Content

9 Preface

13 Digitisation of Archaeology: Review, Critique, and Aspirations
Nicolo Dell'Unto

15 Ancient Remains from the Roman Istanbul: A Transmutation from Stone to Digital
Ylenia Ricci, Giorgio Verdiani, Andrea Pasquali

29 Bali Temple VR: The Virtual Reality Based Application for the Digitalization of Balinese Temples
I Gede Mahendra Darmawiguna, Gede Aditra Pradnyana, I Gede Partha Sindu, I Putu Prayoga Susila Karimawan, Ni Kadek Risa Ariani Dwiasri

41 Mobile Interactive Storytelling at the Ancient Agora of Athens: Exploring the Right Balance between the Site and the Digital Application
Akrivi Katifori, Maria Roussou, Irene Kaklopoulou, Katerina Servi

55 Virtual History – Forum Romanum: Reconstructing an Archaeological Site for Research and Science Communication
Sylvius Lack, Beate Hetényi

63 Making the Absent Present: Virtual Remapping of Jerusalem's Past in the Interactive Documentary *Jerusalem, We Are Here*
Anna Wiehl

77 Combining Visualization of World Heritage and Applied Research
Johanna Leissner, Martin Papirowski, Ralf Schäfer, Oliver Schreer, Christian Weißig

89 From Ruins to Glory: The Recreation of Ancient Greece in Assassin's Creed Odyssey
Stéphanie-Anne Ruatta & Jonathan Dumont

93 Wadi Al Helo VR – A Virtual Visit to a Cultural Heritage Site: Showcasing a Virtual Reality Storytelling Framework
Zlatan Filipovic, Pablo Dornhege, Felix H. Beck

105 The AURORA School for ARtists: Artistic Augmented Reality Applications in Cooperation with the Independent Arts & Culture Scene in Berlin
Maja Stark

107 Banz & Bowinkel, *Untitled (Augmented Carpet)*
Banz & Bowinkel, André Selmanagic, Maja Stark

111 Bianca Kennedy, *Swimming with the Lovers*
Maja Stark, Leonid Barsht

115 Felix Kraus, *Cutting Sunday*
Maja Stark, Elisabeth Thielen

119 Phyllis Josefine, *dvvvdvvv (XR re-vived clothingpieces)*
Maja Stark, Denise Bischof

123 Dani Ploeger, *Smart Fence*
Maja Stark, Elisabeth Thielen

127 Theresa Reiwer, TOVIAS
Theresa Reiwer, Maja Stark, Elisabeth Thielen

131 Ulrike Schmitz, *The lizards are not what they seem*
Maja Stark, Leonid Barsht

135 Dagmar Schürrer, *Untitled (Von der Fläche zur Form)*
Dagmar Schürrer, Maja Stark, Leonid Barsht

139 The Digital Exhibition at the Konzerthaus Berlin: Cultural Participation through Digitalisation
Michael Droste, Annette Thoma

147 Namibia Living Books
Barbara Liebel, Detlef Pfeifer, Jürgen Sieck

159 SmartSquare (Smart Culture in Smart Cities)
Jens Bley, Martin Niggemann, Anais Wiedenhöfer

161 The Future of Classical Music: Is 3D-Sound Giving Music Back its "Soul"?
Stephan Frucht

169 Gleisdreieck Online – An Interactive WebGIS System for Exploring Berlin's Industrial Heritage
Jens-Martin Loebel, Nico Kupfer

181 MauAR – Berlin Wall in AR
Peter Kolski, Markus Abel

183 Arrested Space: Virtual Reality as Representation of Expressionism Concepts of the Visual World
Slawomir Nikiel

191 Managing Large Sets of Multidisciplinary Research Data Using 3D Models of Cultural Heritage Objects and Augmented Reality: Case Study of King's Chinese Cabinet in Wilanów
Piotr Siekański, Eryk Bunsch, Anna Guzowska, Robert Sitnik

201 Development of AR Applications with Different Technologies: A Case Study and Comparison
Denise Bischof, Julien Letellier, Jürgen Sieck

