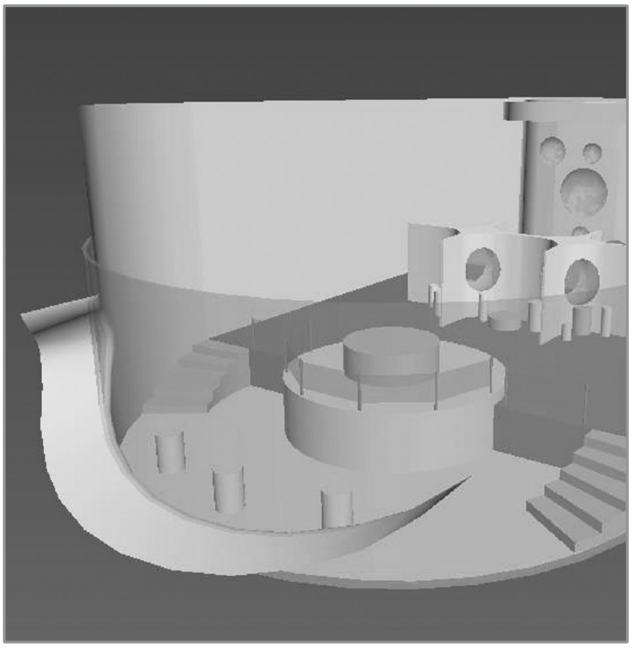

Figure 11. Result of exhibition hall modelling

A great number of printed productions, devoted to the space exploration, were published. The cosmic theme found its embodiment in the packaging design. Children's and Christmas toys were manufactured in the form of rockets and cosmonauts.

Collections, representing "space" products, can’t be found in any of the museums, although some items can be seen at different exhibitions. It is possible that many of these things are still stored in many families, but, unfortunately, they remain less. We wanted to preserve the memory of the legendary era, reflected in simple objects of everyday life of “common soviet people” [2], using the technology of virtual museums. At the moment, our museum of "space" design is implemented without posting on the Internet.

An analysis of various museum sites was carried out to choose the optimal virtual format of the exposition

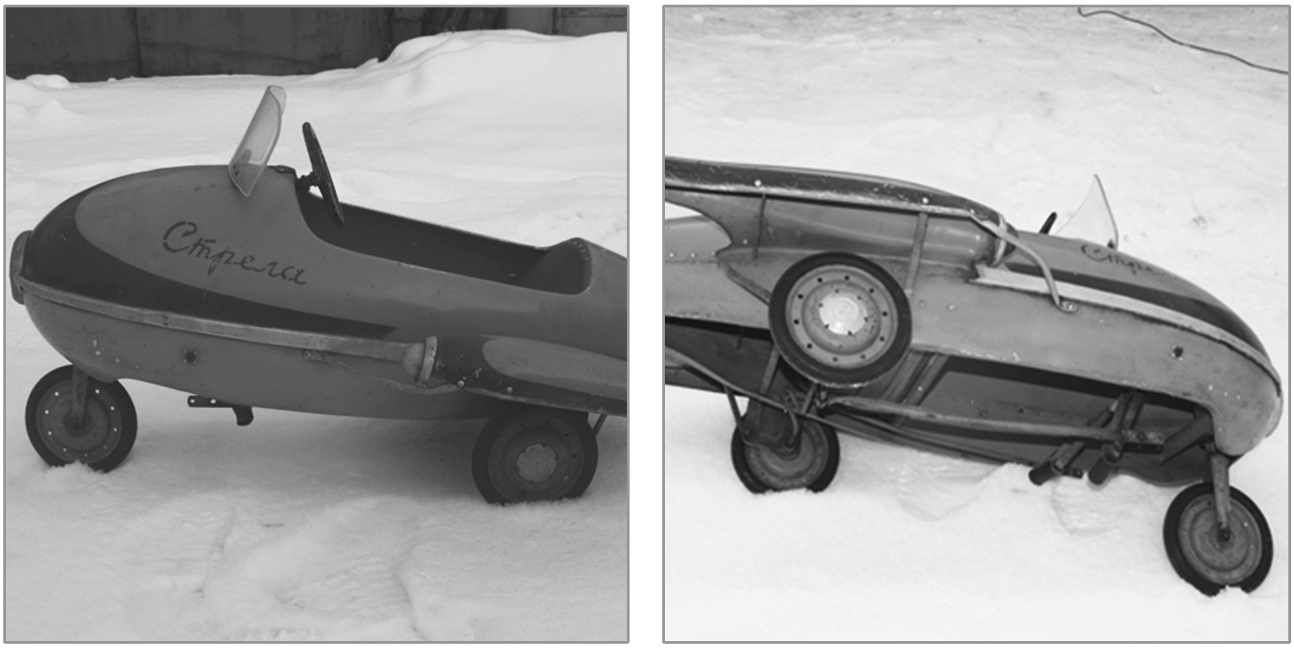

Figure 12. Photos of pedal car for children "Strela" ("Raketa")

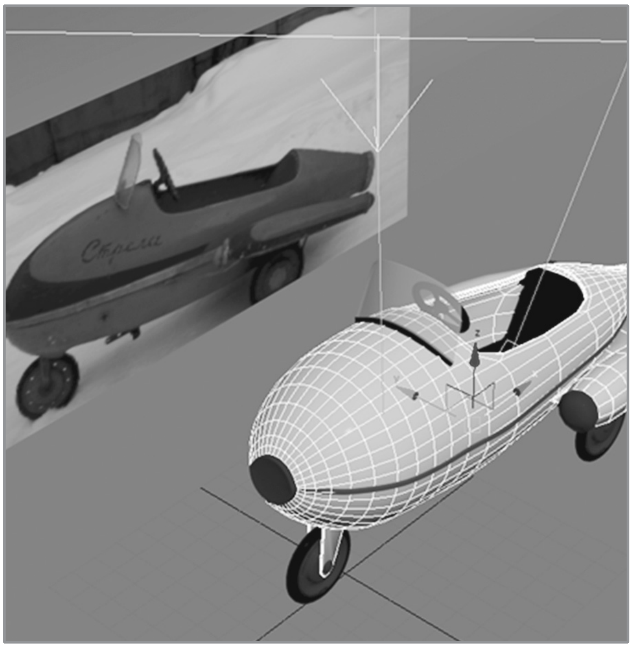

Figure 13. The modelling process

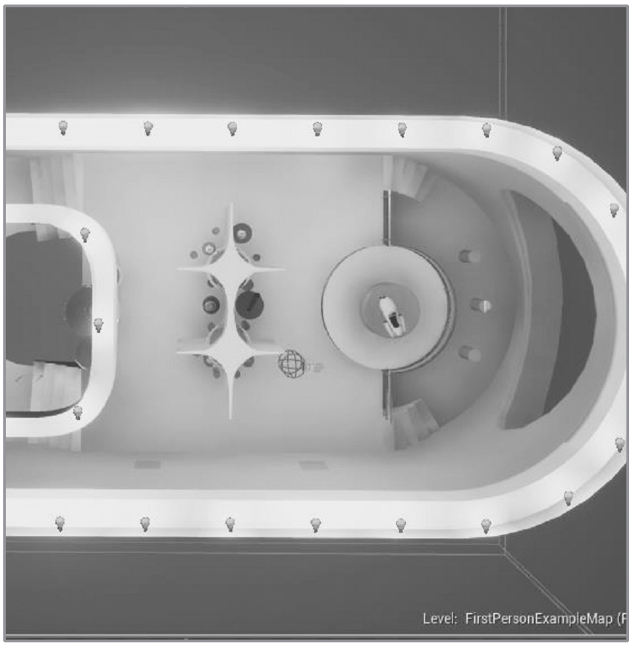

Figure 14. Lighting modelling

and the way to present the exhibits. Now the "virtual museum" term is understood as a 3D space, synthesized on a computer. An excellent example of such a museum is the Virtual Museum of Valentino Garavani (http://www.valentinogaravanimuseum.com/enter-the-museum). The museum consists of many rooms-locations with their own specific design. The very space of the museum departs from real architecture of the museum buildings. Moving around the museum resembles computer games. "Visitors" are allowed to walk around the museum space and turn the "head" in all directions. We used this example as an analog of the technical implementation of the project.

The exhibits of the virtual museum are industrial products that were designed in the 1960s and 1970s in the USSR and which clearly reflect the style and images of

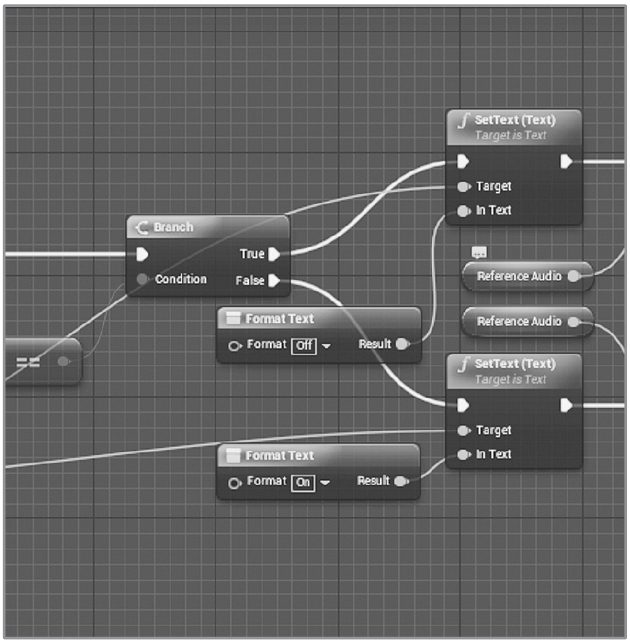

Figure 15. Menu development

Figure 16. Museum “hall” screenshot

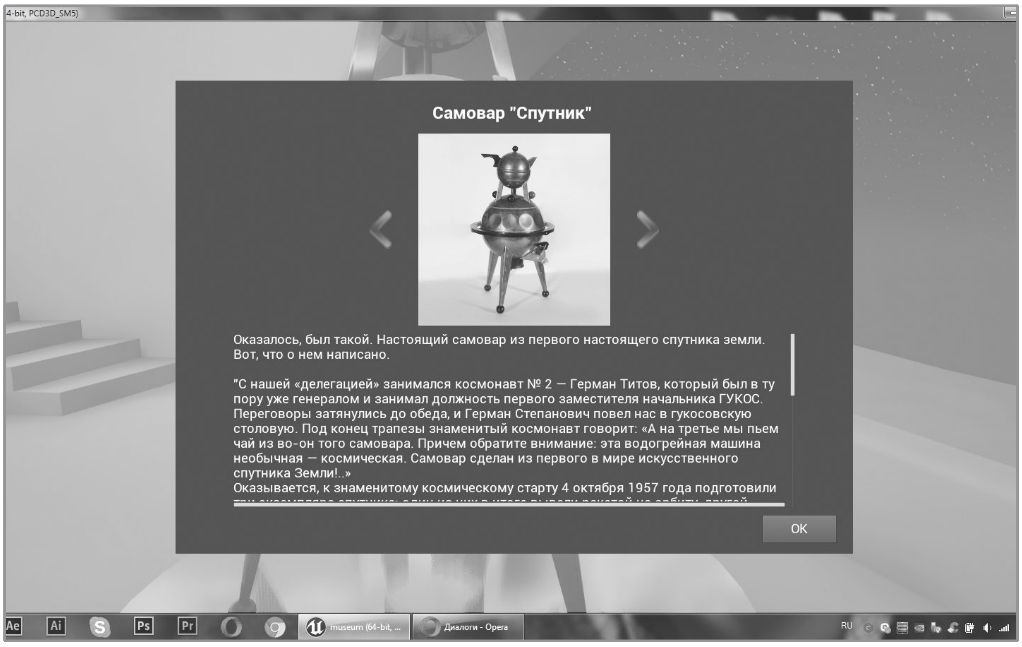

Figure 17. Screenshot with the information tablet

the space age and are examples of quality design. In total, we selected 9 exhibits and several posters. For each of the selected exhibits, a mini-research was conducted in order to present information in the museum in the most accurate and interesting way. The style and forms of the futuristic interiors of spacecraft scenery from Soviet films about space (“Solaris”, “Moscow - Cassiopeia”) were used for the concept of the virtual hall design.

The museum exists as in a form of application that can be installed on a computer as a game.

Autodesk 3ds max was chosen for modeling the hall and exhibits. It is a widely used professional product for 3D graphics creating and editing. To interact with the environment, the game engine Unreal Engine 4 was chosen.

First of all, the space of the hall was modeled. Sketches were made in Adobe Illustrator.

Exhibits, unlike the exhibition hall, were real objects. Therefore, it was very important to model them as accurately as possible, using several projection views. Of great value were side-view photos that were imported into the program for the most accurate modeling.

After all 3d models were ready, they were imported to the game engine Unreal Engine 4. At this stage, the collision was adjusted, the light was tuned, and the textures were applied. The interface also was

In order for the game engine of the Unreal Engine to perceive the models, it was necessary to create UV scan using the Unwrap_UVW modifier for each model. Sweeps can be also done with with projections (on a plane, on a ball, on a cylinder or a cube). To do this, one should select the desired polygons on the model and apply the most appropriate of the projections. After preparing the models, the files should be exported to FBX. It is more convenient to export each model to separate files, for simplified orientation in Unreal Engine in the future. To configure the collision, the standard automatic creation of collisions in Unreal Engine is used, if necessary, they can be corrected manually.

Since no object movements within the project were planned, it was necessary to create static lighting. The light was calculated and built into the textures of objects. The lighting source was PointLight, as it fits most for the main light source (illumination around the perimeter).

For correct interaction with the sound file, we turned it into the wave format. This can be done online – by audio tracks converters. After import, one need to create a Sound Cue, for easy access to the sound through the Blueprints Visual Scripting and more correct settings in the sound file itself. The sound is turned on automatically with the beginning of the session, further tuning can be done through the system of the Blueprints Visual Scripting.

Within the framework of this project, the following interface elements were necessary: menus, information signs, information labels and inscriptions calling for action. Menu and information signs could be called up by pressing the required keys, and all the inscriptions should be highlighted when approaching certain objects. For this, several Widget Blueprints were created. One of them was responsible for the menu, the second for the information signs, the third for the information inscriptions and the fourth for the inscriptions calling for action.

To convey the atmosphere of the mid-20th century, it was decided to use wall posters about space and a soundtrack.

Control is provided with computer's keyboard and mouse. When approaching an exhibit, one can press the key to call up on the screen an information tablet with the text about it and photos.

Thus, we have a room of a virtual interactive museum, which reconstruct the atmosphere of the era of "space" design in the USSR.

CONCLUSION

Modules of the design museum can serve the purposes of education and education of specialists in the field of industrial design. Modern IT technologies allow realization of a project on virtual design exhibitions creation that promotes more active involvement of students in the learning process. Each country where design works were created can be represented in a virtual museum as a participant in a common cultural and historical process, which will present a picture of the global development of industrial design [3]. Participation in the implementation of this project will be a good school for young people studying new technologies and will expand their horizons in the field of material culture and the industrial design history.

References

[1] https://www.bauhaus100.de/en

[2] Р. Абрамов «Музеефикация советского: историческая травма или ностальгия?» http://gefter.ru/archive/11132

[3] E. Sysoeva, L. Korpan. «Discussion of Actuality of the International Virtual Museum of Industrial Design Creation. The Role of the Museum in the Cultural Heritage Preservation and Design Education» Saint Petersburg ITMO University 2016.

DIGITAL HUMANITIES AND EDUCATIONAL PROGRAM «BASICS OF 3D MODELING OF HISTORICAL, CULTURAL AND ARCHITECTURAL OBJECTS»

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Abstract

Wide spread of Information technologies and the expansion of their sphere of usage create new areas of activity, among which Digital Humanities occupies an important place. According to the Manifesto of Digital Humanities, adopted on March 26, 2011, "digital humanities are interdisciplinary in definition and carry all methods, tools and prospects for knowledge related to digital technologies in the humanities". For specialists in the DigitalHumanities field training special educational programs are necessary; these programs should combine studies of information technologies and humanitarian disciplines, aimed at teaching the solutions of, practical tasks, such as digital virtual reconstruction of lost objects of historical and cultural heritage, the creation of virtual exhibitions and museums, the digitization of objects of historical and cultural heritage subject to destruction, etc.

Master's degree in the field of Digital Humanities program is being taught at the Department of Graphic Technologies of the University ITMO (http://gt.ifmo.ru) in the frames of educational direction 09.04.02 “Information systems and technologies: design of human-computer systems”. Also, the staff of the department participates in the development and implementation of the educational program "Basics of 3D modeling of historical, cultural and architectural objects" as a part of INTERGRAD project (http://www.intergrad.fr). INTERGRAD is an innovative international educational project aimed at adapting European curricula to the intellectual and technological

Figure 1. Visit to Olbia: museum

Figure 2. Visit to Olbia: photogrammetry of archaeological excavations

challenges of the 21st century. In the INTERGRAD project new programs and modern educational tools are being developed using digital, optical and multimedia technologies. The partners and participants of the project are: ITMO University (St. Petersburg), the French-Russian Interdisciplinary Scientific Center Poncelet (Moscow), foreign branch of CNRS and Université Nice Sophia Antipolis (Nice). The interaction between educational organizations and employers is important for the development of educational programs aimed at learning to solve professional problems [1].

The interdisciplinary educational program "Basics of 3D Modeling of Historical, Cultural and Architectural Objects" was developed to teach school and university students to design and create 3D models of these objects, which is impossible when studying information technologies only. The interdisciplinarity of the educational program is to study simultaneously with the basics of 3D modeling: the history of art, architecture, composition, some elements of drawing and, in addition, increasing the level of proficiency in Russian, English and French, which is important for reading historical documents in the original language. Thus, the program combines various fields of knowledge - computer science, linguistics, mathematics, art history. At the end of the educational program, students create a collective project using the obtained knowledge and skills, which develops the competencies necessary for them to work in the team, and as a result of learning, the students achieve a holistic view of the development of civilization at each stage and of the contribution of different countries to the pan-European Culture.

The basics of art history and architecture, composition, reading drawings and 3D modeling are taught by teachers of the Department of Graphic Technologies of the ITMO University under specially designed author programs, which consider short learning terms (2 weeks), different levels of students' skills in information technologies, their age from 12 to 18 years old, and also that students are trained in different basic educational programs: both Russian and European. The author's programs are based on the long-term experience of teaching students of the Department of Graphic Technologies of the ITMO University and schoolchildren in the Children's Computer Center of the ITMO University (http://cccp.ifmo.ru), as well as on the classical psychological and pedagogical theory of learning and the activity approach in teaching the basics of Three-dimensional modeling [2].

In the summer of 2016, the educational program "Basics of 3D modeling of historical, cultural and architectural objects" was held in Nice. The key theme of the program was the ancient cities of the Mediterranean. The program studied history of architecture in the Greek and Roman periods, order system in architecture, the laws of buildings proportions of that time. The students learned to analyze the elements of antique buildings shapes, to determine what geometric primitives can be used for composition of complex shapes; this is important for the transition to the 3D buildings models design [3], [4]. For example, the body of a column can be represented as a set of a cylinder and a truncated cone, etc.

Also, students under the guidance of teachers visited the ruins of the Greek Polis Olbia, located on the Mediterranean coast near the city of Hyères. It was possible to examine and compare the different types of buildings and structures of the Greek and Roman periods there, such as a dwelling house, a temple, a square, a well, etc. Also, the students were explained the principles of photogrammetryon the example of Olbia, and fixation photographs

Figure 3. Final project: the Temple

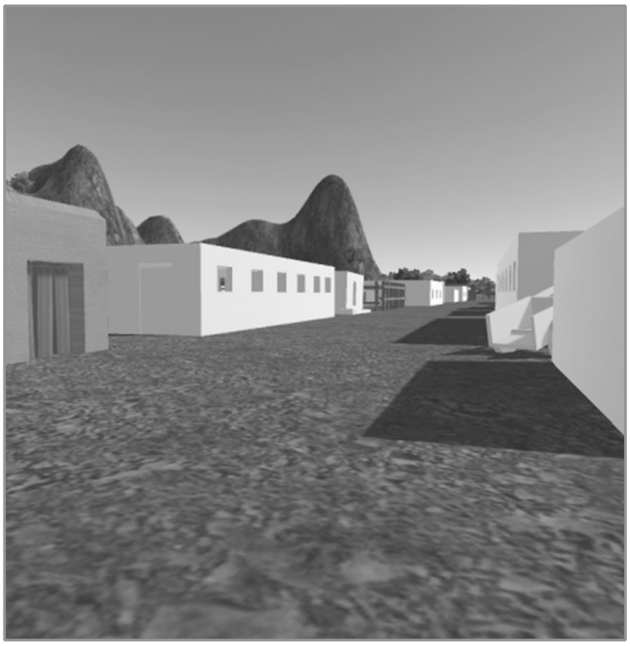

Figure 4. Final project: town square

were made. Thus, the students took part in the digitization of cultural heritage in full accordance with the Manifesto of Digital Humanities.