215 sMapshot – A Historical GPS in the Crowd
Nicole Graf

221 An Intuitive Hand-Gesture Interface for Virtual Reality Applications Based on the Deep-Learning Approach
Mykyta Kovalenko, Paul Chojecki, Ingo Feldmann, David Przewozny

235 Virtual Object Shaping the City: Imaginary Undergrounds in Russia
Daria Radchenko

245 Telling History in Stories: A Mobile, Multimedia Navigation System for Nuremberg's Medieval Dungeon
Jörg Engster

251 Reinstating Relevance of Indigenous Proverbs in Contemporary Societies
Victor Adelakun Omolaoye, Heike Winschiers-Theophilus

Preface

Culture and Computer Science 2019 – Virtual History and Augmented Present

As a rapidly expanding area of computer research, Augmented and Virtual Reality is characterised by a high degree of interdisciplinarity. The entanglement between the real world and computer generated data cuts across, and expands far beyond, disciplines such as Human-Computer Interaction (HCI), Computer Graphics (CG), sensor systems, human-to-machine communication, and machine-to-machine communication on the one hand. On the other hand questions such as the origin of the data, or the impact of such media technologies on our perception and concept of reality are highly relevant in media studies, cultural history and theory, but also in archaeology, ethnology, museology or cultural heritage.

Given this interdisciplinary constellation, one can translate the concept of Mixed Reality (Milgram, Takemura, Utsumi, & Kishino, 2005) or the seamless bridging of the physical and virtual worlds into the linkage between virtual history and augmented present. While the supposedly real is always mediated by natural or artificial senses/sensors having their own history, all we know about history is transmitted through media such as images, texts or archaeological findings, but also through vinyl records, films or computer data. All these media traces generate what we call history. And this history differs from the present and the future precisely in that there are no artefacts or traces for them, whereas possible futures can be designed in the present.

Hence, the representation of history and the presentation of the present and future are two sides of the same coin coming together in today's media and computer technologies. Reconstruction and construction are intrinsically linked to current media techniques and are fundamentally interdependent. The extent to which our *knowledge* of history has changed can be seen, for example, in the media history of archaeology, when current

tools such as Unity are used to render possible historical worlds virtually experienceable. With that in mind, this year's 17th International Conference on Culture and Computer Science aims to address the multifaced bridges between virtual history and augmented present.

The "Culture and Computer Science" conference series brings into focus best practice examples, challenges and future trends in the fields of Augmented, Mixed and Virtual Reality, hybrid systems, 3D technology, data collection and management, media integration, modelling, visualisation and interaction. The authors of this international volume analyse, demonstrate and discuss current research strategies and developments around "Virtual History and Augmented Present". In addition to four invited keynote papers, more than 40 papers were submitted. Each paper was reviewed by three different members of the international programme committee. Our thanks go to the members of the programme committee for their assistance in reviewing the numerous submissions. The international programme committee selected 18 papers and 11 interactive installations and grouped the contributions, together with the 4 keynotes.

Hence, the reader will find an extensive overview of best practice applications of information management, communication, interaction, visualisation, mixed, augmented and virtual reality, audio technology, multimedia, streaming and data processing, and design within a specific cultural context. The contributions analyse and discuss the following key topics:

- Research in Reconstruction;
- Sensorial Narratives;
- Augmented Reality and 3D;
- Digitalisation and Technology;
- Digital Storytelling.

This edition of the series "Culture and Computer Science" was only possible with the continuous support of the *Konzerthaus Berlin*. In this respect, we thank specifically the staff and the artistic director Prof. Dr. Sebastian Nordmann of the *Konzerthaus Berlin*, in whose premises we hold the conference "Culture and Computer Science – Virtual History and Augmented Present". The special atmosphere of the surroundings will

certainly continue to have a lasting effect on all speakers and participants. In particular, we would like to thank Janina Paul and Elena Kountidou from the "Konzerthaus Berlin" for their support of and their engagement with the conference.

Our special thanks goes to all authors, without whose creativity, ideas and hard work it would not be possible to run an international conference and to produce these very interesting and inspiring proceedings.

Finally, this and all previous conferences "Culture and Computer Science", as well as this publication, would not have been possible without the commitment of the staff and colleagues of our research group INKA at the University of Applied Sciences HTW Berlin. In particular, we would like to thank Kerstin Remes, Denise Bischof, Dagmar Schürrer, Maja Stark, Elisabeth Thielen, Julien Letellier and Michael Thiele-Maas.

Carsten Busch, Christian Kassung and Jürgen Sieck

Berlin, May 2019

Augmented Reality:
In this publication, you have several opportunities to use, test and enjoy Augmented Reality. Simply download the app "CLOU" or "INKA-AR" free of charge from the App Store or Play Store, start the app on your smartphone and look out for the AR symbol in the book. Use the app on these pages and study the additional information presented at your smartphone.

The editors acknowledge the support of the Cluster of Excellence *Matters of Activity. Image Space Material* funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany´s Excellence Strategy – EXC 2025.

Digitisation of Archaeology

Review, Critique, and Aspirations

Nicolo Dell'Unto
Department of Archaeology and Ancient History
LUX, Lund University
Box 192, SE-221 00 Lund, Sweden

Abstract

In the last decade, the diffusion of 3D spatial technology has strongly affected the interpretation process undertaken by archaeologists and cultural heritage specialists working with material culture. In specific the possibility to visually analyze in three dimensions complex archaeological environments allowed gaining information before impossible to identify, providing scholars with the opportunity to experience new ways to engage with material culture.

The introduction of these techniques in the frame of archaeological practice was characterized by an intense period of experimentations where several researchers started using these methods as primary source of field documentation. The results of these experiments highlighted the needs of initiating a discussion focused on the way these techniques affects the process of knowledge production. Despite the positive results achieved so far, there is still uncertainty on how the data produced by these new approaches can be employed by future generations of scholars in support of new interpretations.

How will this impact the development of archaeological practice? And in which way will we engage with archaeological data in the future?

Related articles:

1. Dell'Unto, N. (2018). 3D Models and Knowledge Production. Archaeology and Archaeological Information in the Digital Society. Huvila I. (ed). Routledge Taylor & Francis Group ISBN: 9780415788434
2. Landeschi, G., Apel, J., Lundström, V., Storå, J., Lindgren, S., & Dell'Unto, N. (2018). Re-enacting the sequence: Combined digital methods to study a prehistoric cave. Archaeological and Anthropological Sciences. DOI: 10.1007/s12520-018-0724-5
3. Taylor, J., Issavi, J., Berggren, Å., Lukas, D., Mazuccato, C., Tung, B. & Dell'Unto, N. (2018). ‚The Rise of the Machine': the impact of digital tablet recording in the field at Çatalhöyük. Internet Archaeology, 47. Department of Archaeology, University of York.
4. Dell'Unto, N., Landeschi, G., Apel, J. & Poggi, G. (2017). 4D Recording at the Trowel's Edge: Using Three- Dimensional Simulation Platforms to Support Field Interpretation, Journal of Archaeological Science: Reports.
5. Dell'Unto, N. (2016). Using 3D GIS Platforms to Analyse and Interpret the Past. I Forte M. & Campana, S. The Age of Sensing. Springer, series Quantitative Methods in the Humanities and Social Sciences.
6. Dell'Unto, N.; Landeschi, G.; Leander Touati, A.M.; Dellepiane, M., Callieri, M., Ferdani, D. (2016). Experiencing Ancient Buildings from a 3D GIS Perspective: A Case Drawn from the Swedish Pompeii Project, Journal of Archaeological Method and Theory, ISSN 1072-5369
7. Wilhelmson, H. & Dell'Unto, N. (2015). Virtual Taphonomy : a New Method Integrating Excavation and Post-processing of Human Remains. American Journal of Physical Anthropology. ISSN: 1096-8644
8. Berggren, Å., Dell'Unto, N., Forte, M., Haddow, S., Hodder, I., Issavi, J., Lercari, N., Mazzuccato, C., Mickel, A. & Taylor, J. (2015). Revisiting reflexive archaeology at Çatalhöyük : integrating digital and 3D technologies at the trowel's edge. Antiquity. ISSN: 0003-598X
9. Dellepiane, M., Dell'unto, N., Callieri, M., Lindgren, S. & Scopigno, R. (2013). Archeological excavation monitoring using dense stereo matching techniques. Journal of Cultural Heritage. Elsevier. ISSN 1296-2074