Another cognitive excursion was to Villa Grecque Kérylos in Beaulieu-sur-Mer, which was built at the beginning of the 20th century, but completely repeats the three-dimensional solution of the ancient Greek house in both exterior and interior. Here, the students could look in detail at the structural elements of the building and its decor, where the motifs characteristic of the Greek style were used,it was helpful for creating projects of their own.

After having gotthe idea of the three-dimensional and stylistic characteristics of ancient buildings, students created their own projects. Each student has chosen an object for 3D modeling - a dwelling house, a well or a temple, and has drawn series of sketches by hand. Sketches were discussed with the teacher; the most successful ones were selected and served as the basis for creating of 3D model.

The work of students was combined into a common scene using Unity3d. It turned out a virtual interactive city, where one can walk around.

The works were presented at the final session of the INTERGRAD summer school.

The educational program "Fundamentals of 3D modeling of historical, cultural and architectural objects" INTERGRAD is also planned for 2017. The key theme will be "City of the Future" on the example of Nice, with reference to the specific landscape of the city. The students will be invited to consider development of the architectural fantasies theme by different authors of the 20th century, European and Russian, in particular, the so-called "paper architecture" of the 1920s, as well as the proposals of modern architects and urbanists. The result should be a set of 3D models - a visual product that demonstrates the involvement of modern adolescents in the context of Digital Humanities.

References

[1] Климов И.В., Локалов В.А.Организация взаимодействия между системой образования и работодателями в сфере производства 3D-продукции // Преподавание информационных технологий в Российской Федерации: материалы Пятнадцатой открытой Всеросс. конф. (Архангельск, 11–12 мая 2017 г.). - 2017. - С. 206-208

[2] Локалов В.А. Изучение основ трехмерного компьютерного моделирования на основе деятельностного подхода // Информатика и образование - 2015. - № 4(263). - С. 35-42

[3] Makhlay D. O., Lokalov V. A., Klimov I. V. The development of visual thinking in learning computer 3D modeling // Journal of International Scientific Publication: Educational Alternatives. 2014. Vol. 12.

[4]. Lokalov V.A., Makhlai D.O., Klimov I.V., Sopronenko L.P. Students’ Vocational Skills Through 3D-Modelling of Classic Still Lives // EVA 2015 Saint Petersburg. Electronic Imaging & the Visual Arts - 2015, pp. 188-191

Section 4.
3D Reconstructions and Mixed Reality

SPECIFICITY OF 3D MODELING IN THE PROJECTS FOR THE PRESERVATION OF CULTURAL HERITAGE

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Abstract

This article is devoted to the specifics of the creation of three-dimensional models of historical objects in relation to the problems of preserving the digital cultural heritage. The example of the virtual three-dimensional reconstruction of the ensemble of the Solovetsky Monastery in the period of its highest prosperity (XVI-XVII centuries) demonstrated that the process of reconstructing an object has a scientific-research nature, and the key factor in the reconstruction process is the analytical application of existing archival materials and construction documentation in order to ensure the authenticity of the models.

INTRODUCTION

Virtual three-dimensional reconstruction of cultural heritage sites is a combination of research and technological approaches. From the scientific point of view, it is necessary to observe a sufficient degree of authenticity of the object, which is ensured by the high quality of the historical materials concerning the objects of reconstruction and the interdisciplinary nature of the development team.

Historical material analysis is aimed at a comprehensive description of the object of reconstruction by comparing various design documents (drawings) with

Figure 1. Solovetsky Monastery

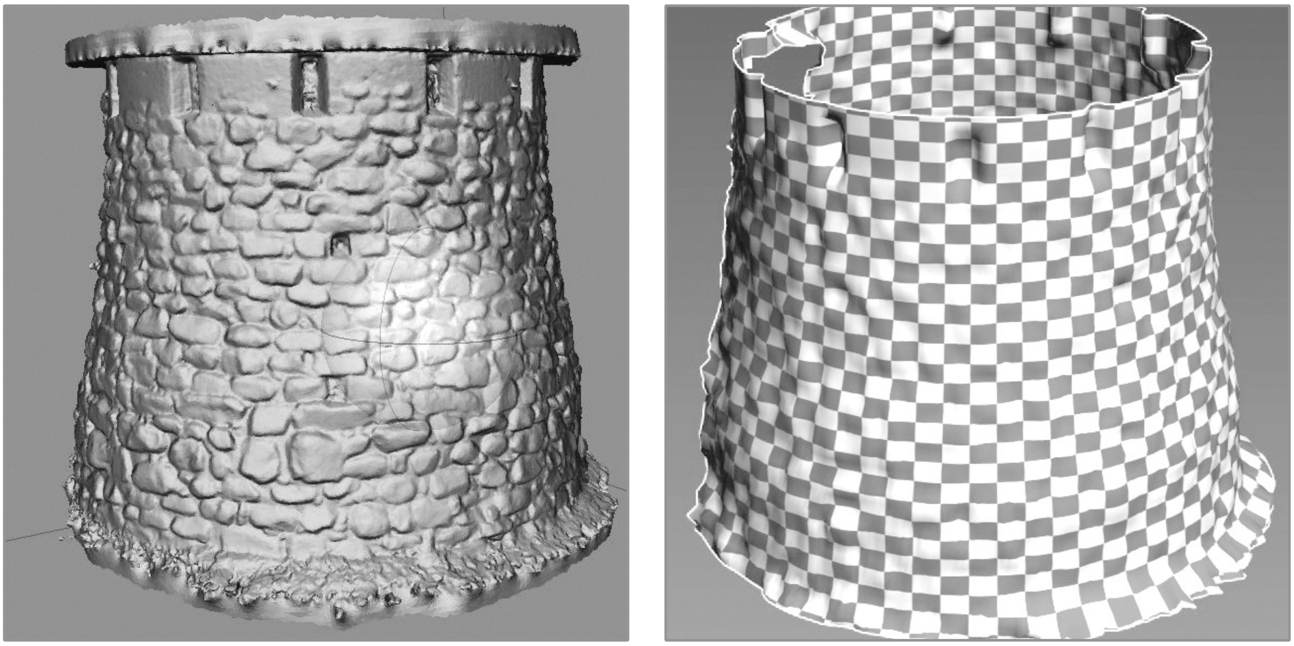

Figure 2. High- and low-polygon models of Spinning tower

each other, as well as with various archive photo and graphic images, etc.

The work of interdisciplinary team assumes close cooperation between specialists in a specific field (museum specialists, archaeologists, historians, art historians) with a technology group whose aim is to reconstruct and visualize the object using the accompanying graphic systems, considering the available documentation, the complexity of its structure and tasks.

«MULTIMEDIA INFORMATION SYSTEM «ARCHITECTURAL ENSEMBLE OF SOLOVETSKY MONASTERY IN THE PERIOD OF ITS HIGHEST PROSPERITY (XVI-XVII CENTURIES)» PROJECT

Within the framework of the Russian Humanitarian Scientific Foundation grant, a multimedia information

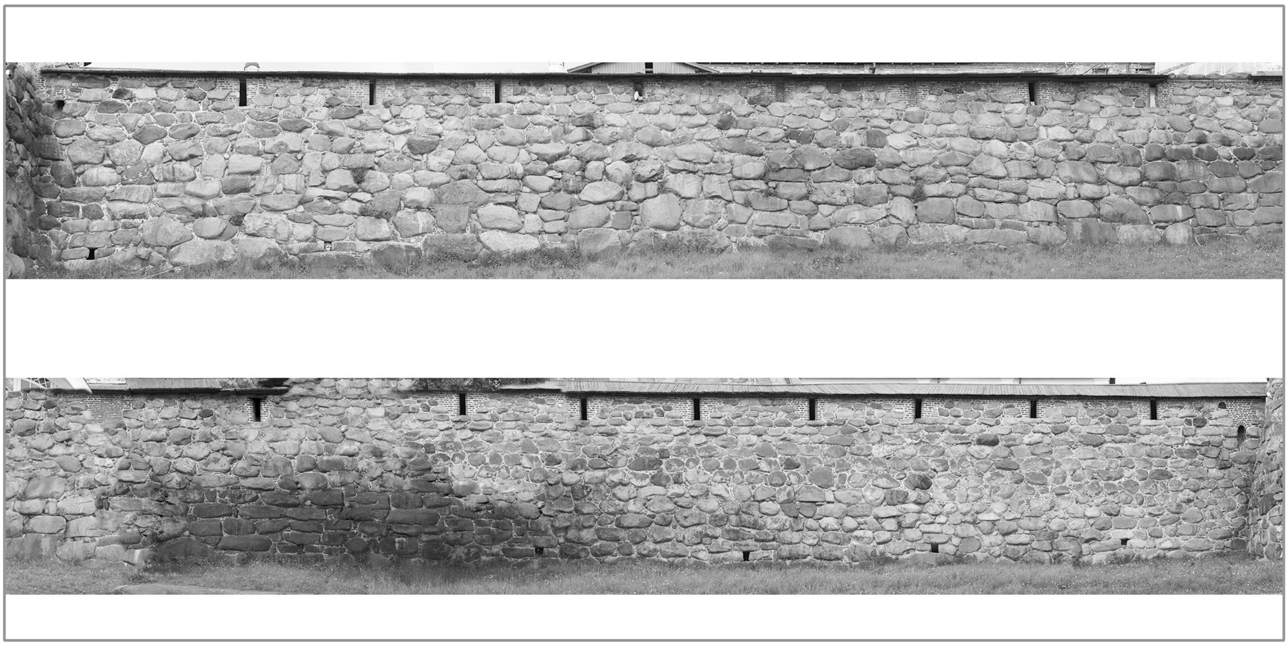

Figure 3. Wall between the Assumption and Spinning towers

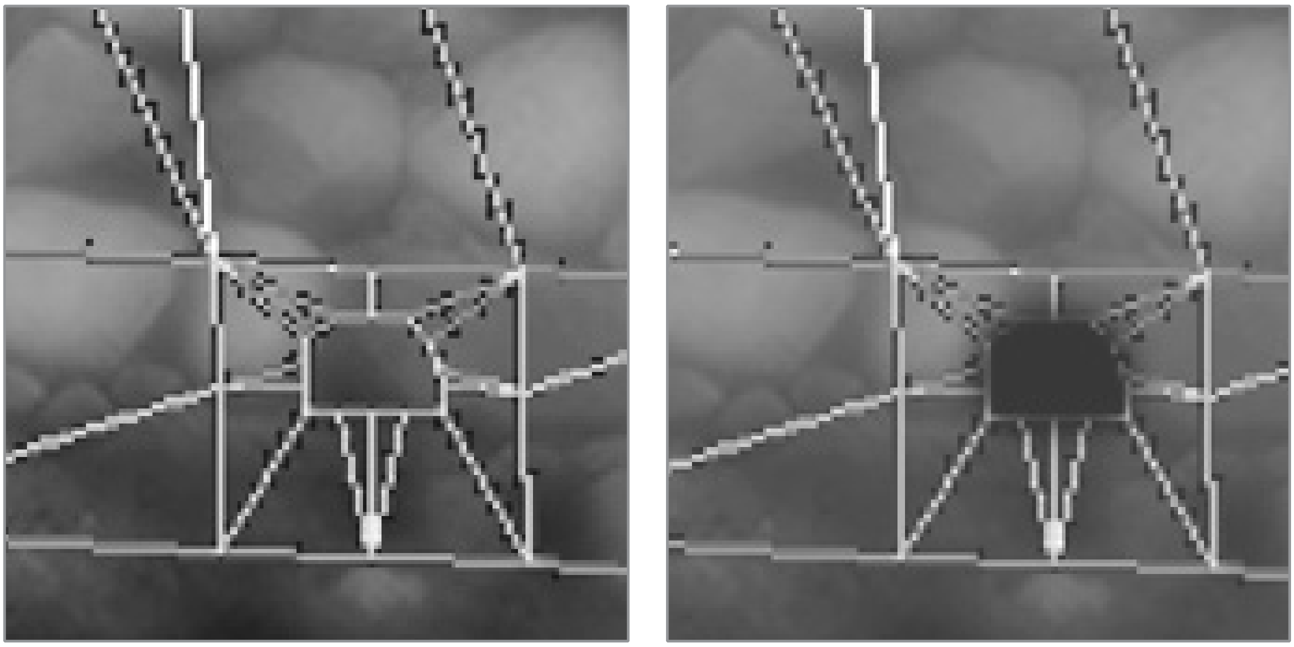

Figure 4. Displacement of the embedded scan map “before” and “after” the mask application

system [1] was created, part of which was the three-dimensional model of the Solovetsky Monastery (Fig.1) for the period of its highest prosperity - the 16th-17th centuries.

The main reason for the implementation of this project was that at the moment the 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. 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. [2]

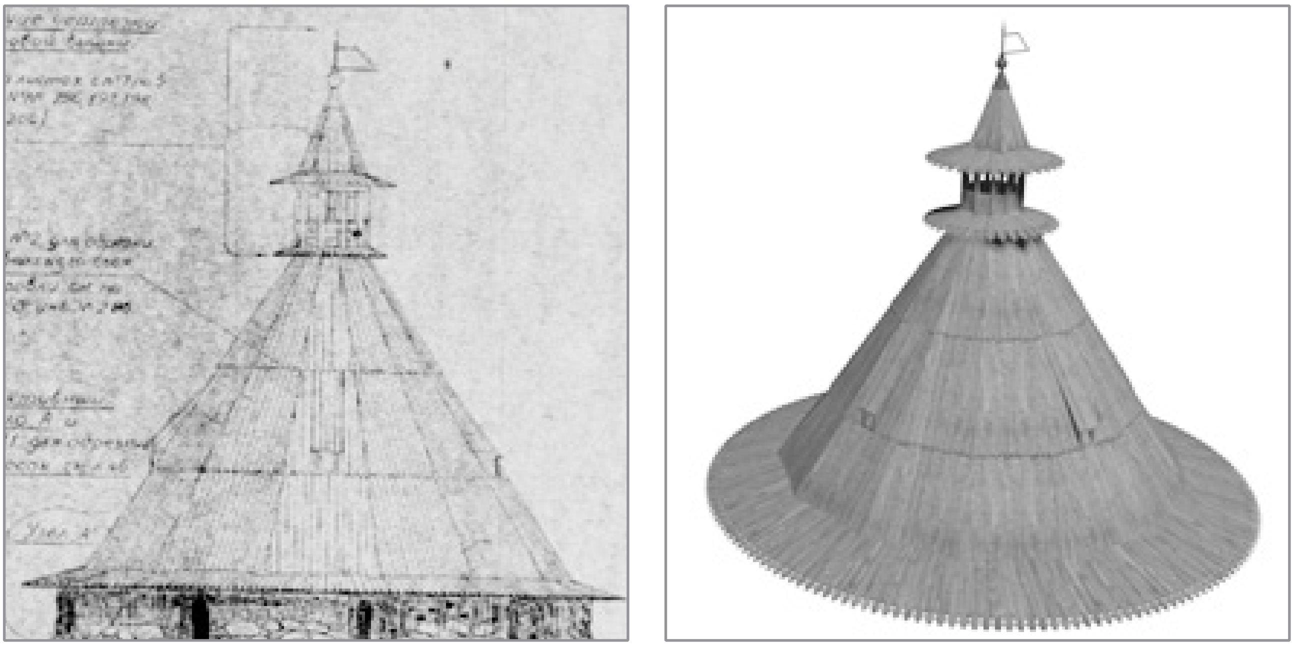

Figure 5. Roofs of the fortress towers modeling

SOLOVETSKY MONASTERY

The Solovetsky Monastery is a vast architectural entity, it is on the UNESCO World Heritage list. It has always played a prominent part in the Russian history and culture, for it was highly instrumental in the advancement of the Russians into the White Sea region, the subesquent exploration of the Arctic Ocean by the Russian mariners and the emergence of Russia as a great Arctic power.

The Solovetsky Monastery was founded in the first half of the XVth century, in 1436, when St. Zosima of Solovki had arrived to the archipelago.

Solovetsky Islands are a unique historic, cultural and natural site, since their preserved ecclesiastic structures, residential buildings, household structures, fortifications, waterworks etc. are unparalleled. The architectural complex took shape between early XVII-th and early XX-th cent. The highlight of the Solovetsky Monastery as a historic and cultural site is the main ensemble that includes the fort, the church complex, residential and household structures, waterworks, operational buildings and units. [3]

SPECIFICITY OF 3D MODELING OF THE SOLOVETSKY MONASTERY

The architectural complex of the Solovetsky Monastery consists of a boulder fortress, a temple complex, cells and economic buildings. The elaboration of the complex modeling is associated with a large number and variety of architectural objects forming the Solovetsky Monastery. For the reconstruction of architectural ensemble of the entire Solovetsky Monastery, as of the period of its highest prosperity (16th-17th centuries), it was necessary to analyze a large number of diverse historical documents. This work is systematically performed by the staff of the Solovetsky Museum - Reserve.

The Solovetsky fortress is represented, mainly, by fortification constructions, including:

- Eight fortress towers (White, Arkhangelsk, Cookery, Kvassovarennaya, Nikolskaya, Korozhnaya, Uspenskaya, Spinning);
- Eight sections of fortress walls, connecting towers (spindles).

Also the Annunciation Gate Church can be concidered as a part of Solovetsky fortress, as it adjoins the fortress walls and is a part of the fortress spin between the Uspenskaya and the Spinning Towers.

The main feature and complexity of the reconstruction of such objects is the uniqueness of their structure and the texture of the materials from which they are constructed. In this case, an important task, after modeling the geometry of fortifications, was the transfer of unique boulder masonry of the construction. Each wall constructed from boulders of its own size of and masonry, due to the historical features of the building and the construction technologies used, and these characteristics should not be neglected.

Photogrammetry methods and the method of generating of extrusion maps and normal maps based on photographs were chosen as the most appropriate for the reconstruction of such textures.

At the first stage, three-dimensional support models of fortress towers and walls between them were created according to the drawings. In a number of cases, there were discrepancies between the data in the drawings made at different times by different restoration groups.

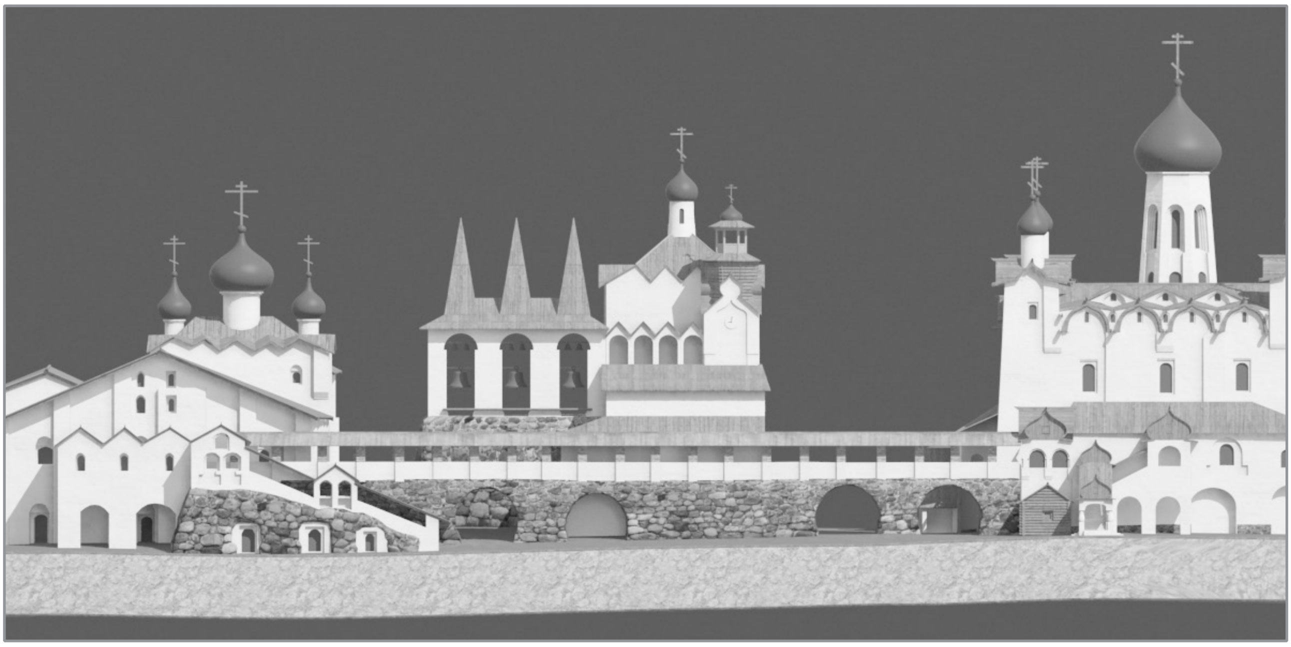

Figure 6.The Temple Complex of the Solovki Monastery

These problems were analyzed together with a team of professional architects and employees of the Solovetsky Museum and optimal solutions were worked out.

Part of the objects (Korozhnaya tower, Spinning tower, some walls (spindles)) have been restored from photographs using photogrammetry technology. As a result, high-polygonal models of areas of objects were obtained, with the shape reproducing the forms of real objects with a high degree of accuracy.

From the modeled towers and wall elements, heightmap and normalmap maps were produced and applied to previously created low polygonal copies of the models of these objects. Also, texture maps were done (Fig.2).

Special "patches" based on existing textures were created in the graphics editor for parts of objects that were not included in the photo because of the impossibility or difficulty of access.

Thus, thanks to the photogrammetry technologies, it was possible to obtain three-dimensional models of a high degree of reliability, both in terms of geometry and texture maps, in order to obtain information on the shape of real objects and transfer it to reference models.

For a number of objects, high-resolution texture maps (about 35,000 pixels on the long side for the spindles) were manually combined from the available photographs for use as textures on models (Fig.3).

In order to optimize performance, reduced copies of textures (16K, 8K, 4K) were created to use them at distances that do not require high resolution. To ensure that the objects that have been folded from the boulders do not look flat, heightmap and normalmap maps were generated with special software on the basis of the images, for application to the reference models produced according the drawings.

Another difficulty was the use of height maps to "extrude" parts using the Displacement algorithm. Since the obtained maps didn’t cover 100% of the whole object, in the places of sharp transition of the form (loopholes, joints of objects), the algorithm gave an unacceptable result, "tearing" the model (Fig.4).

To solve the problem, additional masks were created for all objects based on the texture scan, which, when mixed with the previously obtained height maps, eliminated the emerging unwanted artifacts. The texture of the brick was also generated using photographs. Thus, the embossed map-based relief smoothly passes into the geometry of the loophole without holes and other artifacts.

Roofing on walls and fortress towers was modeled in accordance with the available archive drawings (Fig. 5). The shape of the tents on the towers corresponds to the representation of architects and historians about the shape of the tents of that time, which were made on the basis of available materials from graphic images of that period.

Exept the fortifications, the temple complex of the Solovetsky Monastery was also reconstructed (Fig.6), including the Assumption Church, St. Nicholas Church, the Refectory Chamber, the Kelar Chamber and the Spasso-Preobrazshensky Cathedral.

All the buildings, except for St. Nicholas Cathedral, have not undergone significant changes since their construction, so for their modeling it was sufficient to analyze the restoration drawings and some reconstruction drawings for the XVI-XVII century.

The main difficulty was some discrepancy between drawings made by different groups at different periods of time. When such problems occurred, priority drawings were selected by the staff of the archive of the

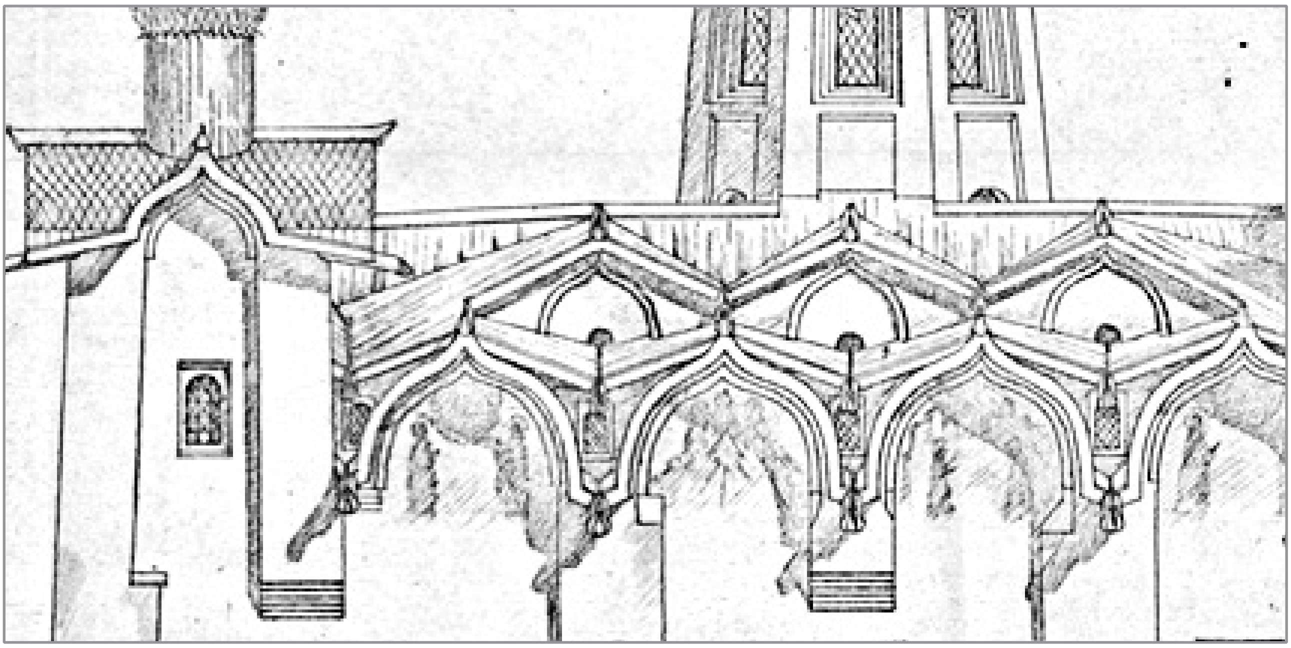

Figure 7. Roof of the Spasso-Preobrazhensky Cathedral

Figure 8. St. Nicholas Cathedral Reconstruction

Solovetsky Museum. As an example the roof of the Spasso-Preobrazshensky Cathedral can be discussed (Fig.7).

Three versions of the roof configuration were identified and analyzed, including the existing modern roof, and the most reliable variant selected.

Some drawings of the facades of the Temple also had some discrepancies in the arrangement of windows, heights and sizes. All such discrepancies were analyzed by the staff of the archive of the Solovetsky Monastery, and the most correct reference drawings were chosen.

The St. Nicholas Cathedral did not survive to the present day in the form in which it was in the early 17th century (Fig.8). Its image is most realistically preserved only on the Zubov brothers engraving, depicted in the 18th century. Some architectural elements were created by analogy with other buildings of that time (roof-"barrels", a log-eight, a belfry by analogy of the belfry of the Assumption Monastery in Tikhvin).

The cathedral was reconstructed by architects in the form of axonometric plane according to various data, and the three-dimensional reconstruction was based on the plan. Also, according to the drawings and existing images, the reconstruction of the Assumption Church and the Refectory Chamber was done.

CONCLUSION

Based on the experience, it is possible to identify the key elements of professional virtual three-dimensional reconstruction of cultural heritage sites: a competent interdisciplinary team consisting of cultural heritage experts and experts in historical modeling; the availability of the necessary historical materials for the reconstructed facility; and a software and hardware platform that is adequate to the tasks assigned.

ACKNOWLEDGEMENTS

Multimedia information system «Architectural Ensemble of Solovetsky Monastery in the Period of its Highest Prosperity (XVI-XVII Centuries)» is available online at: http://solovky.ifmo.ru/.

This work was supported by the project “Multimedia information system «Architectural ensemble of the Solovetsky monastery in the period of its highest prosperity (XVI-XVII centuries)»” (Grant № 16-01-12022, Russian Foundation for Humanities).

References

[1] Multimedia information system «Architectural Ensemble of Solovetsky Monastery in the Period of its Highest Prosperity (XVI-XVII Centuries)».URL: http://www.solovky.ru/

[2] Web portal «Solovetsky National Historic and Architectural Museum».
URL: http://www.solovky.ru/

[3] Nikolay Borisov, Artem Smolin, Valentina Zakharkina, Pavel Shcherbakov, Denis Stolyarov, Sergei Shvemberger, Elena Logdacheva, Ludmila Nikitina, Vasiliy Trushin, Arseniy Nikolaev "Virtualization of the Cultural Heritage of the Solovetsky Monastery", XV. Culture and Computer Science. Augmented Reality, May 18th–19th, Berlin, Germany, 2017. – P. 153-161

LIVING CONCERT HALL

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Abstract

The paper presents the first results of the APOLLO project. The APOLLO project is a joint project between the Konzerthaus Berlin and the research group INKA based on the University of Applied Sciences in Berlin (HTW Berlin). The project has set itself the task of developing different Augmented and Virtual Reality applications for the Konzerthaus Berlin to establish them atthe Konzerthaus Berlin, at the home of the visitors, in different schools, or at different urban spaces in Berlin.

The first subproject “Konzerthaus plus” is ready to use and published in the App and Play store. In this subproject the digital print medium of the concert hall, the seasonalmagazinewill be expanded with digital content. Together with the concert hall staff, the idea arose of expanding the booklet with the aid of the Augmented Reality.

INTRODUCTION

In many areas, print media is still one of the most important forms of public relations. This is especially true for concert halls, like the Konzerthaus Berlin[1]. Within the research project APOLLO[2] we are trying to incorporate Augmented and Virtual Reality applications while making sure that the main attraction of the Konzerthaus, the music and the building itself, remains omnipresent. With this constraint in mind, the goal was to augment the seasonal magazine with 3D objects, videos, audio and text, accessible through the user’s smartphone.

PREVIOUS WORK

Since the development of the first Head Mounted Display (HDM) by Ivan Sutherland [1] up to the present day the development in the area of AR has progressed enormously.

[1] https://www.konzerthaus.de/en/

[2] https://inka.htw-berlin.de/inka/de/project/apollo/

Figure 1. Two different sides and markers of the magazine. Test it with the application[3,4]. Additionally feel free to use the magazine[5] as printout or direct on screen

Figure 2. UI of the application with marked area

[3] https://play.google.com/store/apps/details?id=de.konzerthaus.khbexplorer

[4] https://itunes.apple.com/us/app/konzerthaus-plus/id1218227009?l=de&ls=1&mt=8

[5] https://www.konzerthaus.de/media/filer_public/cd/2e/cd2e3866-7dd9-4186-8b53-8fe5749a9903/khb_saisonbroschuere_17_18_einzelseiten_web.pdf

AR allows the user to view the real world with superimposed computer-generated content and adds to the reality. It is not the goal in the AR to replace the real environment. The focus is on the addition of additional artificially generated content that can be displayed and registered geometric correctly in real-time and which gives the user the ability to the user to interact with the artificial elements [2, 3].

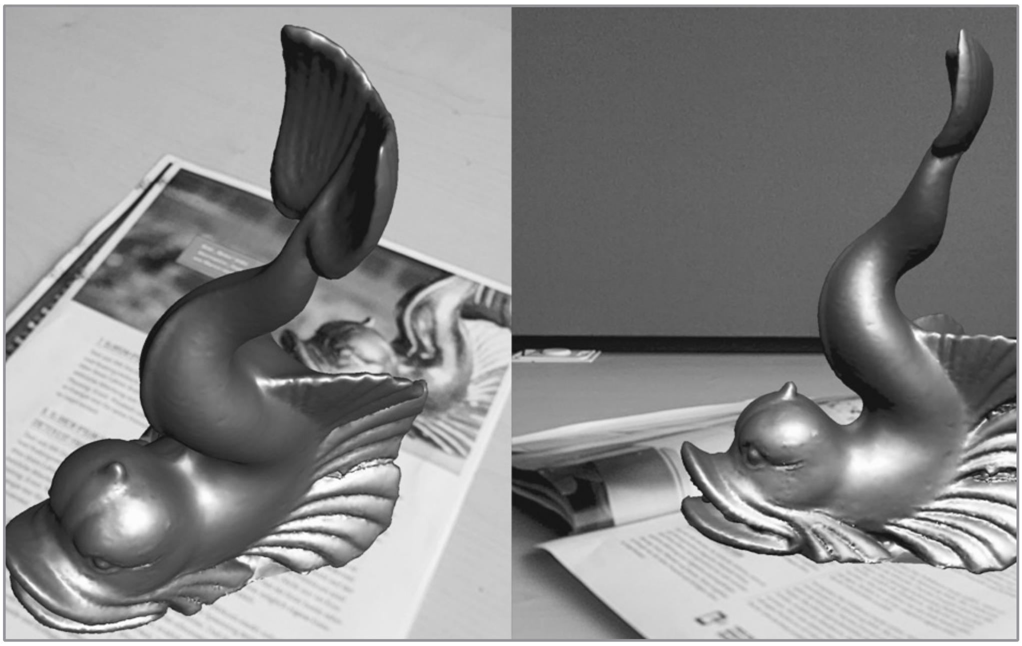

Figure 3. Augmented 3D model from different perspectives

Registration refers to the process overlaying objects of the real scene with computer-generated objects and artifactsof geometrically correct and is one of the great research topics in AR [2, 3]. The user will accept AR contents only if they are inserted consistently into the AR scene. The necessary information for the registration is extracted from features or feature points of the real scene [4]. The authors in [4] define two categories of registration approaches.

In the first approach, sensors are used to obtain the information for the consistent insertion of the content. Sensors such asmechanical, magnetic, ultrasonic or optic sensors can be used to obtain this information [4]. External sensors often allow very high accuracy but also often prove to be disadvantageous since they must be calibrated with great effort. Due to the rapid development in the field of smartphones, it is also possible to use smartphones and their internal sensors as a technical platform for AR applications.

Computer vision and image processing are defined as a second approach. They offer the potential for accurate tracking without the use of additional sensors. The necessary information for the registration is gained through the tracking.

The use of image recognition in AR for tracking is widespread. Due to their simplicity and accuracy, tracking techniques based on markers are some of the most commonly used techniques in AR [5]. The simplicity and accuracy is based on the design of the markers. The predefined shape and the high contrast of the embedded pattern make them easily recognisable in most setups [5]. Dibidogs children storybook[6] contains also AR markers to enrich the user experience.

[6] http://www.dibidogs.com/files/3113/9323/2202/DIBIDOGS_BROCHURE_EN.pdf

Markerless augmented reality techniques allow the use of natural images as targets or bases for the placement of superimposed virtual objects. The natural images correspond to parts of the real world, which are captured by the camera of the AR-system and are examined for their natural features such as edges, corners or texture patches [6]. The authors in [7] describe a markerless AR application for picture books.

MOTIVATION

The content in print media is based on the presentation text and image. Classical print media consist of static content and offer poor or no interactivity [8]. The desire to expand the classic print media with the possibilities of the information technology has already existed for some time. Various attempts are being made to enrich and expand classic print media with links, QR codes or additional media such as CD or DVD. These extensions can, of course, help to provide additional information and media that cannot be printed to the reader of the print media. But most of the time this additional information offer leads to the fact that the direct relation to the actual medium, the printed medium, will be lost. The research group sees in AR the great advantage that the printed medium has to be directly interacted with in order to obtain the additional contents.Moreover, there is a direct interaction between the user, the mobile device of the user and the printed medium. As a result, the reference to the printed medium is always ensured.It is important to establish a contextual relationship between the digital extensions and the printed medium.If this contextual connection is ensured, AR is the medium of choice for expanding printed content.

Figure 4. The three augmented video players are placed on the page. In the upper part of the page the currently active video is displayed. The printed page displays a frame of each of the three videos

With the introduction of the application, in addition to the intention to transform the magazine into a real hybrid media experience, also two more goalsare pursued.

A further motivation in the use of AR in combination with the season brochure is the mediation of new technologies in the field of IT. In the period from May 1, 2016 to March 15, in 2017 the age groups of the concert hall visitors were determined by surveys.The results show that 10% of visitors to the concert hall can be counted to the age group of up to 17 year olds, 9% to the group between 18 to 29 years, 19% to the age group of 30 to 49 year olds, 23% to the group of 50 to 69 year olds and 6% of visitors are older than 70 years.

Through the use of attractive and modern smartphone-based additional offers, the project also hopes for an increasing attention by users younger than 29 years.

Last but not least, the development of the application is driven by the motivation to inspire older people with the possibilities of modern technologies and to entice them to try it out. The chosen application concept and interaction concept is very simple and does not need skills in the usage of digital and interactive applications. The application must only be started and the camera of the device should be aligned to the appropriate page.

APPLICATION CONCEPT

Among many others, the Konzerthaus Berlin publishes a new magazine for every season. This publication is the most important for the concert hall and has a massive reach. The goal of this application is to enhance the contents of their seasonal magazine.

One of the major challenges during the concept phase was to take the relatively high age group of the regular Konzerthaus visitors into account. This means that many users of the application will be around the age of 50 to 70, which lead to a conservative approach in designing the augmented reality content. The application is only extending the content but not replacing any of the essential information. We also ensured that the interaction with the application is as intuitive as possible (see chapter "Use of Media and Interactive Elements").

APPLICATION DEVELOPMENT

Initially, we developed individual iOS and Android applications to test our ideas. The intended augmentations for the magazinerequire features such as natural images as markers, audio and video playback on individual pages, and extended tracking, where users can move the camera away from the markers with the augmented content still visible. This allows for content to extend over the physical boundaries of the pages. During the first phase, we compared the performance on the respective platforms and thoroughly tested different AR toolkits. We quickly settled on Vuforia[7] as our main library, because it provides many of the features we needed for our application scenarios, as described above.

The Vuforia platform supports a variety of AR features such as marker-based and markerless tracking and object recognition. Another feature is extended tracking, which allows for the visualisation of large objects, models and media even if the corresponding marker is no longer in the field of view of the camera and provides the possibility to view AR contents beyond large areas.

[7] hhttps://vuforia.com/

Figure 5. Augmented map with its interactive elementsas cardboard holder

Vuforia allows implementing AR applications using either cloud- or device-based marker recognition. The main benefit of cloud-based marker recognition is the related Vuforia Web Service (VWS) API, which allows developers to dynamically change markers for published applications without the need to update the application itself. However, for the cloud-based recognition to work a permanent internet connection is needed and the recognition time is highly dependent on the speed of the internet connection. For device-based recognition all markers are present in the application and updates to the marker database are only possible through an update of the application. For regularly changing content this may be unfavourable, but the content of the seasonal magazine is fixed and we therefore decided to use device-based recognition for this project.

We also considered a web-based solution, since modern browser platforms provide many APIs that, theoretically, make AR in browsers possible. However, performance is still a big issue and we needed to be able to target some older devices as well. However, these devices do not always have the newest browser versions. We are constantly reviewing the current status of the Web APIs to prepare for a possible switch in future applications.