Ancient Remains from the Roman Istanbul: A Transmutation from Stone to Digital

Ylenia Ricci, Giorgio Verdiani, Andrea Pasquali
Dipartimento di Architettura
Università degli Studi di Firenze
Via della Mattonaia, 8 50121, Firenze (FI) Italy
yleniaricci.bnd@gmail.com,
giorgio.verdiani@unifi.it, pasqualiandrea@yahoo.it

Abstract

This research focuses on three Gorgon protomes located in today's Istanbul, Turkey. The aim is to give an identity to these elements, a retro-design, starting from the documentation to reach the virtualization of the ruin. The Basilica Cistern is the largest of all the hundreds of ancient cisterns that rise below the city of Istanbul. Inside the cistern there are these big stones representing the Medusa's head, mythological character of important interest in the artistic scenario, from the eighth century BC until today. The intent is to bring back to life an architectural element of the past, through a virtual musealization that outlines the history of these sculpture, placing them in their hypothetical original context and propose new tools of knowledge of the architectural heritage.

1 Basilica Cistern

1.1 Istanbul – Historic and Geographic Site

The city of Constantinople did not come out of nowhere, or just after the arrival of Constantine I and the division of the Roman Empire into two parts in 324 DC. When the Romans started the urbanization by making it part of the empire, the population of the ancient city of Byzantium was mostly formed by Greeks. The city was destroyed by Septimius Severus for political reasons and later rebuilt by himself, with an agora, baths, a hippodrome, as well as a large square surrounded by arcades. These buildings were decisive for the arrangement of the main roads, the public squares, the palace and some important buildings of the future Constantinople. [Mang78]. The centrality of Byzantium attracted Constantine I who, on 11 May 330 DC, founded it again as "Nova Roma". Soon the city assumed the name of Constantinople, "City of Constantine" (in Greek Costantínou pólis) and became the capital of the Easter Roman Empire with an important role in the Mediterranean trade. Constantine also began a huge construction project, and with the abandonment of the ancient acropolis and the Roman agora, the center of the city moved to places frequented by the emperor, as the forum of Constantine. [Russ16] Despite the strong Christian imprint that the city quickly assumed, it preserved for the moment the ancient temples because the pagan cults were tolerated, which changed at the time of Theodosius. From the VI century AD, during the Empire of Justinian, the city became "the City unparalleled", whose prestige derived mostly from the urban structure, with architectures considered great and harmonious at the same time. [Bass15]. While its powerful walls protected it over the centuries by the invasions of Arabs, Bulgarians and Serbs, the trades of its markets and the strength of its army made it a very rich and powerful city. The Roman-Byzantine era of the city lasted about 11 centuries and has left numerous monuments to the city, including the majestic basilica of Santa Sofia (Hagia Sofia) and the underground cisterns. The end of the Byzantine Constantinople was May 29, 1453, the day on which Muhammad, the Ottoman sultan conquered the city. Like the Byzantine emperors before them, the Ottoman sultans also made a great effort to retrain the city, building works designed to fascinate

the citizens of Constantinople and the visitors. As it was for the Byzantine Empire, the Ottoman Empire also experienced a slow decay over the centuries, which eventually led to the fall of the empire in 1922 and the founding of the Republic of Turkey. In the twentieth century the name of the city was transformed into Istanbul, as the city is still called today.

1.2 Medusa's Head – the Sculptures

The Basilica Cistern, in Turkish *Yerebatan Sarnici*, is one of the biggest ancient below the ground of Istanbul. The Cistern is located 150 meters South-West from Santa Sofia, in the historic peninsula of *Sarayburnu*, built in the 6th century during the reign of Justinian I, Emperor of the East. The term Basilica came up from the fact that it was built under a large public square, the *Stoa Basilica*, built around the 3rd-4th century during the early Roman period as a center of commerce then destroyed from a fire in 476. In the early Byzantine period, the Emperors built cisterns within the walled city to satisfy residents' water needs, in particular during the wars. After the Ottoman conquest of Constantinople, the Ottomans used the water from the Cistern to irrigate the gardens of the Topkapi Palace, however, after installing their relatively modern water system, they stopped using it. Forgotten by the city authorities, it was rediscovered only in 1545, thanks to the French archeologist Petrus Gyllius.

This cistern has the size of a cathedral and it is an underground chamber of about 138x65 meters – about 9,800 squares meters - capable of holding 80,000 cubic meters of water. The ceiling is supported by 336 marble columns, 9 meters high, arranged in 12 rows of 28 columns spaced 5 meters each other. Fifty-two stone steps lead to the entrance of the cistern. The Cistern is surrounded by a refractory wall with a thickness of 4 meters and covered with a waterproofing mortar. [Onlu10].

Fig. 1: Rendering image of the interior of the Cistern Basilica

During the 1985 restoration, 50,000 tons of mud were removed from the cisterns, and a system of platforms was built to replace the boats once used to visit the cistern. It was opened to the public in its present condition on 9 September 1987. In May 1994 it has been subjected to one additional cleaning. [Bars90]. Located in the northwest corner of the Cistern there are the two huge blocks of stone, representing the head of Medusa in slightly different poses and finishing.

1.3 The Structure of Cistern Basilic – Historical Phase

The heads of Medusa in the Istanbul Cistern are clearly fragments coming from a previous building. The origin of the two heads it is unknown, but it is thought that the heads were brought into the cistern after having been

removed from a late Roman period building. [Bars92]. They may be parts of some ruined architecture (maybe the Constantine's Gate, but it is a hypothesis impossible to verify), or something never completed. One of the Medusa's heads is positioned upside down and the other sideways. So, even if these stones are depicting a myth capable to petrify an enemy, and for this reason being an excellent symbol to put like a "shield" on the entrance of a gate, their destiny was being used to support columns, placed underwater, with these interesting faces turned on one side or completely upside up [Kald16].
According to some other interpretations, these heads were positioned like that to cancel the power of the petrifying gaze of the Gorgon, however, it is necessary to think that they have been placed in this way for the condition of the piece, the two sides with a less irregular to bear the columns, a practical solution due to the nature of the material instead than to legendary features.

2 From Stone…

2.1 Survey – Digital Photogrammetry

The operations of digitalization of these sculptures have been carried out through the process of photogrammetry. The survey was structured in two campaigns, one in 2014 having for subject of the mission the two sculptures present in the Basilica Cistern; the other in 2017 that completed the survey operations with the registration of the data on the Medusa's head at the Archaeological Museum of Istanbul. The decision to carry out the process using digital photogrammetry was due by the ease of acquisition of the relevant data and the immediate availability of registration of the chromatic information, necessary for completeness of the virtual outcome and useful for comparative studies in the research program. Listing, briefly but for completeness, the technical specifications of the instrumentation used; to produce a set of images in the 2014 campaign, the camera in use was a Nikon D800e digital SLR with a 36.3 Megapixel unfiltered sensor, a camera capable to get high resolution images keeping a low level of noise even in high ISO settings, a proper condition for the low light of the

cistern. After some evaluations, the lens used for the two photographic sets was a Sigma Zoom 12-24mm F4.5 set on 20mm stopping down at its full opening F4.5. The choice of a significant wide-angle lens was due to more than one aspect: with a wide angle lens the risk of micro-blurred images at low shutter speeds is reduced; the strong perspective may be useful in the photogrammetry process; the wide field allows to work easily in the quite narrow space around the heads and avoiding the tourists walking around. The camera sensor was set at ISO 6400, in this way the shutter was operated at a speed about 1/3 and 1/8 accordingly to the lighting conditions. All the shots were taken with the camera handheld, so there was the need to a certain skill in keeping a stable position and avoid any significant shaking while shooting.