After we had been sure that all aspects of our envisioned application were possible on both Android and iOS, we were ready to improve our development flow. The switch from a prototypical to a consumer-ready application quickly showed that development for individual platforms would be too tedious and time-consuming. Several aspects, like application state, animations, and lightning of the 3D scene, would have to be implemented twice. Early on, we considered a few of the leading 3D game engines and decided to use Unity[8], because of the excellent integration with the Vuforia framework.

Our team, that included four developers, was able to split the workload to different aspects of the application, e.g. importing of the 3D assets, lightning, and animations. Afterwards, each team member focused on the implementation for the different pages. The building process for the final apps was an automated process thanks to the Unity engine.

USE OF MEDIA AND INTERACTIVE ELEMENTS

In order to retrieve the additional content with the smartphone, the user has to start the application and scan the selected pages with the camera of the device. All pages that are supported by AR content have been marked with a symbol. In order to support the user during this process, a simple user interface was developed. The user gets the scan area through the user interface to adjust the camera optimally (see Figure2).

In the marked area of the UI, the user has to center the page of the magazine. If the corresponding page is recognized as a marker, the additional contents are visible on the screen of the mobile device as virtual overlay on the page of the magazine.

In order to offer as varied content as possible, different media such as images, 3D models, video, audio and simple interactions were used.

3D models are used to support the content of the magazine and enhance it graphically. These were delibe-

[8] https://unity3d.com/

Figure 6. Stack of photos (left) and the photos distributed on the magazine (right)

rately implemented without the possibility of interaction to ensure easy access. An example of an overlay of the magazine with a 3D model is shown in Figure 3.

To display the superimposed videos with the AR application, a gallery metaphor was used to select the different sequences. The selectable videos overlay the placeholders in the magazine displayed in the magazine. A play button is displayed on the different sequences. The interaction for playing the videos was deliberately chosen to be recognized by the users. By activating the play button, the corresponding video is moved to the edge of the magazine and played back. The shift enables the users of the magazine a more comfortable and ergonomic usage of the mobile device.

The concert hall has a partnership with various venues and musicians from Estonia, Lithuania and Latvia this year. In order to provide readers with an expanded range of information about this partnership, a map was added to the magazine. With the help of the application, this card can be expanded to get the individual venues displayed. The venues are represented by a graphic representation of the participating houses and cultural institutions on the map. These appear animated and graphically displayed in a cardboard-like look. The representation as cardboard holder was chosen to change from the two-dimensional representation of the printed card in the magazine to a three-dimensional representation for the AR visualization. (see Figure 5).

In order to show some of the possibilities of AR and to accustom users to the possibilities of interaction with AR for the future, a hidden feature was installed. If the device is aligned above the map so that a single graphical element is focused, different sounds are played for the individual elements. This is intended to show that AR is not limited to visualization only. Users should also be accustomed to the possibilities of interaction in AR through this playful and exploratory approach.

Another content, which is supported by AR, are the seasonal highlights. On one side of the magazine, different photos are displayed. This limitation does not allow all the highlights to be displayed. With the help of the AR application further highlight pictures are offered to the reader. These are offered as an interactive photo stack by the application. The play button was also used to illustrate the interactive nature of this medium. After pressing the button, the images of the photostack are spread over the side of the magazine in an animated way. When creating this media type, care was taken that the virtual images do not overlay the images of the magazine.The user can increase the size of any of the augmented images by clicking on them (see Figure 6).

LOGGING AND TESTS

First tests were carried out internally with the staff of the project as well as employees in Konzerthaus Berlin and some external testers.The first test phase focused on ensuring that the application worked flawlessly and that all media were displayed correctly.The first test also had to ensure that the application runs reliably and stableon different devices based on the iOSand Android operating system and that the pages of the magazine are reliably recognized as markers.The various devices of the participants were used as test devices (Samsung Galaxy Note 4, Samsung Galaxy S4, Huawei Nexus 6P, iPhone 6, iPhone 6s and iPad Air 2).With the selected devices, no problems were observed regarding the differences in hardware such as screen resolution, camera, processor and memory or with different operating systems and respective versions. All selected markers of the magazine were recognised quickly and reliably. The recognition of the markers, processing by the application and presentation of the content takes place during the period of a video frame.The markers were selected jointly with the concert hall being the driving force, so that they match in content but also meet the criteria for markerless AR.

In order to use the individual builds and versions of the test phase, the possibilities of iTunes Connect[9] and Apple's Testflight[10] were used. Testflight is a mobile iOS Application and was used to load and run the application on the mobile device, as well as the capabilities of the iTunes Connect Web platform, applications for iOS can be distributed very easily to a selected group of testers. A big drawback was the procedure, which had previously to be performed for testing iOS applications. Testers were unable to install the applications themselves. They had to release the serial number of their device, the developer had to enterthe devices with into the developer platform of Apple. Subsequently, the application could be played directly on the device via XCode, or provisioning profiles and application could be made available via a link. 150 test devices could be entered there. In Testflight you can perform your tests with a maximum of 2000 external testers.

Testflightand iTunes Connect makes the test process easier and accelerate the ability to publish new builds and updates. Only the build is uploaded and the testers are defined for the test. After an examination ofthe application by Apple, each user can install the application independently with Testflight. Serial numbers are no longer needed to be sentto the developers. Thus, changes and updates can be made available to the testers in rapid succession.

The markers used for the development correspond to the layout and design of the final magazine. Due to very tight deadlines the printed version of the current magazine was not availablein the test phase and so the pages that were used for the application had to be printed out on single pages. In order to check whether the glossy paper of the brochure leads to problems, a magazine from last year was used as test material. The results of this test confirmed that the glossy paper does not appear to influence the detection accuracy.Finally, the test was carried out with the printed magazine. Differences in the recognition of the markers of the test phase compared to the final product could not be determined. Only the curvature at the binding of the individual sides of the final magazine led to jumps in the representation. This behavior was only isolated and observed with strongly curved sides.

CONCLUSION

The algorithms for recognizing the sides of the magazine, implemented in Vuforia, work reliably, stably and with a high acquisition speed. All media, which were defined during the concept phase, could be implemented with the desired high demands on design and aesthetics.It is also possible to developAR applications for the stores of Apple and Google with the help of Vuforia and Unity in a short time. Apple's App store has already accepted the application and it can be installed.The application can also be obtained through the Google Play Store.

The application “living concert hall magazine” was introduced on 4 May 2017 together with the new printed season magazine of the Konzerthaus Berlin to the general public as well as to the press, radio and TV stations on 4th May 2017 with a public event in the Konzerthaus Berlin.

ACKNOWLEDGEMENTS

This paper describes the work undertaken in the context of the project APOLLO hosted by the research group Information and Communication Systems INKA and the Konzerthaus Berlin that is generously funded by the European Regional Development Fund (ERDF).

References

[1] Sutherland, I. E. (1968). A head-mounted three dimensional display (pp. 757–764). Presented at the Proceedings of the December 9-11, 1968, fall joint computer conference, part I on - AFIPS '68 (Fall, part I), New York, New York, USA: ACM Press. http://doi.org/10.1145/1476589.1476686

[2] Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., &MacIntyre, B. (2001). Recent advances in augmented reality. Computer Graphics and Applications, IEEE, 21(6), 34–47. http://doi.org/10.1109/38.963459

[3] Azuma, R. (1997). A Survey of Augmented Reality. Presence Teleoperators and Virtual Environments, 6(4), 355–385. http://doi.org/10.1162/pres.1997.6.4.355

[4] Pang, Y., Yuan, M. L., Nee, A. Y. C., Ong, S.-K., &Youcef-Toumi, K. (2006). A markerless registration method for augmented reality based on affine properties. Proceedings of the 7th Australasian User Interface Conference, 50. http://doi.org/10.1145/1151758.1151760

[5] Li, J., Slembrouck, M., &Deboeverie, F. (2015). A hybrid pose tracking approach for handheld augmented reality. Proceedings of the 9th International Conference on Distributed Smart Camera – ICDSC '15. http://doi.org/10.1145/2789116.2789128

[6] Barandiaran, I., Paloc, C., &Graña, M. (2009). Real-time optical markerless tracking for augmented reality applications. Journal of Real-Time Image Processing, 5(2), 129–138. http://doi.org/10.1007/s11554-009-0140-2

[7] Kao, T. W., & Shih, H. C. (2013). A study on the markerless augmented reality for picture books. IEEE International Symposium on Consumer Electronics (ISCE), 197–198. http://doi.org/10.1109/ISCE.2013.6570182

[8] Perey, C. (2011). Print and publishing and the future of Augmented Reality. Inf. Services and Use, 31(1-2), 31–38. http://doi.org/10.3233/ISU-2011-0625

[9] https://developer.apple.com/testflight/

[10] https://itunesconnect.apple.com

360° VR PRODUCTION FOR THE HERMITAGE MUSEUM PRACTICE

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Abstract

Emerging technologies and digital storytelling platforms promise to become a very important element in the development and evolution of museums practice by creating immersive, story-driven, and contextualizing visitor experiences. This paper focuses on the potential of 360° virtual reality film and presents our filmmaking case study of the project "The Hermitage VR Experience" — VR journey through the history of the Hermitage — shot on the museum location. We try to analyze new approach to storytelling, and filming techniques, observing the process of project creation.

INTRODUCTION

In the age of digital media, traditional forms of audiovisual storytelling used by museums for expanding and fostering visitors' knowledge of historical events, figures, facts, as well as lost artifacts, no longer satisfy the modern target audience which anticipates a more spectacular and entertaining experience, and a more engaging interaction with the content. However, there is a way to significantly change this situation by using the evolving digital technologies, in particular 360° VR film.

360° VR film is «an immersive experience using prefilmed real-world content as the central media» [1]. The use of VR headset transforms the viewer from the simple observer of the action happening on the cinema/computer screen into that immediately present in the virtual space, able to explore by means of having control of the viewing direction. 360° VR film transports viewers into different environments that envelope the audience and create a sense of immersion and empathy. This opportunity became available, to a great extent, due to new 360° technology advancements in cameras (that can record a scene in 360-degree), stereoscopic video and content-viewing hardware, also known as head-mounted displays.

Screen media uses narrative creation methods, generated and time-tested by the longstanding practice of film, TV and video production, which remain "viable" in the context of active implementation of digital technologies (whether it be the use of modern digital cameras, digital visual effects, etc.). However, recent technological innovations connected with the development of 360° VR technologies force the creators of virtual-format films to deviate from the established connotations of traditional narrative, that is to put aside the variety of tried and tested methods, and to search for new ways to efficiently use the possibilities of VR technologies, which are capable of not only immersing the viewer into the story world but also creating a significant narrative experience.

We conducted a film-making case study of the first 360° VR film produced for the State Hermitage Museum: an ambitious project, shot on the Hermitage grounds with innovative technology. The 360° VR project "The Hermitage VR Experience" is a collaboration between video production studio Super 8 and Videofabrika company, with the support of the State Hermitage Museum.

We try to analyze new approach to storytelling and filming techniques, observing the process of its creation, focusing on the following questions: what does the project narrate and what are the subtleties of the narration? What were the problems facing the creative team and the Hermitage administration? What are the specific features of 360° VR film-making, and how does the method of staged re-enactment complicates the production of such project? How does the Hermitage plan to implement this project in its museum practice? What are the prospects of VR format development?

"THE HERMITAGE VR EXPERIENCE" PROJECT

About the project

Like any other museum, the State Hermitage uses storytelling as an effective tool for sense-making and knowledge creation. Primarily, it refers to the arrangement of the exhibition areas, as well as the information told by tour guides or audio guides. In recent years, the museum has been actively exploring the possibilities of digital storytelling which uses interactivity and visual techniques of digital media for storytelling purposes (on-site and online).

The 360°-VR-technology-based project “The Hermitage VR Experience” is one of the latest innovations in the Hermitage museum practice, which has an invaluable experience in maintaining and promoting global and national cultural heritage. The project serves educational and entertainment purposes and has a broad target audience aged between 12-70. The project proposes a collective viewing of the 360-degree video wearing a virtual reality headset, in a special hall with 20 comfortable seats in the “public forum” space of the General Staff Building of the State Hermitage.

The development of the project “The Hermitage VR Experience” is in fact a start-up for the production studios (Super 8, Videofabrika), which have by now accumulated the experience of producing 360° VR video in the fields of entertainment, tourism and advertising. The development of the project for and in cooperation with the Hermitage is a new and unique experience of VR storytelling and film production, which required finding solutions for various non-routine tasks.

360° VR film is based on the re-enactment of the true events of the important period in the 250 years of the Hermitage outstanding history: from the date it emerged as the private collection of Catherine II (1764) to the date it was open to public as the Hermitage Imperial Museum (1852) — and historical figures (Empress Catherine the Great, Emperor Nicholas I, etc.). Accompanied by a unique guide being the main narrator, the viewer can explore historical events described in the VR film, “be transferred” into the Hermitage art repository, where they will meet the director of the museum, M.B. Piotrovsky, as well as to the roof of the Hermitage which overlooks the vast Neva river area, the magnificent historical center of St. Petersburg, as well as the beautiful complex of buildings housing one of the largest museums of the world.

What makes this project unique is the extensive use of 360° VR format staged re-enactment, based on pre-filmed real-world content. In whole, the events of nine scenes (out of twelve) have been re-enacted: Catherine's Museum in the mezzanine of the Winter Palace; The Hanging Garden of the Small Hermitage; The Petrovskaya Gallery; The Raphael Loggias; Field Marshal's Hall — the fire; Jordan Staircase; The Malachite Room of the Winter Palace; The Main Staircase of the New Hermitage.

It is a very difficult task to achieve accuracy of historical re-enactment in the context of video recording of a real-world scene, where every single part of the interior is in view, all the time, especially when it comes to re-enacting the start of a big fire in the Winter Palace on December, 17, 1837. Here, the crucial part of success relies on the active participation of scientists and experts in this field. In case of "The Hermitage VR Experience", it was Dr. T. L. Pashkova, — the leading research associate of the State Hermitage Museum, the author of the script of the project, who was present at all shootings, and who was constantly giving advice to the crew as to the adequacy of re-enacted events, their credibility.

Almost all the events have been re-enacted in their original place – in the interiors of the Hermitage visually consistent with that historical period. There was only one exception: Scene II. Catherine's Museum in the mezzanine of the Winter Palace. It required reconstruction of the place, because the interiors of the Catherine epoch didn't survive to this day. This scene was shot in the Lenfilm studios pavilion.

The introduction of the guide/narrator who is present in every scene and who is communicating with the viewer, intensifies the feeling that everything that happens is real. As in most of today's 360° VR films, the viewer is given the role of the observer who can at the same time control the camera angle, look around and above and see the real cinematographic image.

Due to the cutting-edge technologies, even the sophisticated Hermitage visitor will be given an opportunity, on one hand, to learn interesting facts from the museum's history and, on the other hand, to get an overall feeling that he or she participates in historical events.

360° VR Storytelling and Filmmaking

360° VR film requires a different cinematic grammar than traditional 2D movies. The study of technical and narrative possibilities of 360° video, of the experience of 360° film production by Russian and international colleagues, helped the crew to better understand how to create a better sense of immersion, how to achieve coherence in the stories, how to guide attention in VR?

“While working on “The Hermitage VR Experience” I had to forget many things from my previous experience of creating traditional videos", says the project's executive producer Anastasia Mitrokhina. With 360-degree video, everything is always in the shot, implying that every subject is in there. It's the very thing that makes the medium so powerful, but it's also the reason I've had to rethink everything.

The action in 360° VR unfolds around the viewer. Here we don't have fast cutting, stylized transitions, short cut-in scenes, close-ups. Instead of controlling the audience's point of view, we create the environment which encourages the viewer to explore the space. In order to produce proper "participation effect", one requires certain artistic and creative skills and knowledge, as well as thorough understanding of various technical details.

The specifics of film production in 360° VR films basically applies to all stages of the project implementation, from the development of concept, script and storyboard, including the choice of camera angle and movement, and the work of actors on set, to the post-production stage (editing, computer graphics).

In view of the fact, that camera placement and its distance from the actors (camera shot) influence the immediate perception of the narrated story by the viewer, this issue was treated with very careful attention. Proper camera placement is crucial not only for creating a convincing experience of the viewer, but also for minimizing the problems of video stitching during post-production. The fact that in 360° video the cameraman doesn't stand behind the camera and cannot control the actions and movements of the objects required holding scrupulous rehearsals on set.

Sergey Zakharov, the project's creative producer, who has a long-term experience of working with 360° video, points that while working on the project he was once again convinced that "one has to think in terms of scenes and not single shots, the stage setting, camera placement and movement, the actions of the actors throughout the scene (regardless of whether they stepped outside the scope of the "main camera" or not) - all this has to be elaborated in great detail".

In the context where the viewer can determine the picture frame or change the perspective as he or she wishes, the crew used different methods of focusing the viewer's attention with the help of leads, which hinted at the appropriate viewing direction. These were: sound effects, the voice of the guide/main narrator, lighting effects, glances of the actors, certain actions of the actors. Such leads which help to hold the viewer's attention on the story and thus maintain its coherence were developed for each scene at the pre-production stage and, when necessary, corrected on set.

There are so many different open problems and challenges with storytelling in 360 – degree film. The convention "rules haven't been written yet, and so there's a large amount of space to experiment with what works and what doesn't work" [2].

Although, the project creation process included such important stages as experience design and prototype testing, it is only after the project has been released (June 2017) and has operated within the walls of the State Hermitage for a certain period of time that we will be able to answer some very important questions, like: how does "The Hermitage VR Experience" project really work in museum practice, what possibilities does this new form of storytelling open up for the museum? It will certainly require conducting additional research.

360° VR Film among other VR formats

360° VR film is one of the most rapidly developing VR formats (360 VR film, interactive 360 VR film, 360 Virtual Reality). In most of 360° VR film projects, the viewer is simply "transferred" to another space, is immersed into it as an invisible observer, and can explore it by controlling the viewing direction. Interactive possibilities of 360° VR film are relatively weak compared to interactive 360° VR film, or "real Virtual Reality", that refers to VR content that is computer-generated.

In virtual reality, the user is able to move around the space, interact with virtual objects, and even influence the way the story unfolds. The use of headsets which support room-scale tracking provides gamers and users with the freedom to walk around and interact in the virtual world. For example, the user can lean towards or approach the game character really closely and, in fact, physically affect their reaction. At moments like that, the "participation effect" becomes incredibly powerful, if not to say fully immersive.

By all means, each of the above-mentioned formats which uses the affordances of its medium can find its own particular application in museum practice.

SUMMARY

360° VR film production for museum practice is not easy, especially when it comes to historical re-enactment of real events and historical figures. In order to tell an authentic story set in 360° virtual environment, which will provide the viewer with a significant narrative experience in the context of museum objectives, it is required to not only have a good grip on other different approaches filmmakers need to take as compared to the creation of a traditional film. Rigorous examination of how this new medium — 360° VR film — operates in museum practice is necessary in order to identify its constraints and affordances.

Being very protective of traditions, the Hermitage is highly open-minded with regard to any new opportunities which can help engage modern audience in researching and exploring the resources and exceptional nature of not only museum collections, but also the museum history itself. In the context of Russia lagging behind other countries in terms of exploring and implementing new technologies and practices by museums, "The Hermitage VR Experience" project can help social and cultural institutions find effective solutions for maintaining and promoting cultural values.

References

[1] Foundry web-site: https://www.foundry.com/industries/virtual-reality/vr-mr-ar-confused

[2] #125: Rob Morgan on Narrative Design in VR & escaping the uncanny valley via interactive social behaviors in NPCs. Voices of VR Podcast. http://voicesofvr.com/topics/vr-cinema/ http://voicesofvr.com/topics/vr-cinema/

3D-DIGITIZING OF ROCK ART IN THE ALTAI MOUNTAINS

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Abstract

The progress of information technology in the field of three-dimensional high-precision digitizing and visualization of material objects can allow greatly facilitate the task of precise and full documenting of research objects, that in turn made possible to conduct a detailed study of archaeological objects including rock art. 3D models of rocky surfaces allow to conserve the complete information about relief and the figure applied on it that gives the chance to conduct a research in vitro. Three-dimensional scanning on the basis of the structured light was used in case of a study of petroglyphs on the river Chagan in 2015-2016.

Various petroglyphs of South-Eastern Altai is concentrated in the valleys of the small rivers originating in the glaciers and flowing into the Chuya. In highlands of Altai since ancient times has formed and developed a culture based on moving cattle. The most numerous archaeological objects are petroglyphs. In the valley of the Chagan, they are made in the technique of knockout, engraving, refinishing and continuous "carpet" cover rock plane on the banks of the river. Ancient layers covered by later layers, many of the figures renewed. Documentation at the present stage includes mapping, reproduction of petroglyphs in various ways, fixation on a digital camera for further laboratory study of the received information. The most informative stored three-dimensional models

Figure 1. 3D model of a rock panel with the image plane of the chariot, obtained with the use of structured light 3D scanner

Figure 2. 3D model of a rock panel depicting a chariot with the release of the picture by the mathematical subtraction of the smoothed model from the original

of petroglyphs, which allows to study the shape of decorings and engravings, to show the fine lines, working with the exact parameters of the depth and topography of the rock surface.

Often petroglyphs are barely visible on the surface of the stone and are visible only when using side lighting, which requires the researcher works in a narrow period of time of sunrise and sunset or in the dark with the use of lighting. 3D models allow to get all the petroglyph surface data, that could be analyzed later in laboratory. There are several basic methods of obtaining three-dimensional models, including photogrammetry, laser scanning and scanning method of structured illumination. Photogrammetry is one of the most affordable methods for three-dimensional modeling of real objects based on a set of digital photographs made at different angles relative to the object. This method, first of all, convenient because of the technical equipment only requires a digital camera and computer with specialized software. Using photogrammetry, it is possible to obtain a relatively accurate three-dimensional models of objects with automatically generated texture (color information of the points of the model) [1]. However, this method is difficult to apply for modeling mild relief rock carvings. First, it often happens that the ratio of the depth of the shape to the width and length is so small that cannot be distinguished by software algorithm in the processing of the photos and have to limit the area of the shooting small fragments of the studied plot. Secondly, when photographing petroglyphs with a significant increase and at an angle to the rock surface rises the problem of the small depth of field of the imaging space, whereby only a small part of the picture is in the zone of sharpness. This fact also complicates the work of a software algorithm for constructing three-dimensional models or makes it impossible.

Laser scanning is based on obtaining information about the distance traversed by the laser beam scanning device to each point of space around the device. This technology allows to build fairly high-quality three-dimensional images of the surrounding space, however, laser scanning devices are very expensive and generally not focused on taking pictures of small objects and surfaces with weak relief. Unlike other methods, three-dimensional scanning using structured illumination provides a high speed retrieve model and can be applicable to relatively small objects and weak terrain. However, for three-dimensional scanning require special lighting conditions: in conditions of open spaces work have to perform is actually at night, or use special filters that reduce the negative effects of daylight.

In 2015-2016 Our aim was creation and processing 3D models of petroglyphs Kosh-Agach district of the Altai Republic (right Bank of the river Chagan) and the organization of a database on cultural heritage of the region. The location of the petroglyphs Sook-Tyt includes images from different eras from the bronze age to modern times, made in different techniques [2], [3], [4], [5], allowing to test the technologies of three-dimensional scanning for a number of different types of rock reliefs.

For three-dimensional scanning we use 3D scanner, enhanced resolution of 5 megapixels. After the installation of 5MP cameras on the second zone scanning, 3D resolution has improved from 0.23 mm to 0.12 mm. Therefore, the following scan parameters: size of scanning area: 300*225*225mm; 3D point accuracy (standard deviation): 0.05 mm; 3D resolution: 0.12 mm; working distance: 0.52 m; resolution of camera: 5 MP; projector resolution: 1280x800p; minimum time of a single image: 15 sec.

As part of the expedition, 2016 with the team of authors was accomplished typical three-dimensional scanning of petroglyphs of various epochs, including a multi-figured composition depicting a chariot of the bronze age, represented in Fig. 1.

To the obtained model of the chariot has been applied to the algorithm for the manifestation of the pattern, the essence of which consists in the following steps: 1. to apply to the received three-dimensional model of the surface smoothing algorithm of the topography; 2. apply the resulting smoothed model on the original method of "subtraction". The result is shown in Fig. 2.

As a result, we have been designed method of obtaining high-quality three-dimensional models of the petroglyphs. This technique was used to record petroglyphs painted on the cliffs in various ways, in particular in the technique of fine engraving. The obtained results are suitable for remote study of rock art subjects in the laboratory.

References

[1] Cheremisin D. V., Kazakov V. V., Kovalev V. S., Zharikova M. V. Opyt trehmernogo skanirovanija naskal’nyh risunkov s pomoshh’ju tehnologii strukturirovannogo podsveta // Problems of Archaeology, Ethnography, Anthropology of Siberia and Neighboring Territories. Vol. XXI. Novosibirsk: IAET SB RAS Publ., 2015, Vol. XXI. pp. 446-450. (In Russ.)

[2] Okladnikova E.A. Graffiti Kara-Oyuka, Vostochnyj Altaj // Material'naya i duhovnaya kul'tura narodov Sibiri. Leningrad, 1988. In: Sbornik Muzeya Antropologii i Etnografii, T. XLII. - pp. 140-158 (In Russ.)

[3] Cheremisin D.V. Naskal'naya kompoziciya s izobrazheniem kolesnicy i ”tancorov” iz Chaganki (Kara-Oyuka), Altaj // Archaeology, Ethnology, & Anthropology of Eurasia, № 1, Institute of Archaeology and Ethnography SB RAS Press, Novosibirsk, 2003, № 4, pp. 57-63.

[4] Cheremisin D.V. Issledovanie petroglifov yugo-vostochnogo Altaya v 2006 g. // Problems of Archaeology, Ethnography, Anthropology of Siberia and Neighboring Territories. Novosibirsk: IAET SB RAS Publ., 2006, Vol. XII. Pt.1, pp. 501-504. (In Russ.)

[5] Cheremisin D. V., Miklashevich E. A., Bove L. L. Dokumentirovanie naskal'nyh izobrazhenij Jugo-Vostochnogo i Central'nogo Altaja v 2013 godu // Problems of Archaeology, Ethnography, Anthropology of Siberia and Neighboring Territories/ - Vol. XIX. Novosibirsk: IAET SB RAS Publ., 2013, Vol. XIX. pp. 369-373. (In Russ.)

Section 5.
Optical Technologies

STABLE METHODS FOR RESTORATION OF DISTORTED IMAGES AND SPECTRA

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Abstract

The article is devoted to the application of the apparatus of integral equations (IE) to the restoration of distorted (smeared, defocused, noisy) images and to the restoration of continuous spectra in the inverse problem of spectroscopy. The problem of solving the IE is ill-posed (unstable), therefore, the equations are solved by the Tikhonov regularization method using the Fourier transform and quadratures. Various distorted images of people, objects, fast moving targets, astronomical objects, offices, gray and color, model and real, as well as the results of their restoration are given. Continuous spectra, smoothed by the instrumental function of the spectrometer (and noisy), as well as spectra with overlapping lines and restored spectra are also presented.

Figure 1. Smeared image (smear Δ = 20 pixels, angle of smear θ = 27°) and unsmeared instrumental impulse noise (fraction of noisy pixels d = 0.02)

INTRODUCTION

Images of objects (people, texts, aircrafts, etc.) can be distorted (smeared, defocused, noisy) [1–3]. In Fig. 1, the smeared image and unsmeared instrumental impulse noise are presented. The smear was due to the shift of the camera, and the noise arose due to the failure of a number of pixels of the CCD-matrix camera, as a result, so-called "broken pixels" have arisen.

RESTORATION OF SMEARED IMAGES

Distortions can be eliminated by mathematical and computer way. For this, it is necessary to solve a set of one-dimensional Fredholm integral equations of the first kind of convolution type [3, p. 79]:

$$\int_{-\infty}^{\infty} h(x-\xi)\, w_y(\xi)\, d\xi = g_y(x) + \delta g\,, \tag{1}$$

where

$$h(x) = \begin{cases} 1/\Delta, & -\Delta \le x \le 0, \\ 0, & \text{otherwise}, \end{cases} \tag{2}$$

moreover, the x (and ξ) axis is directed along the smear, and y is perpendicular to the smear. Here, h is the point spread function (PSF); w and g are the intensity distributions over the true and smeared images, respectively; δg is noise; Δ is the smear value. Equation (1) is valid for each y-line of the image (how many lines the image has, so many equations (1) need to be solved; while y plays the role of a parameter).

The problem of solving the IE (1) is ill-posed (unstable). A stable solution can be obtained, for example, by the Tikhonov regularization method [3, p. 88]:

$$w_{\alpha y}(\xi) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{H(-\omega)\,G_y(\omega)}{|H(\omega)|^2 + \alpha\omega^{2p}}\, e^{-i\omega\xi}\, d\omega\,, \tag{3}$$

where $H(\omega)$ and $G(\omega)$ are the Fourier transform of the functions $h(x)$ and $g_y(x)$; ω is the Fourier frequency; $\alpha > 0$ is the regularization parameter; $p = 1, 2, 3, \ldots$ is the regularization order.

To restore the image, we first filter the noise in the image in Fig. 1 by the median filter with the sliding window 3x3, and then we remove the smear by the Tikhonov regularization method for $\alpha = 10^{-3}$. As a result, we get a well-restored image (Fig. 2).

However, the solution w_α is very sensitive to the accuracy of knowledge of smearing parameters Δ and θ. The example in Fig. 3 shows that with accurate knowledge of Δ and θ, we get a good image restoration, and for Δ and θ, which differ slightly from the exact Δ and θ, the restoration is unsatisfactory.

Another example of a smeared color image and its fast restoration [4].

RESTORATION OF DEFOCUSED IMAGES

If an image is defocused, then it can be restored by solving the two-dimensional integral equation [3, p. 159]:

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} h(x-\xi, y-\eta)\, w(\xi,\eta)\, d\xi\, d\eta = g(x,y) + \delta g\,. \tag{4}$$

Equation (4) can be solved, like Eq. (1), by the Tikhonov regularization method using the two-dimensional Fourier transform by a formula analogous to (3) (for details, see [3, p. 176]). Defocusing is usually caused by an incorrect focus setting. Each point on the object is transformed in an image into a homogeneous disc of radius ρ or a Gaussian spot, etc. [3, p. 159–160]. In Fig. 5, the defocused image of the Moon (file moon.tif) and its restoration are given for exact and inaccurate ρ.

Another example (Fig. 6): a defocused office shot and the restored image.

(a) (b)

Figure 2. Distorted (a) and restored (b) images

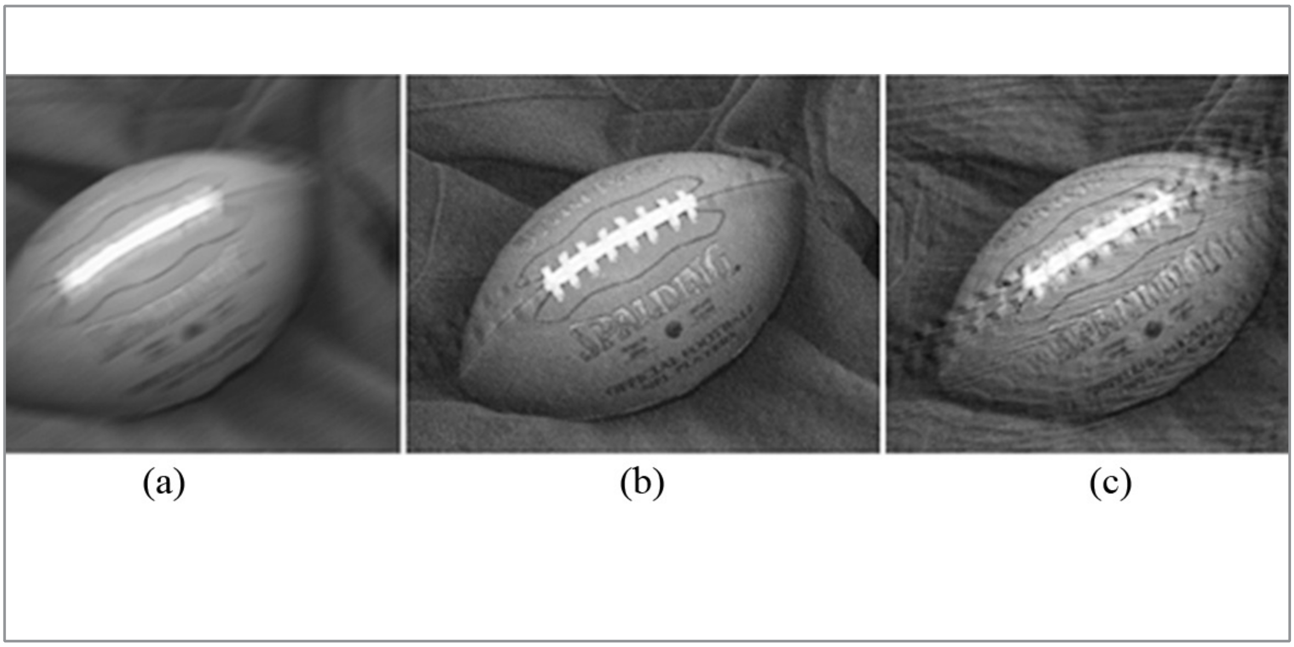

Figure 3. (a) Smeared image football.jpg 256x320 pixels, $\Delta = 15$ pixels, $\theta = 30°$;
(b) restored image for exact Δ and θ;
(c) restored image for $\Delta = 17$ pixels, $\theta = 32°$

RESTORATION OF SMOOTHED SPECTRA

A spectrum is the dependence of the radiation intensity on the frequency ν or the wavelength λ.

The fine structure of a spectrum can be smoothed with the response function (RF) of a spectrometer. The restoration of a spectrum is described by the integral equation [3, 5]:

$$Az \equiv \int_a^b K(\lambda, \lambda')\, z(\lambda')\, d\lambda' = u(\lambda), \quad c \le x \le d\,, \tag{5}$$

where K is RF of the spectrometer, z is true (desired) spectrum, u is measured spectrum.

Figure 4. (a) Smeared image, (b) restored (within 1 second) image

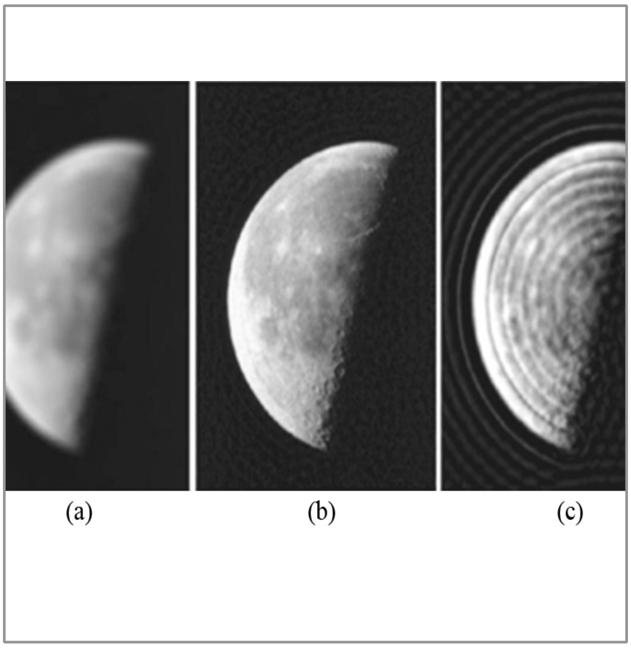

Figure 5. (a) Defocused image (ρ = 10 pixels);
(b) restored image for exact ρ = 10;
(c) restored image for inaccurate ρ = 12

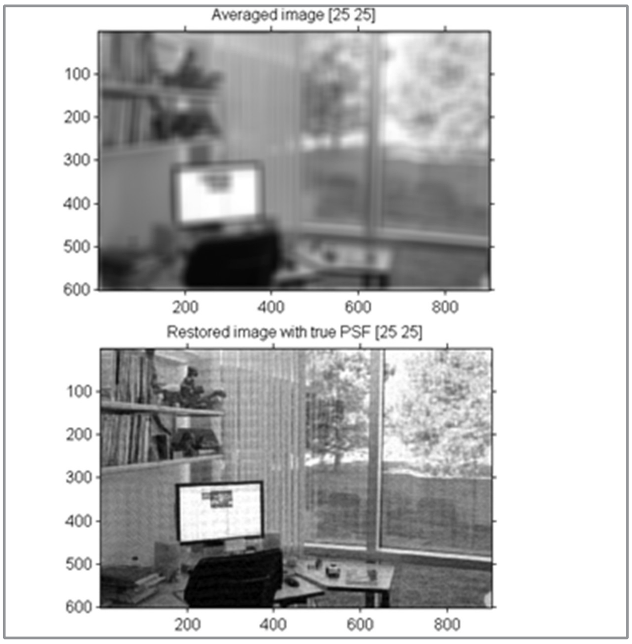

Figure 6. A defocused office shot and the restored image

An example (Fig. 7). The measured spectrum $u(\lambda)$ and the RF K in the form of a Lorentzian (dispersion RF) are known [5, 6].

In Fig. 8, the restored spectrum $z_{\propto}(\lambda)$ obtained via solving the equation (5) by the Tikhonov regularization method is presented.

SEPARATION (DIVISION) OF OVERLAPPING LINES

Let us consider one more inverse problem of spectroscopy.

Let several close lines partially overlap.

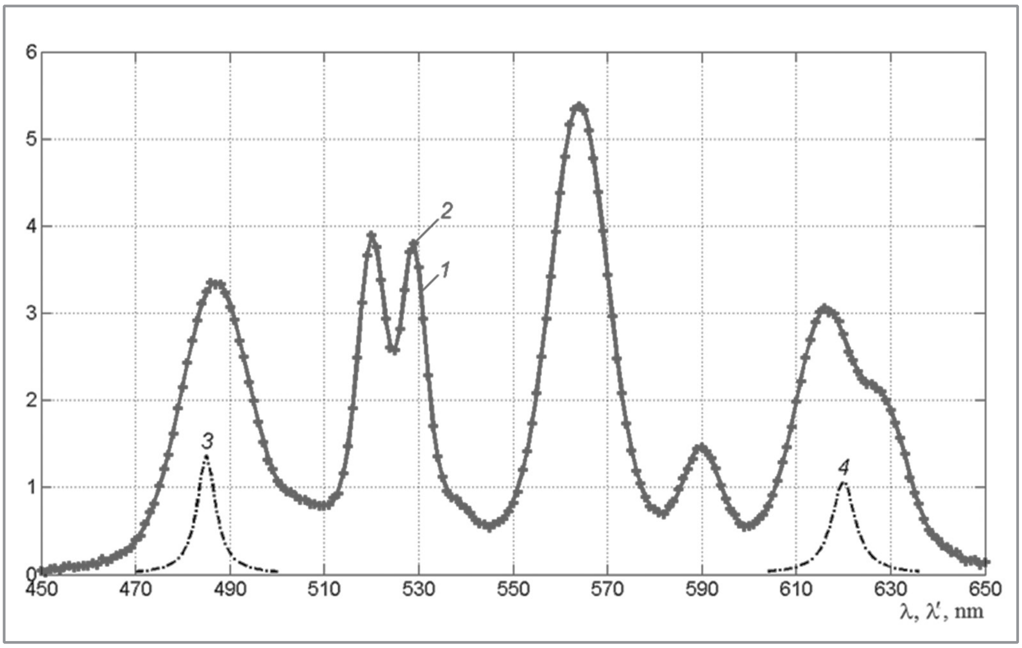

Figure 7. 1 – measured spectrum $u(\lambda)$ without noise; 2 – noisy spectrum $\tilde{u}(\lambda)$;
3 and 4 – two cross sections of RF

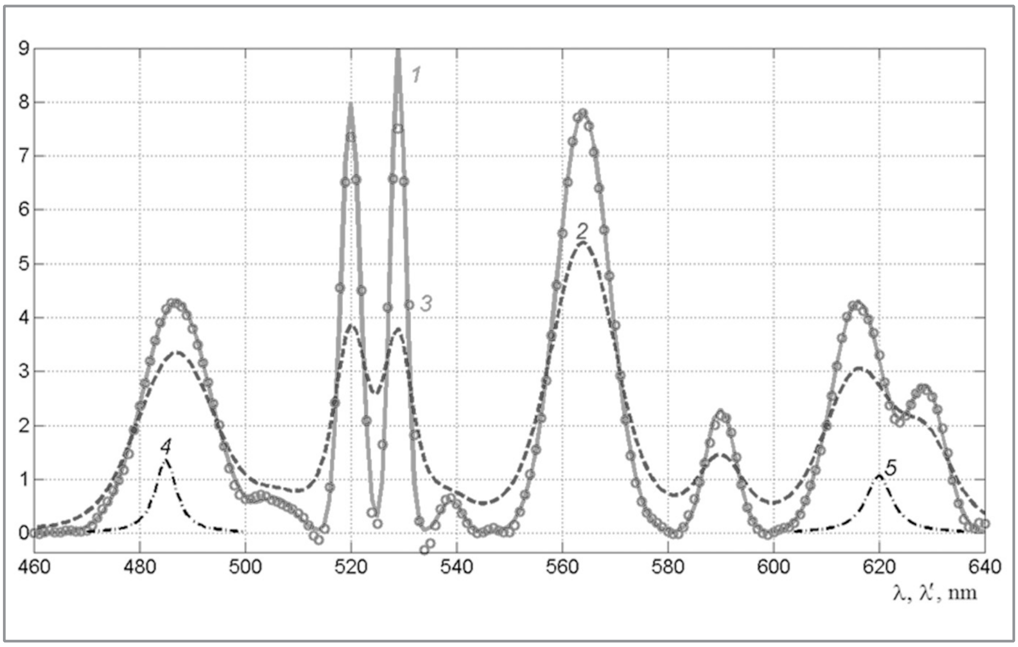

Figure 8. 1 – true spectrum $\bar{z}(\lambda)$; 2 – measured spectrum $u(\lambda)$;
3 – restored spectrum $z_\alpha(\lambda)$ for $\alpha = 10^{-2.2}$; 4 and 5 – two cross sections of RF

In Fig. 9, there are three overlapping lines with their profiles $z_1(\lambda)$, $z_2(\lambda)$ and $z_3(\lambda)$. However, these profiles are unknown, and the total spectrum is known:

$$z(\lambda_i) = z_1(\lambda_i) + z_2(\lambda_i) + z_3(\lambda_i), \quad i = \overline{1, m}, \quad (6)$$

where m is number of discrete samples of λ.