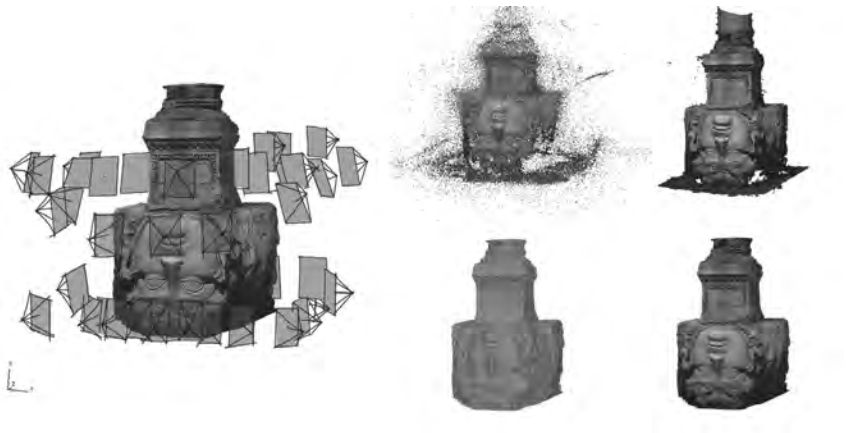


Fig. 2: Point cloud and mesh surface of the digital photogrammetry workflow

While in the 2017 campaign, the same instrumentation was used but in an external photographic set with a soft light day. Therefore, it's possible to established shooting conditions which are more in keeping with the recording aimed at the digital photogrammetry process [MaPa15].

2.2 Reconstruction – Direct 3D-modelling

The process of digital restitution, of three sculpture, was solved thanks to Agisoft Photoscan, through a canonical workflow of the program we have obtained the three digital models of the Medusa Heads, all accompanied by color map. For their use, both in the Maxon Cinema 4D environment,

aimed at rendering, and in the Unreal Engine platform, for the creation of the VR application, the models were submitted to the baking process through xNormal.

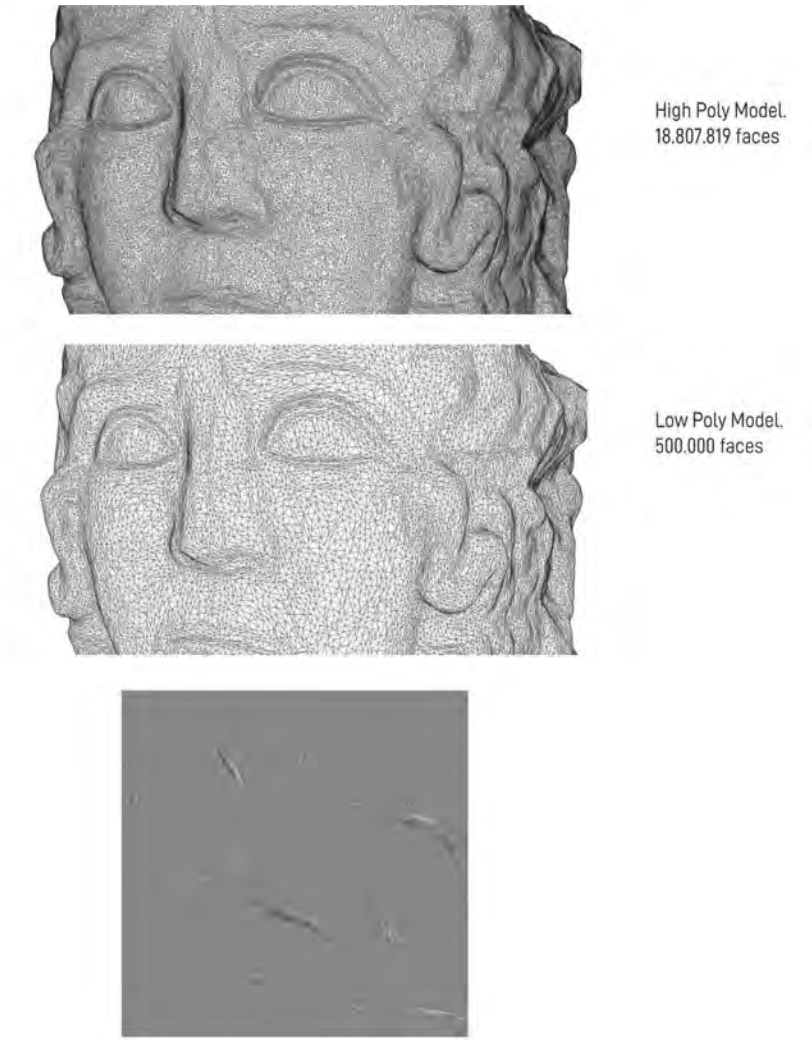


Fig. 3: Comparison between high-poly and low-poly mesh and normal map

This led to a virtual copy well aligned with reality, maintaining an optimal level of scientific data. The reconstruction of the Basilica Cistern was based on existing surveys, creating a dimensional model, not complete