The problem of finding the individual profiles $z_1(\lambda)$, $z_2(\lambda)$ and $z_3(\lambda)$ over the total profile $z(\lambda)$ is solved in the following way.

It is assumed that the individual components (lines) are, for example, Gaussian with the following parameters: amplitude A, coordinate of the maximum λ_0 and SD σ (in all 9 desired parameters). The parameters are found by minimizing the discrepancy functional:

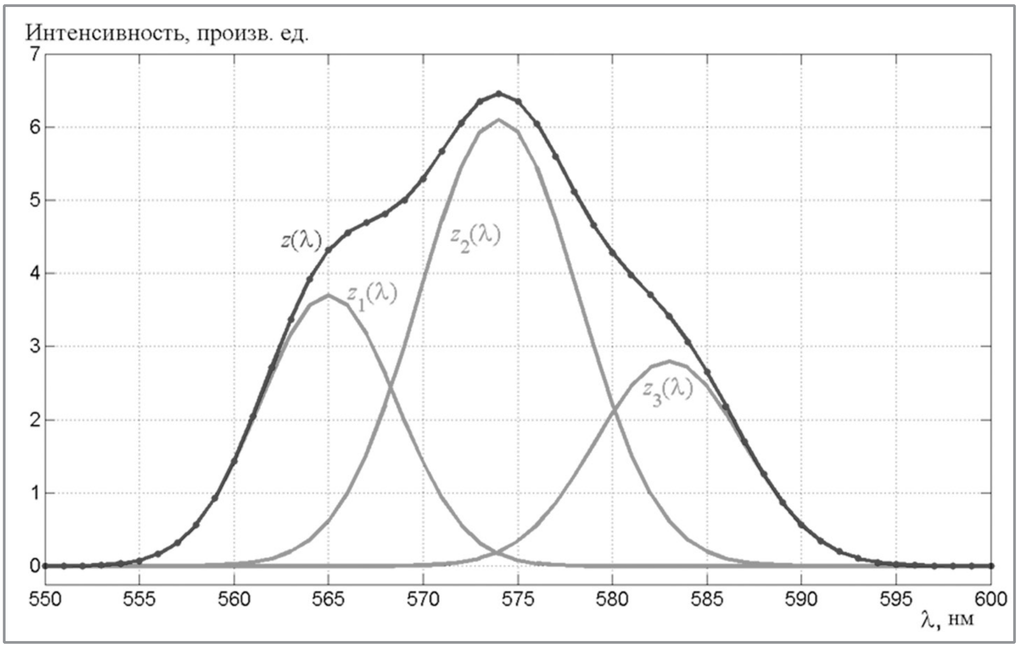

Figure 9. Profiles of three overlapping lines and the total spectrum z(λ)

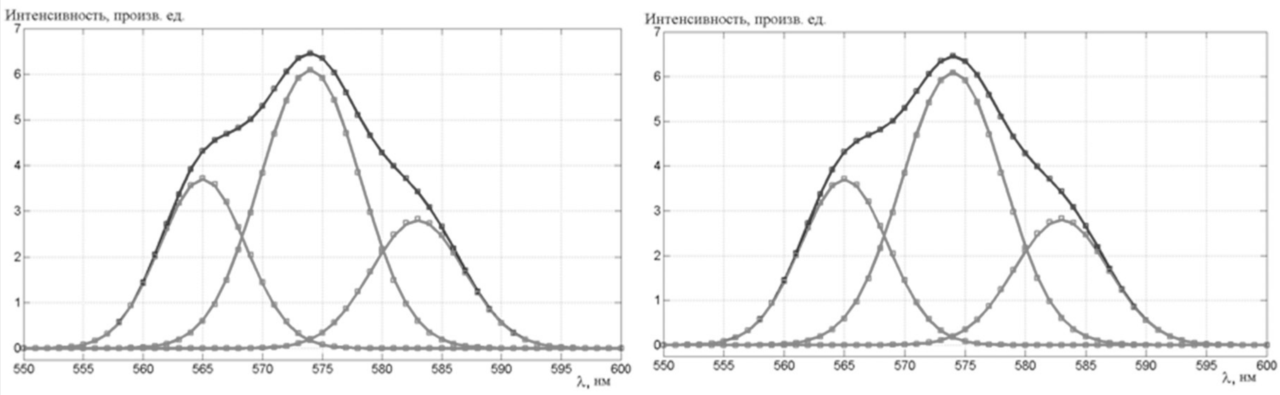

Figure 10. (a) The Nelder–Mead method; (b) the coordinate descent method

$$F = \sum_{i=1}^{m} (\tilde{z}_i - z_i)^2 , \tag{7}$$

where $\tilde{z}$ is the measured total spectrum (without noise or with noise), and z is the calculated spectrum in the form of a sum of Gaussian (see (6)). The Gaussian parameters are chosen such that $F = \min$. To minimize F, we used the methods of Nelder–Mead [7] and coordinate descent [8]. In Fig. 10, the found line profiles are shown.

Conclusion

In the article, we showed briefly the solution of two applied problems (image restorating and spectrum processing) based on the use of a single mathematical apparatus – integral equations.

References

[1] R.H.T. Bates, M.J. McDonnell, “Image Restoration and Reconstruction”, Oxford: Claren-don Press, 1986.

[2] R.C. Gonzales, R.E. Woods, “Digital Image Processing”, 2nd ed. Upper Saddle River: Prentice Hall, 2002. 793 pp.

[3] V.S. Sizikov, “Inverse Applied Problems and MatLab”, St. Petersburg: Lan' Publ., 2011. 256 pp. (In Russian).

[4] V.S. Sizikov, A.K. Ilyin, “On Restoration of Smeared Color Images”, Scientific and Technical Journal of Information Technologies, Mechanics and Optics, vol. 17, no. 3, pp. 417–423, 2017. doi: 10.17586/2226-1494-2017-17-3-417-423

[5] V.S. Sizikov, A.V. Krivykh, “Reconstruction of Continuous Spectra by the Regularization Method Using Model Spectra”, Optics and Spectroscopy, vol. 117, no. 6, pp. 1040–1048, 2014. doi: 10.1134/S0030400X14110162

[6] V.S. Sizikov, A.V. Stepanov, “Method of Training Examples in Solving Inverse Ill-Posed Problems of Spectroscopy”, Scientific and Technical Journal of Information Technologies, Mechanics and Optics, vol. 15, no. 6, pp. 1147–1154, 2015. doi: 10.17586/2226-1494-2015-15-6-1147–1154

[7] D. Kincaid, W. Cheney, “Numerical Analysis: Mathematics of Scientific Computing”, 3rd ed. Providence, RI: AMS, 2009. 788 pp.

[8] V. Sizikov, V. Evseev, “Bars and spheroids in gravimetry problem”, https://arxiv.org/ftp/arxiv/papers/1604/1604.06927.pdf

DESIGN OF ERGONOMIC ILLUMINATION SYSTEMS FOR CULTURAL, MEDICAL, EDUCATIONAL FACILITIES

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Abstract

LED panels with light-guiding plates can be good substitution of traditional lighting fixtures in museums. They can provide high quality of comfortable general lighting at public places. This article describes design of LED light fixtures for cultural, medical, educational facilities, where applied strict requirements for illumination. Authors made optical design of round light-guide plate with microstructures, which is component of LED panel, and developed solution technology for producing light-guide plate by CO2 laser machine-tool, and got sufficient results by comparing simulation model of light-guide plate and produced light-guide plate.

INTRODUCTION

Today in Russia there is a governmental program [1, 2], which is directed to replacement of non-efficient lighting fixtures, like incandescent lamps, luminescence lamps, mercury-vapor lamps and other gas-discharge lamps. All public utility companies, for example, educational facilities, medical facilities, cultural facilities, should apply LED lighting fixtures. That light fixtures have got good effectiveness, can save energy consumption and money, therefore, the market of LED lighting is growing day by day.

A typical light fixture consists of PCBs with LEDs, driver, body frame (heater), diffuser of light or lenses, reflectors for LEDs, commutation wires. The most

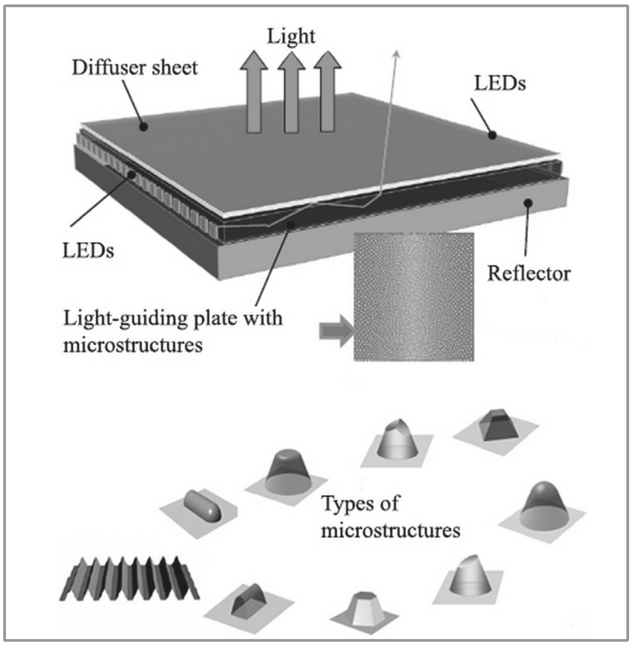

Figure 1. Light propagation in light-guiding plate and types of microstructures

popular kind of LED light fixtures, used in most cases, is office LED light fixtures. That light fixtures usually have sizes such as 600mm x 600 mm, 300mm x 600mm, 1200mm x 300mm and etc. There is a variety of office LED light fixtures, offered in our country, outstanding factories make LED light fixtures with different characteristics, provide high quality production and warrant reliable rate. On the other hand, there are small manufacturers, that make cheaper light fixtures, but the quality of production in many cases is not good, that can influence people health, especially vision.

There are several important parameters of light fixture – overall luminance (cd/m2) of light fixture and equability of luminance, expressed by maximum and minimum luminance ratio of emitting surface. Human eyes react to these parameters. LEDs have very high lumen efficiency and compact sizes, during the operating, high luminance of LEDs may cause discomfort of eyes. Certainly, for light fixtures, which used in public places, are applied different kinds of diffusers of light: matte, “crushed ice”, “prismatic”, “pearls”, but sometimes it is not enough to meet the implementation requirements. Therefore, in spite of energy efficiency, it should not be forgotten about comfort. Not all LED light fixtures could be used in schools, hospitals or museums, requirements for lighting are very strict [3].

Trends of light fixtures development shows, that energy efficient is improved, and energy consumption is decreased. That parameters are provided by applying high energy efficient LEDs with high luminance. Therefore, if high energy efficient LEDs will be used in traditional construction of LED light fixtures, it will be difficult to say about ergonomics. Actually, there is a problem, how can provide low energy consumption of light fixture without discomfort for human’s eyes.

There are varieties of suitable technical solutions – one of them LED light fixtures with backlight modules (LED panels with BLM). The basis of this device is phenomena of propagation light in optical medium by the law of total internal reflection and scattering at the microstructures. Due to special position of LEDs on the end-face of light-guiding plate with microstructures and diffuser sheet, light scattering is provided and such kind of light distribution is more comfortable than direct lighting. Principle of performance of LED panels was kept from LCD displays, where light-guiding plates and backlight modules are applied for a long time.

Domestic market offers varieties of LED panels, but most of them are being produced in China and other countries. There are many reasons, why LED panels are not produced in our country. One of them is connected with absence of technologies for light-guiding plates production. The authors have great experience in optical design of different light-guiding plates and illumination systems [4, 5, 6, 7, 8]. But for complex development LED panels, especially light-guiding plates, besides designing is a need to develop manufacturing technology. At the beginning of research, review of technologies for manufacturing light-guiding plates and forming microstructures was prepared. Authors made a suggestion about application laser machine tool for manufacturing light-guiding plate. For experiments, round LED panel with round light-guiding plates were chosen.

Principle of light-guiding plates performance

The main physical phenomenon of light-guiding plate is light scattering at microstructures is shown on Fig.1. Light from LED is directed to end-face of light-guiding plate, after entrance in plate light is propagated in optical medium due to internal total reflection. For remove light from light-guiding plate, it is obligatory that surface has microstructures (dimples). When light achieve microstructures, it is scattered and directed to output surface [9].

For achievement equal level of luminance at whole emitting surface of light-guiding plate, it is necessary to create especial density distribution of dimples. For defining optimal distribution of microstructures, it is need to simulate light fixture and make optical design for calculated luminance.

Selection of operating mode of laser machine tool

Before modeling light fixture, we investigated technical opportunities of laser machine tool for forming hemispheres microstructures at Plexiglas.

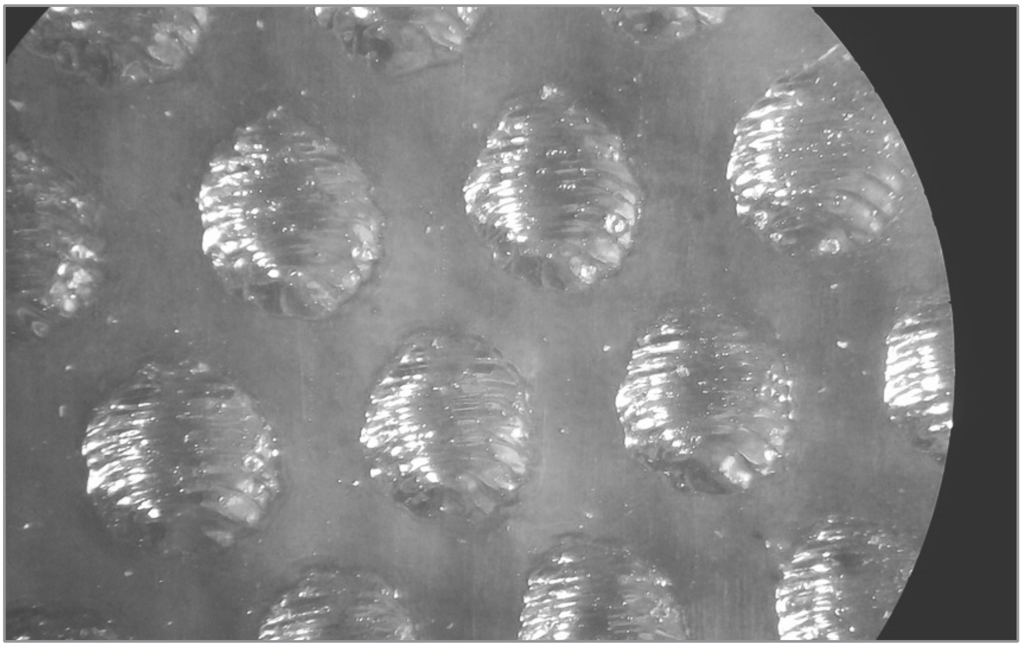

Figure 2. Microstructures

We tested several modes of power level and movement speed of laser had. Laser machine tool has got CO2 – laser tube, power of tube was 40 W, this equipment could provide engraving and cutting Plexiglas, wood, plastic and other nonmetallic materials [10]. Connection with laser machine tool was provided with PC, the software for setting parameters of levels of speed and power was Corel Draw. This software is oriented for working with raster images and vector images, and it has a software plugin for control laser machine tool. Dimples shape was set as hemisphere, we chosen between different sizes from 500 μm to 1000 μm. Dimples was formed at small areas. After laser engraving, we observed shape and relief for every test dimples by microscope, during observing we measured overall dimensions of dimples. It was revealed, that at high energy levels, dimples have cylindrical shape, not semi spheres. In addition, at high level of power energy, we observed a lot of products of combustion.

During selection optimal speed of movement laser had, we observed, that dimple's cross section of shape was changing from round to elliptical when speed was increased.

For choosing optimal operating mode, it was performed several dozen tests. However, ideal dimple shape was not achieved: formed microstructures were similar with elliptical, but radii was differed by 10 percent. Also, formed dimples have random air bubbles, and about seven-ten grooves were at one dimple.

Finally, we determined that for achieve optimal shape of dimples with diameter of cross section equal 700 μm, it is needed to set laser power as 14 W, and to set speed of laser as 2 m/sec.

The best parameters of dimples, with random air bubbles and grooves, were applied in the computer model.

Modelling and optical calculations

Optical calculation was done in program complex Lumicept [11]. For making physical correct model of light fixture, we provide next operations. At first, we made equidistant distribution of dimples and fabricate light-guiding plate at machine tool. We used special method of forming local-equidistant distribution of microstructures, which exclude moire [12]. In this method, local scattering properties are achieved due to variation of local densities of repeated scattered microelements, and distribution periodicity is reduced by local variation coordinates of scattering microstructures.

The second step consists of, that we made calculation with equidistant distribution of dimples, and made some adjustments, in order to model of light fixture would be similar with real light fixtures. During making settings in computer mode, end-face of light-guiding plate was set as real, with some irregularity of surface and small inclination. So, we set optical properties not only at light-guiding plate and dimples, but also at light diffuser and at body frame surface.

Therefore, we could trust the correctness of our model. At third, it was performed optimization of dimple distribution for achievement equitability of luminance. When dimple distribution had been received, new light-guiding plate was produced by laser machine tool.