accurate, but optimally proportioned for the description of the real atmosphere of the environment. Virtual modeling was performed with Maxon Cinema 4D which allowed easy management of the primitive components and an immediate control of the topology on the mesh surface. The modeling process was addressed with a canonical model design. Since the Basilica Cistern is an example of a Roman style construction, typological groups have been identified to be managed as elementary cells for series reproduction by rendering instances. To these were added some detailed components, placed near the area of movement in VR, to take care of the setting in the proximity of the user. Both for the modeling of the environment and in the finishes, the construction of the surface took place with attention to cleaning and optimization; the result is a 3D model that responds to the real but totally optimized in the topology. This provided a strong reduction in rendering times. The management of texturing took place based on a photographic investigation. By comparing images of direct sampling with web photographs, the basic textures for the environment have been selected. Through post-production operations on the original texture (the color map), similar material maps have been created, useful for the complete definition of the peculiar characteristics of the surfaces (displacement map, diffuse map, etc) [GuAn16].

3 …to Digital

3.1 Engineering – Digital World Management

For the virtual/augmented realities it was preferred to optimize the 3D models in two different solutions, one oriented to “on-site” presentation, with a structure based on the use of an Oculus Rift viewer and a virtual environment developed in Unreal Engine; the other oriented to “on-line” presentation, with a structure based on common display and/or personal devices, optionally used inside cardboard/cardboard-like viewers.

3.2 Employment – VR Application

The aim of VR is to simulate a real environment through new technological means, to give the user experiencing it the impression of actually

being immersed in that environment. To achieve however, a virtual environment is not easy and requires time, research and investment. An important role in the growth of this sector have been video games, which have created a huge market by acting as a driving force for technological development. The purpose of our work is to virtualize the ruin, to create new opportunities and new tools for the researchers and the knowledge of the built heritage. To this end, the Unreal Engine software was used for rebuilding the Cistern and to offer a format that can be reused in any museum context. With interactive virtual visits, which is an active type of communication, we can provide to the visitor a picture as complete as possible of the ruin and the current context in which it is located, allows you to offer the user a personalized training experience in which he himself chooses what to display and what information to extract based on his personal interests, an active participation of the user is required. With the technologies currently available, the use of interactive virtual visits can take place in multiple ways. We thought about using QR code that can give you access to the documentation to get a clear idea of the nature of the protomes and the various 3D models, Rendering 360, and VR. During the many trials carried out with some users who had the opportunity to immerse themselves in the VR environment of the Basilica Cistern we had noticed how they were getting used to the new means in a very little time. At first they were impressed by the reality of the space they were in and in a second moment they started to become acquainted with the use of the joystick and the interaction we put inside the VR scene, like the viewing of some video that came out approaching some QR code.

Fig. 4: QR code

4 Conclusion

4.1 Issue

At the end of the processing procedures, it is possible to focus on significant issue and precautions. The working group is made up by researchers with an experience already active on the workflow presented, so the procedures applied have been organized with respect to past experiences. This cognitive framework has been improved through the confirmation or failure on management in the individual work steps. Among the observations found we can identify the most relevant. First, the need for the correct managing of the 3D model. It should be emphasized that attention must be mainly directed to the model planning phase. For the project we must distinguish: the analysis of the morphological components, the primitives and the identity-formal characteristics of the environment to be modeled; and the purposes of the product model, usage of data processed (what it should be used for) and the virtual reality structuring software (export processes and format file). From this analysis, by crossing the said prerogatives, it will be possible to design an operational program to obtain a model: constituting an instance-based system therefore optimized the polygon density of the mesh; organizing for polygonal objects already divided or structured for the easy and optimal application of the scripts in VR environment; ordering the surface dimensionally and topologically to facilitate control in the texturing phase. To the above, we add the observations on the assembly process of the rules of operation of the virtual environment. Within the virtual environment, particular attention must be given to the quantity of FPS that will then be rendered in real time during the execution of the app. These frames allow us to have a smooth flow and therefore to be able to fully appreciate the potential of this technology. To make this possible, the previously explained process of reducing meshes and polygons it's very important. The many elements and materials are managed through a blueprints visual scripting that allows you to manage every single action, from the movement of the water, to the various sounds that can be add into the VR environment and the various actions related to the movement of joysticks. We must always try to balance the coexistence