Producing prototype model

We have got a production model of round LED light panel, which consist of light-guiding plate, LEDs, driver, body frame (heater), diffuser of light, and reflector. This LED panel is import production, but we could compare

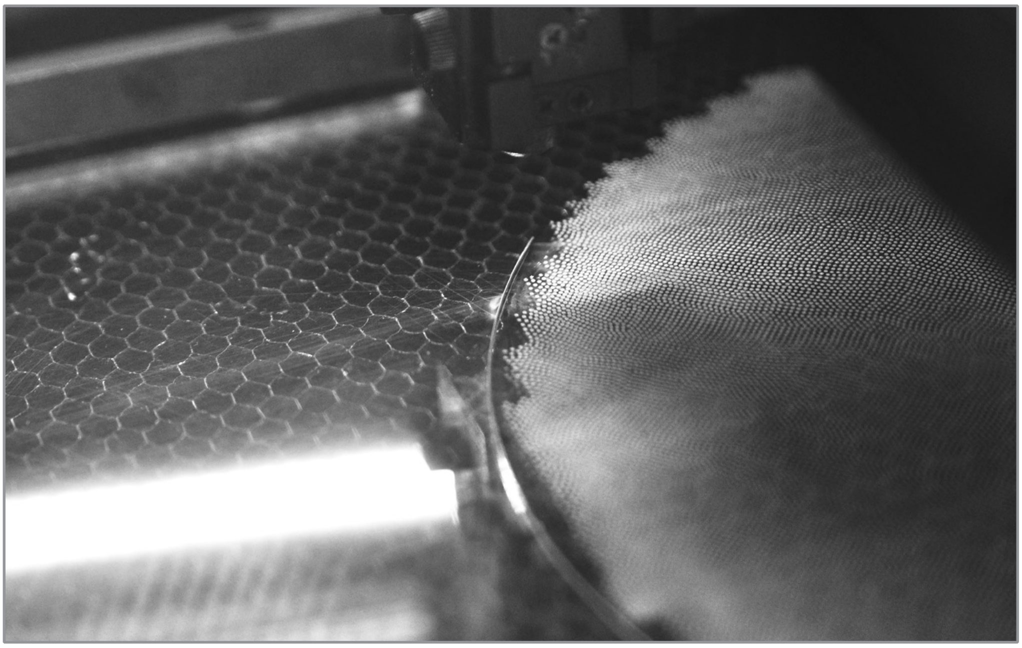

Figure 3. Process of producing light-guiding plate

our prototype of light-guiding plate with another one in identical conditions, in the same construction of LED panel. Plexiglas was chosen by the way of optical material. Light-guiding plate was round, diameter was 257.5 mm, thickness was 4 mm. Dimple was a segment of sphere as shown on Fig.2, diameter of segment was 700 mkm, height was 12 mkm.

Producing of light-guiding plate consists of two steps: the first was forming microstructures; the second was cutting of material.

We applied laser for material processing without oxygen stream, because it helped to avoid spraying of combustion products around plate, and around microstructures. Products of combustion have such negative impacts on the light scattering.

One of the positive features of laser cutting is producing transparent and smooth end-face, where input light has small losses.

Time for producing one prototype of light guiding plate was 40 minutes, process is shown on Fig.3. One the one hand, this time for producing prototype is normal, but on the other hand, for large manufacturing it is very slowly.

The main advantage of suggested producing technology is absence of very expensive equipment, such for punching or molding. Suggested technology is very convenient for producing small batch of lighting fixtures. If a museum, or another public place, needs individual lighting fixtures of such type, it will be able to be produced with this technology.

Measuring and results

Produced prototype was set in light fixture body frame, after that measuring of lighting and electrical parameters was provide in photometric laboratory JSC «Svetlana-LED» [13], so original light fixture with its own light guiding plate was measured too. We compared parameters of both light-guiding plates. We measured luminance of emitting surface by different direction with luminance meter Konica Minolta. For measuring luminous flux and luminous intensity distribution curve we used goniophotometer system "Everfine", results are shown on Fig.4. After measuring lighting parameters, to see luminance distribution, exactly bright and dark areas, we made photos with camera Nikon D90, shutter speed was at level 1/4000 sec, diaphragm was at level F=10, photos are shown on Fig.5. We explored photos with luminance variance, and analyzed quality of producing. We observed areas with different luminance, after that identified the reasons for the difference calculation.

Conclusion

Authors can achieve good results in developing simple technology for producing light guiding plates with microstructures. By comparison produced prototype light-guiding plate with serial light-guiding plate, it was found, that light flux is differ by 5%, 1224 lm has produced prototype, 1290 lm has another one. Measurement uncertainty of goniophotometer system is 5% too. Ratio of luminance maximum and luminance minimum produced prototype light guiding plate was less than 10%, ratio of serial light-guiding plate was 30%, results are shown on Fig.6. Obtained results is differing from calculation model, this could be caused by inaccurate data of optical parameters of plexiglas, and geometrical parameters of dimples.

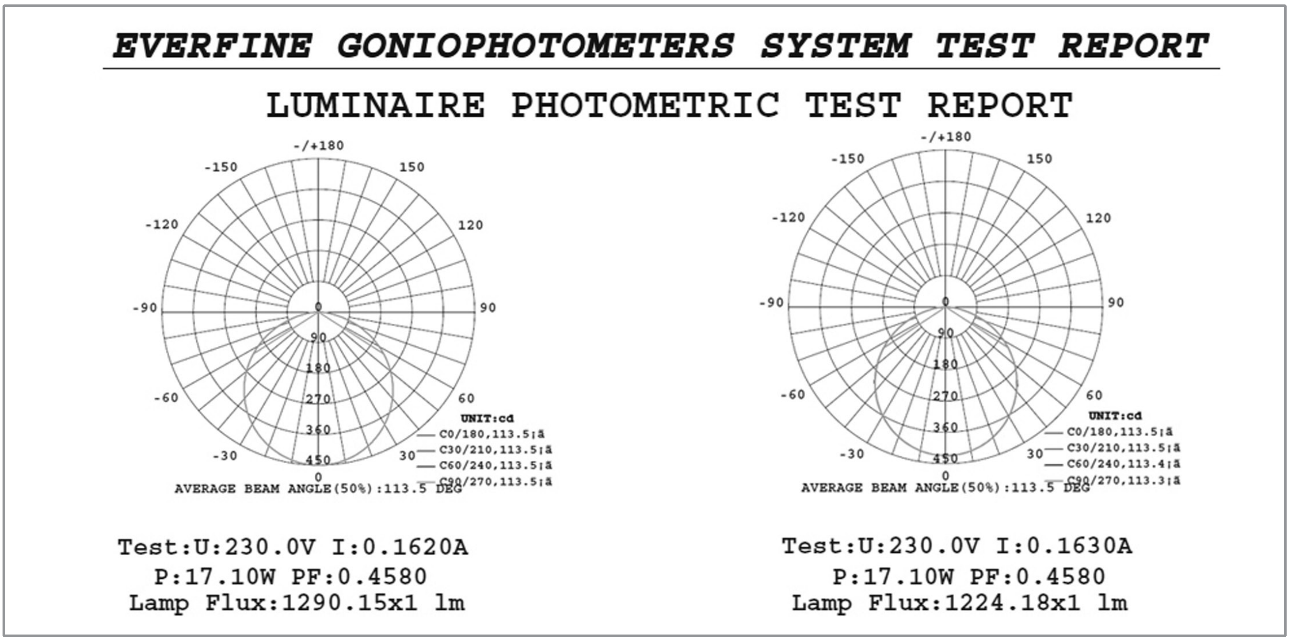

Figure 4. Luminaire photometric test report. Original light-guiding plate (left), produced prototype (right)

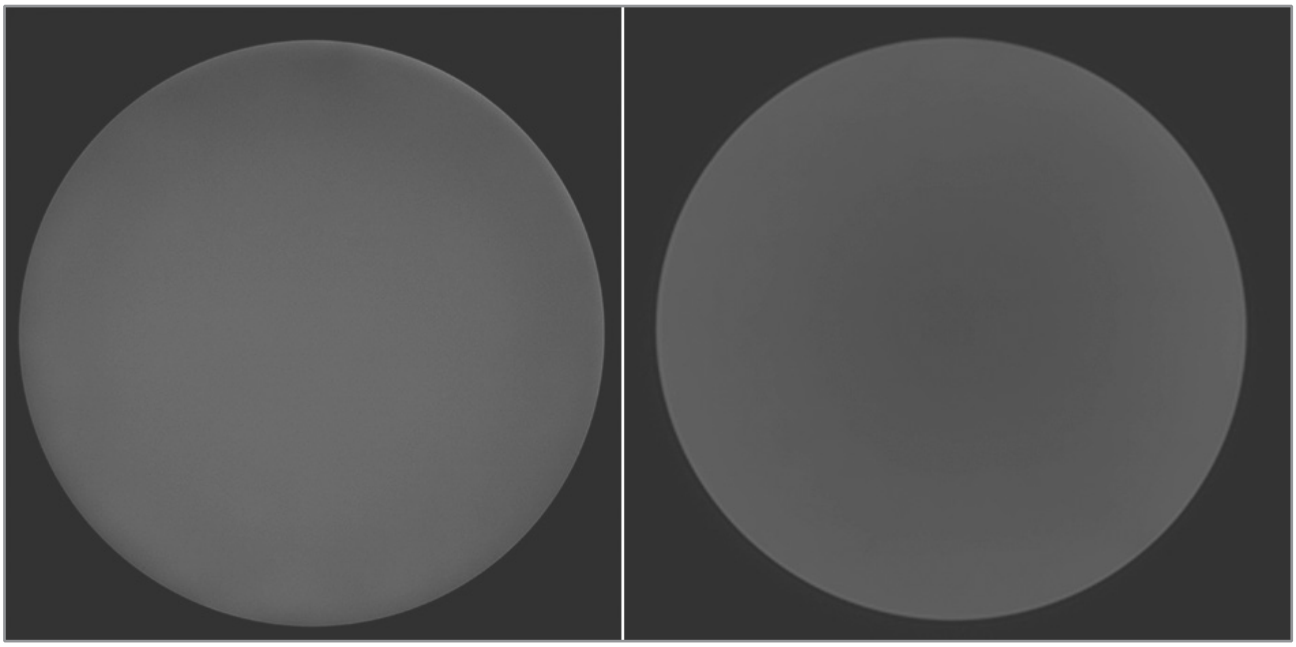

Figure 5. Photos of emitting surfaces of LED panel. Original light-guiding plate (left), produced prototype (right)

Applying of suggested technology can solve individual tasks in projects of illumination museums, social and public places. Applying laser machine tool is adaptable approach for producing light guiding plates, and allows to producing different forms. Results of measurement producing light-guiding plate are just as well as serial light-fixture. This technology has good prospect, it can be applied not only for light fixtures producing, but also for producing of light-technics, based on light-guiding plates.

References

[1] Постановление Правительства Российской Федерации от 28 августа 2015 г. N 898

[2] Постановление Правительства Российской Федерации от 7 марта 2017 г. N 275

[3] Письмо Г. Г. Онищенко N 01/11157-12-32 “Об организации санитарного надзора за использованием энергосберегающих источников света”

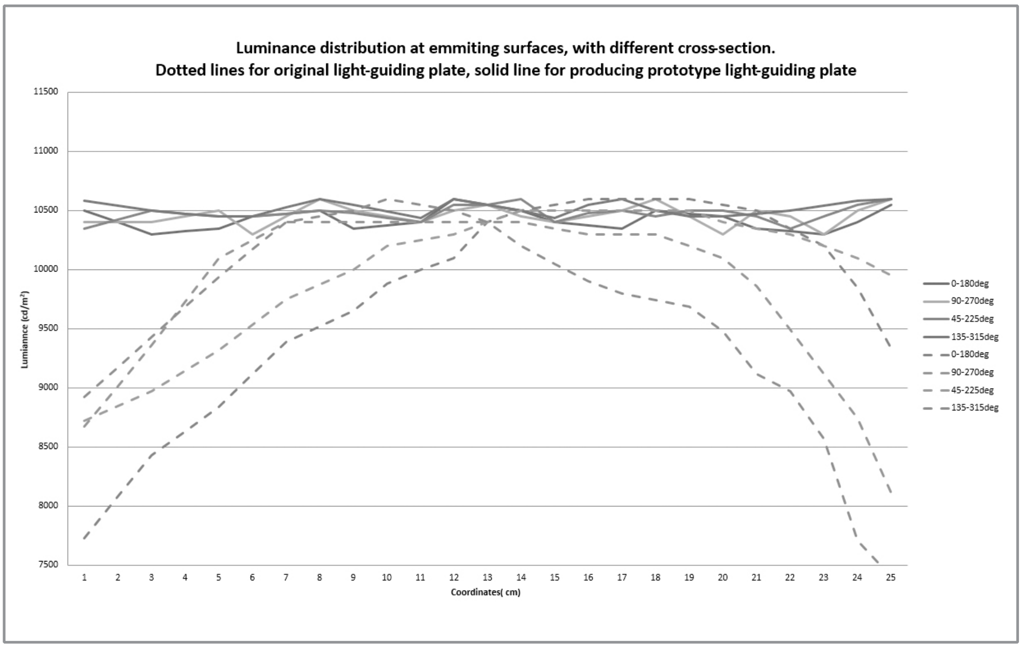

Figure 6. Luminance distribution at emitting surfaces

[4] D. Zhdanov, A.A. Garbul, V. Mayorov, V.G. Sokolov, I.S. Potemin, T. Hyodo, A.G. Voloboy, V.A. Galaktionov, “Automatic design of illumination systems”, Optical Review, IET, Vol. 20, No. 2, pp. 155-159, 2013

[5] А.А. Гарбуль, Д.Д. Жданов, И.С. Потемин, В.Г. Соколов, “Применение методов двунаправленной стохастической трассировки лучей для задач анализа рассеянного света и проектирования осветительных систем”, XI Международная конференция “Прикладная оптика-2014”: Сборник трудов конференции - Т. 2. - С. 97-101, 21-24 октября 2014г.

[6] А.А. Гарбуль, Д.Д. Жданов, И.С. Потемин, В.Г. Соколов, “Моделирование и оптимизация осветительных систем с рассеивающими микроструктурами на кривой поверхности”, XI Международная конференция “Прикладная оптика-2014”: Сборник трудов конференции - Т. 2. - С. 106-110, 21-24 октября 2014г.

[7] D.D. Zhdanov, V.G. Sokolov, I.S. Potemin, A.G. Voloboy, V.A. Galaktionov, N. Kirilov, “Modeling and Computer Design of Liquid Crystal Display Backlight with Light Polarization Film”, Optical Review, IET, Vol. 21, No. 5, pp. 642-650, 2014

[8] Д.Д. Жданов, А.Д. Жданов, И.С. Потемин, В.Ю. Венедиктов, В.А. Галактионов, “Быстрый метод построения локально-эквидистантных распределений геометрических объектов осветительных систем”, Оптика и спектроскопия, Т. 119. - № 2. - С. 329-336, 2015.

[9] D.D. Zhdanov, I.S. Potemin, N. Bogdanov, A. Voloboy, A. Garbul, V. Sokolov, V. Galaktionov, “Computation model of the physically accurate simulation of the light transformation on the free form surfaces with micro-elements”, EOSAM 2016, IET, Vol. 2, pp. S04, 2016

[10] GCC. [Online]. Available: http://www.gccworld.com/goods.php?act=view&no=41

[11] Integra. [Online]. Available: http://www.integra.jp/en/products/lumicept

[12] D.D. Zhdanov, A.D. Zhdanov, I.S. Potemin, V.Y. Venediktov, V.A. Galaktionov, “A method of fast building of locally equidistant distributions of geometrical objects of illumination systems”, Optics and spectroscopy, IET, Vol. 119, No. 2, pp. 311-317, 2015

[13] ЗАО “Светлана-Оптоэлектроника”. [Online]. http://www.soptel.ru

VIRTUAL PROTOTYPING OF COMPLEX ILLUMINATION SYSTEMS FOR CULTURAL, MEDICAL AND EDUCATIONAL FACILITIES

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Abstract

This article describes methods of physically accurate simulation of lighting devices, which is required for design, photorealistic visualization and virtual prototyping of LED-based light fixtures and imaging systems in target environment. In addition, results of virtual prototyping of various lighting and observation systemsare presented.

INTRODUCTION

In now days, requirements to energy efficiency of light fixtures is constantly growing. This result in lighting technologies changing from solutions based on luminous and incandescent lamps to LED-based ones. From optical modelling point of view, typical modern light fixture consists of LEDs array, reflectors and light guide plate with scattering microelements on it, providing necessary spatial and angular luminance distribution.

When creating light fixture for cultural, medical or educational facilities, special illumination conditions are required. This leads to requirements for special angular intensity distribution and illuminance distribution on the illuminated surfaces. Additionally, when illuminating pieces of art or designing illumination systems for medical equipment it is important to take optical properties of illuminated objectsin account because they influence global scene illumination process. Real prototyping of such devices that takes in account not only light source properties, but also surrounding objects geometry and their optical properties requires large investments in production. On other hand, it is possible to make a virtual prototype of luminaire in its real environment with specified optical properties, design desired illumination distribution and check its ergonomics in virtual environment.

To solve arisen problems, authors have developed virtual prototyping methods and software that allows physically accurate simulation of complex luminaries in real environment conditions. Physically accurate definition is required for light source (LEDs) model [1], geometrical scene where it should be located and optical properties [2] of these objects.

Virtual prototype of illumination system includes not only physically correct rendering methods and models, but also optical effect like aberrations and stray light.Virtual prototyping methods can be applied not only to non-imaging optics, but also to imaging optics. For example, it can be applied to render images formed on sensors of real optical systems.

To create a physically correct model of virtual prototype the most appropriate method is bidirectional stochastic ray tracing solution utilizing result of successive backward and forward Monte-Carlo ray tracing. This allows not only to visualize luminance distribution but also to render the virtual image formed on the camera sensor with taking diffuse scattering on all illuminated surfaces in account.

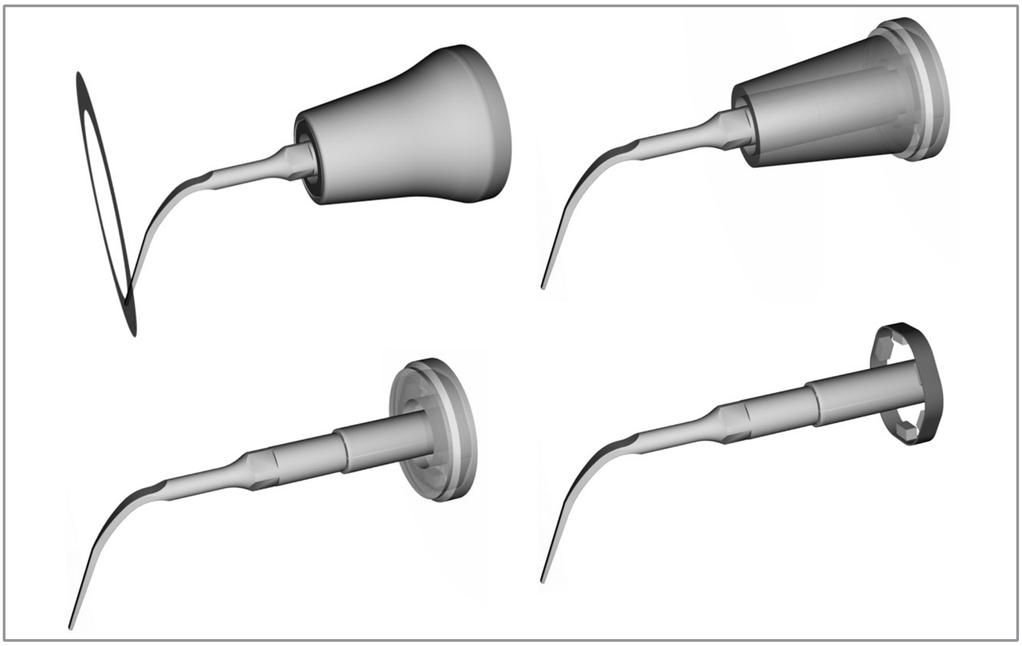

Figure 1. Scheme of dental scaler. Top row from left to right: assembled scaler with circular illumination design area; scaler with removed covering cap. Bottom row from left to right: scaler with covering cap and light guide removed; scaler with covering cap, light guide and clear plate removed

Solving rendering equation with stochastic ray tracing

Physically accurate account of the light scattering on diffuse surfaces is provided by the rendering equation (1) [3]. In an optical system that entails multiple diffuse reflections of light rays, the rendering equation builds up into an infinite recursive sum of brightness integrals over the total sphere on the surface in the point of observation.

$$L(\vec{p},\vec{v},c) = \tau(\vec{p},\vec{v},c)\left(L_0(\vec{p},\vec{v},c) + \frac{1}{\pi}\int_{4\pi} BSDF(\vec{p},\vec{v},\vec{v}',c)L(\vec{p},\vec{v}',c)(\vec{n}\cdot\vec{v})d\omega \right)$$

(1),

where:

L_0 $(\vec{p},\vec{v},c)$ – own luminance of the object at the observation point,

$\tau(\vec{p},\vec{v},c)$ – transmittance of medium between observer and observation point,

$BSDF(\vec{p},\vec{v},\vec{v}',c)$ – luminance factor of the surface (or Bidirectional Scattering Distribution Function) in direction from light source to observer,

$L(\vec{p},\vec{v},c)$ – luminance of external illumination inside of solid angle dω in direction to observation point,

$\vec{n}$– surface normal in the point of observation.

To solve rendering equation, the following three basic methods of stochastic ray tracing are applied:

I. forward stochastic ray tracing;

II. backward stochastic ray tracing; and

III. bidirectional stochastic ray tracing.

The choice of the ray tracing method depends on the region in which the integration can be performed most efficiently; i.e., the effective region of integration is maximal. In turn, the effective region of integration is determined by parameters of the observer, light sources, and optical properties of the optical system elements.

We have implemented these three methods of stochastic ray tracing. When rendering an image created by optical system we can choose either forward or backward stochastic ray tracing. The method choice bases on probability of rays hitting target. Forward stochastic ray tracing method is chosen if rays emitted by light source hits image plane with probability higher then rays emitted by image plane hits light source. In other case, backward stochastic ray tracing is chosen.

Forward stochastic ray tracing

Let us look atoptical system, when forward stochastic ray tracing method is better than backwardone. Forward stochastic ray tracing methodis usually used in case when we need to design lighting optical system where design target is illumination of some area or luminance flux. Following example shows lighting system of ultrasonic dental scalar (Fig. 1). The device model consists of the following elements:

• Covering cap made of stainless steel. The geometry of the element is fixed during the design;

• Tube made of stainless steel. The geometry is fixed during the design;

• Ring-shaped clear plate made of some transparent material. The geometry may be changed during the design. Distance between the edge of covering cap and clear plate is 16.5mm;

• 6 LEDs as a light source and LED support;

• Light guide between covering cap and steel tube. The geometry may be changed during the design.

Figure 2. Illuminance distribution for different shape of output face of ring-shaped clear plate. From left to right: plane surface; microgeometry with spherical elements;toric surface

Optical properties of dental scaler materials [2] and LEDs are measured with help of corresponding measurement equipment [1]. Design aim is to provide maximum illumination of illuminated ring zone by varying clear plate geometry.

In this case, source of illumination are LEDs of small size, while illuminated zone is rather big ring area around the tooth gum. As illuminance in an integral of luminance (2) and light sources are relatively small, the optimal illuminance calculation solution here is direct stochastic ray tracing method.

$$E = \int_{\Omega} L(\varphi, \theta) \cos\theta \, d\omega \tag{2}$$

By varying shape of output face of ring-shaped clear plate in this virtual prototype of ultrasonic dental scalar, it became possible to double illumination in design area. Additionally, uselessness of light guide between covering cap and stainless tube was discovered, as removing it gives almost no effect on illumination of design area. Fig. 2 shows initial and final design of clear plate with corresponding illuminance distributions in target area.

This example shows advantage of forward stochastic ray tracing method. Luminance calculation time was about 5 minutes. To calculate the same luminance distribution with backward stochastic ray tracing it will require hours of calculations.

Backward stochastic ray tracing

In some cases backward stochastic ray tracing method is preferable.This method in usually used in case of photorealistic image rendering in virtual prototypes of imaging optical systems [4]. This method is usually used in case when light source occupies big enough part of scene and detector area is relatively small. Good example of backward stochastic ray tracing method usage is rendering of image formed by imaging optical system.

Fig. 3 shows an example of optical system used in medical endoscope. Optical system consists of:

- 9 lenses in 3 groups with diameters from 6.4mm to 1.5mm;
- Image sensor, size is 1.6mm x 0.8mm;
- Total optical system length from first lens to image sensor is 17.6mm;
- Optical axis is shifted to use half of the device height; the other half will be later used for observed objects illumination.

This optical system have wide view angle and that is why backward stochastic ray tracing is preferable [5]. To use backward stochastic ray tracing method effectively first we needed to find location of exit pupil. Usually exit pupil position is calculated for each image sensor pixel area with help of backward deterministic ray tracing. Image points where exit pupil position was not calculatedare interpolated by their neighbor areas. Next, information about exit pupils for image sensor pixels areas was used to speed up rendering in virtual prototype of endoscope imaging optical system.

The image formed by virtual prototype of endoscope was compared with its real prototype on a grid image. After overlaying images taken by real and virtual prototypes, grid lines have aligned perfectly (Fig. 4). In this example, virtual prototype of optical system used in endoscope provided absolute correspondence of virtual and real prototypes. Such prototype can be used to design optical system and test it in their destination environment without manufacturing of real prototype.

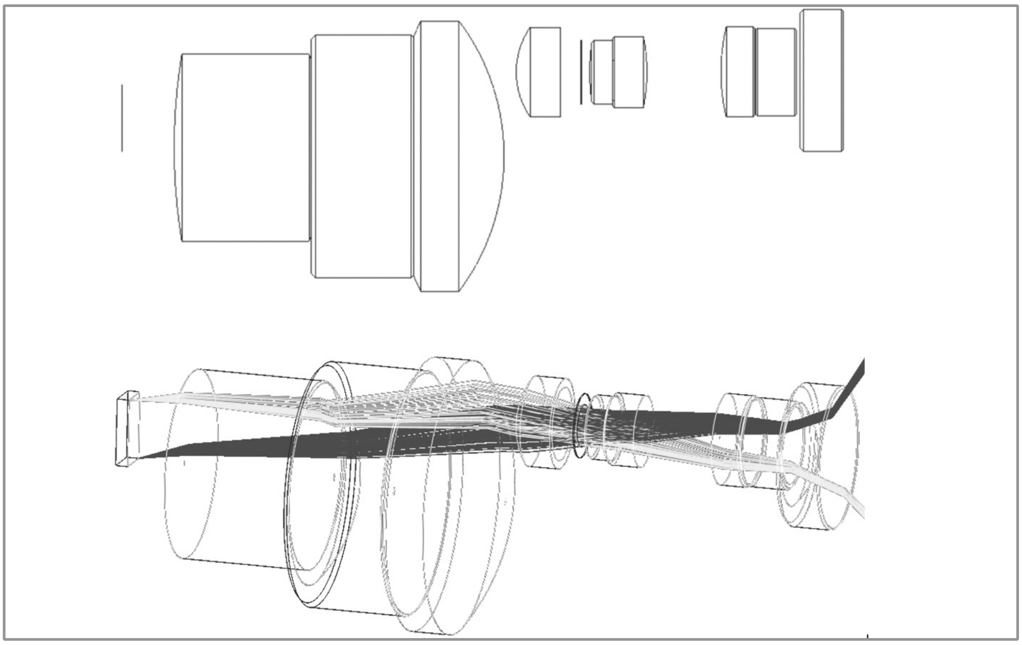

Figure 3. Lens camera of medical endoscope with shifted optical axis. From top to bottom: general scheme of endoscope optical system; rays that form image in sensor corner points

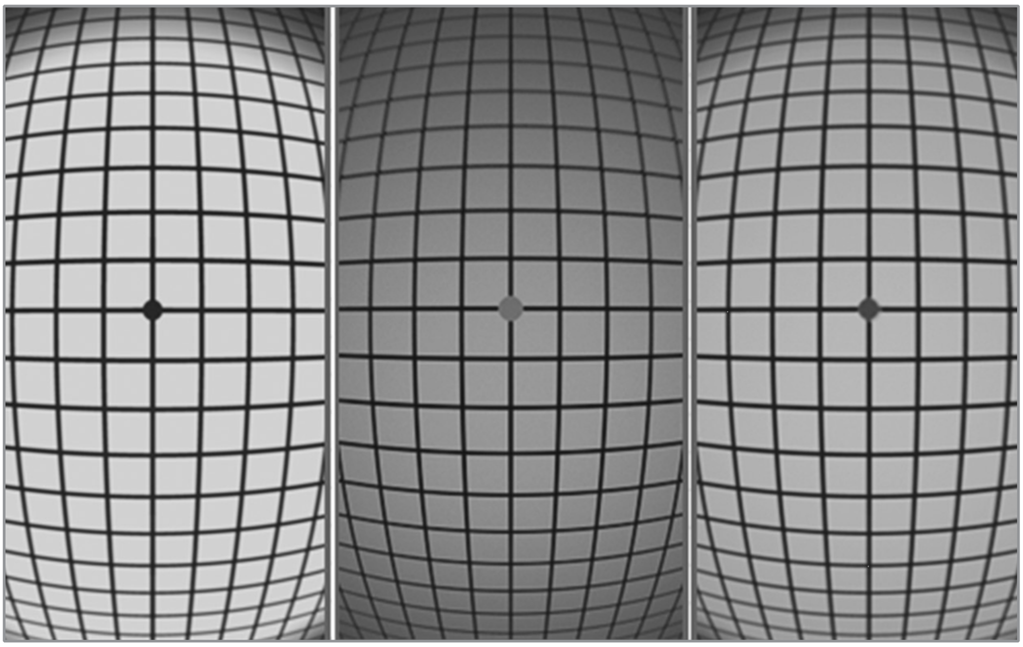

Figure 4. Comparison of real endoscope image with its virtual prototype. From left to right: image taken by endoscope; image taken by virtual prototype; merge of both images. Different illumination color was chosen intentionally

Bidirectional stochastic ray tracing

If contribution of secondary lighting to the integral luminance value is essential then the most appropriate method to solve the rendering equation is the bidirectional stochastic ray tracing. This method can include photon maps to increase quality of caustic illumination calculation.

In our implementation, bidirectional stochastic ray tracing is a sequential stochastic tracing of backward and forward rays and special processing of saved paths. In result of the ray paths processing the following four sources of luminance are formed:

- visible luminance of light sources; i.e. the luminance formed by traces of backward rays without any diffuse scattering;

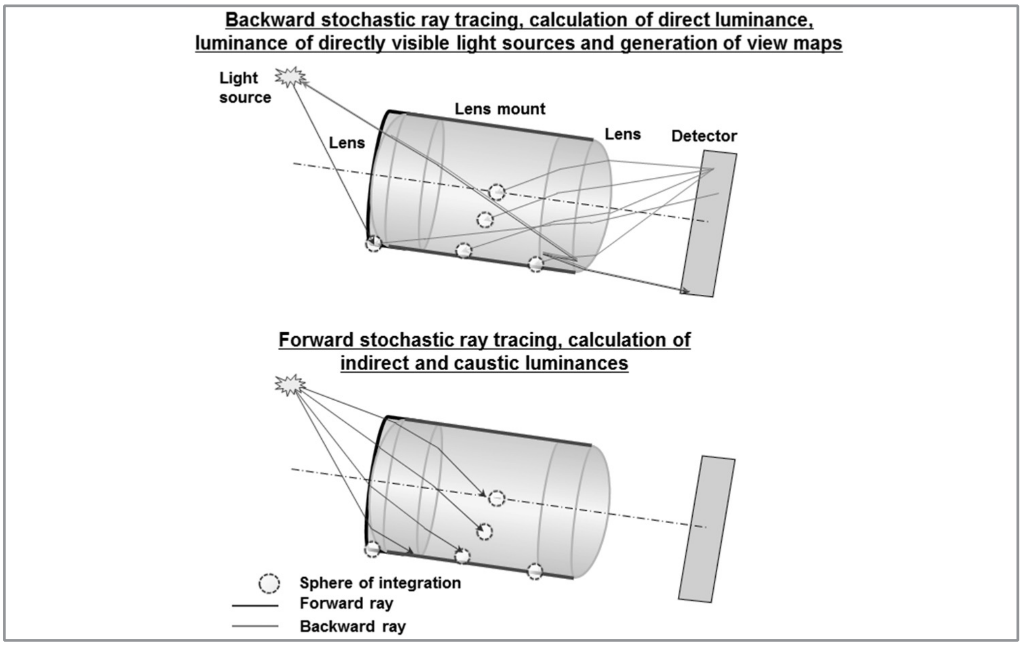

Figure 5. Two stages of bidirectional stochastic ray tracing

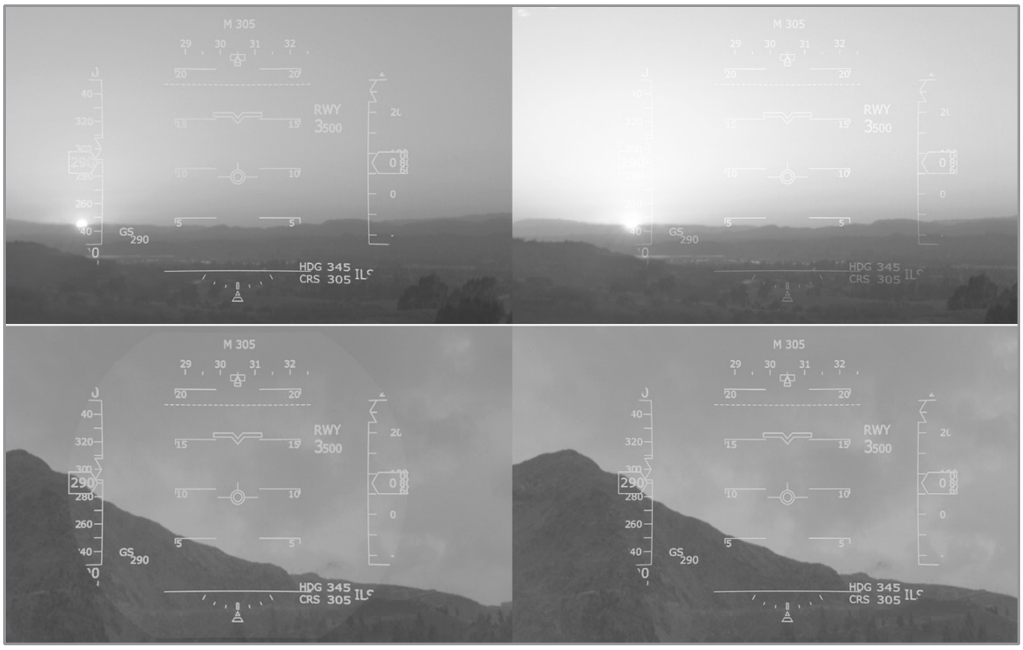

Figure 6. Aircraft projection head up display virtual prototype. Left images for high projector light source luminance, right images for low one

• primary or direct luminance; i.e. the luminance formed by lights directly illuminating the point of observation;

• caustic luminance; i.e. the luminance of directly viewed diffuse objects formed by light sources which illuminate the point of observation without scattering;

• secondary luminance; i.e. the luminance formed by diffusively scattered rays with two or more scatterings on the traces from light source to the point of observation.

This method is preferable when imaging optical system contains diffuse surfaces. It is applicable in analysis of stray light [6] (Fig. 5) or during design of projection system of head up display systems, especially ones containing diffuse microstructures [7] and sheets.

Bidirectional stochastic ray tracing combines all the main advantages of the forward and backward ray tracing and, in addition, allows us to find the most suitable place for the integration of caustic and secondary luminances.

We developed the algorithm of bidirectional stochastic ray tracing which includes two stages (Fig. 5). Image shows possibility of this algorithm to calculate stray light and as result render image with taking stray light in account. On the first stage, the backward rays are traced and the direct luminance and the luminance of directly visible light sources are calculated. Also the photon maps as an array of spheres of integration with centers in the point of intersection of backward rays with diffuse surfaces of the optical system are stored. On the second stage, the forward rays are traced and the secondary and caustic luminances are calculated in the areas of intersection of the forward rays with the photon map that is spheres of integration.

Bidirectional stochastic ray tracing method is highly effective in virtual prototyping of projection optical systems with diffuse sheets, like ones used in projection displays. In addition, this method allows modeling of the rear projection effect, which is stray light on image. Fig. 6 shows an example of design of projections head up display system that will be used in near future in aircraft pilot training equipment. Stray light appears here because of non-absolute contrast of liquid crystals matrix used to form head up image.Virtual prototype helps to see how head up display light source luminance affects visibility of objects behind it. Virtual prototype images (Fig. 6) shows how use of high projector light source luminance will blind the pilot.

CONCLUSION

Competition on the market constantly grows and it results in decreasing time allocated for new product research. Virtual prototyping is an innovative tool to reduce illumination design cost and it is becoming more and wider used in market. We suppose that in near future virtual prototyping will be usedwherever possible to create a physically correct model of lighting systems in their target environment.

Described solutions were implemented in Lumicept (SPECTER) software package [8] and can be used for virtual prototyping of illumination design. Authors are constantly evaluating this software package by adding support of new optical effects. In addition, effective support of modern, multi-processor and distributed systems is in development.

References

[1] D.D. Zhdanov, A.A. Aleinikov, A.D. Zhdanov, N.B. Deryabin. “Construction of a model of a continuous light source specified by a fixed set of rays”, Programming and Computer Software, vol. 42, №. 6, pp. 333–340, 2016.

[2] Letunov A.A., Barladian B.H., Zueva E.Yu., Veshnevetc V.P., Soldatov S.A. “CCD-based device for BDF measurements in computer graphics”, 9th International Conference on Computer Graphics and Vision Proceedings, Russia, Moscow, pp.129-135, 1999.

[3] J. T. Kajiya. “The rendering equation”, Computer Graphics, SIGGRAPH '86 Proceedings, vol. 20, pp.143-150, 1986.

[4] D.D. Zhdanov, A.A Garbul, I.S. Potyemin, I.V. Valiev, V.G. Sokolov. “Application of stochastic ray tracing for the real lens image image synthesis”, GraphiCon2016 Proceedings, Russia, Nizhny Novgorod, pp.29-33, 2016.

[5] I.L.Livshits; M.V.Letunovskaya; I.S.Potemin; S.G.Okishev and D.D. Zhdanov. “Aberration vignetting phenomena and its visualization in wide angular objectives”, SPIE Proceedings, Optical Design and Testing VII, vol.10021, 100210A, 2016.

[6] D. Zhdanov, I. Potemin, A. Garbul, V. Sokolov, A. Voloboy, and V. Galaktionov. “Application of bidirectional stochastic ray tracing for stray light simulation in optical systems”, Conference proceedings of 10th International Conference on Optics-photonics Design & Fabrication, Weingarten, Germany, 29S1-08, February 28th - March 2nd 2016.

[7] D.D. Zhdanov, I.S. Potemin, N.N. Bogdanov, A.G. Voloboy, A.A. Garbul, V.G. Sokolov, V.A. Galactionov. “Computation model of the physically accurate simulation of the light transformation on the free form surfaces with microelements”, EOSAM 2016, Berlin Adlershof, con. vent. Exhibition Centre, Germany, TOM2 S04, 26-30 September 2016.

[8] Lumicept – Integra Inc. http://www.integra.jp/en/products/lumicept

Сборник трудов конференции EVA 2017 SAINT PETERSBURG. Electronic Imaging & the Visual Arts. Vol.1 – СПб.: Университет ИТМО, 2017. – 118 с.

XX Международная объединенная конференция «Интернет и современное общество» (IMS-2017)

EVA 2017 SAINT PETERSBURG
Electronic Imaging & the Visual Arts
Труды конференции. Вып.1

Дизайн и верстка Л.М. Корпан

Редакционно-издательский отдел Университета ИТМО

Зав. РИО Н.Ф. Гусарова
Подписано к печати 21.06.2017
Заказ № 4048
Тираж 100 экз.
Университет ИТМО. 197101, Санкт-Петербург, Кронверкский пр., 49