of all these elements and their quality to have a usable product and that does not create problems for the human eye during VR immersion.

Fig. 5: Screenshot by Unreal engine

Finally, the fundamental observation on the management of the objects resulting from digital photogrammetry cannot be overlooked. Please note that the input of the work is generated from the theme of cultural heritage. The scientific consistency management is fundamental. The 3D model calculated in the phase of processing of the photographic survey, performed with respect to appropriate and verified references [MaPa15], must be did to the best of the software working parameters. Also, the subsequent optimization phase, necessary for the annexation in the VR environment, will have to be carried out through careful baking processes. Cautiously checking the consistency between the high-poly and the low-poly model.

4.2 Cultural Heritage Digital Archive

At the end of the research, it is worth to remember that the process was aimed to create a complete product, as its main purpose. Integrating the main result, the use of the VR experience in the cultural heritage, the creation of a virtual temporal reality. This records the conditions of the artifact at the time of the survey and makes it accessible and perceptible in the future. Constituting a chronological archive of the conditions of the

building and its temporal evolution. Archiving of the cultural heritage that evolves its form, compared to that of the current literature, widens the possibility of analysis and study of the object with the sensory increase of relationship with it. Opening to new methods of study, today as for future researchers.

Acknowledgements

This research has been developed as a personal subject by the authors, tools and software used for it are licensed or property of the Didalabs system, Dipartimento di Architettura, University of Florence. The authors want to greet Seda Sakar and Serkan Golkanp for their valuable support to the photogrammetry survey at the Istanbul Archeological Museum and Zeynep Ceylanli and Pelin Arslan for their kind indications and translations.

Literature

[Adam94] Adam, Jean-Pierre: 1994, L'arte di costruire presso i romani, materiali e tecniche.

[AFSS11] Agarwal, Sameer; Furukawa, Yasutaka; Snavely, Noah; Simon, Ian; Curless, Brian; Seitz, Steven M. and Szeliski, Richard: 2011, Building Rome in a Day, in ACM, Vol. 54, No. 10, October, pp. 105–112, 2011.

[Apol16] Apollonio, Fabrizio I.: 2016, Classification schemes and model validation of 3D digital reconstruction process, in Proceedings of the 20th Cultural Heritage and New Technologies, Museen der Stadt Wien – Stadtarchäologie, W. Börner, S. Uhlirz (editors), Vienna.

[Bars90] Barsanti, Claudia: 1990, Note archeologiche su Bisanzio Romana, in Costantinopoli e l'arte delle province orientali, a cura di F. de' Maffei. C. Barsanti, A. Guiglia Guidobaldi (Milion 2), Roma 1990, pp. 11–72

[Bars92] Barsanti, Claudia: 1992, Costantinopoli: testimonianze archeologiche di età costantiniana, in Bonamente – Fusco, pp. 115–150.

[Bass15] Bassett, S.: 2015, The Urban Image of Late Antique Constantinople, Cambridge.

[FrCa04] Freely, J.; Çakmak, A.S.: 2004, Byzantine Monuments of Istanbul, Cambridge University Pres, London, UK

[GrRZ04] Grün, A.; Remondino, F.; Zhang, L.: 2004, Photogrammetric Reconstruction of the Great Buddha of Bamiyan, Afghanistan, in The Photogrammetric Record 19 (107), pp. 177–199, Blackwell Publishing Ltd. UK.

[GuAn16] Guidi, Gabriele and Angheleddu, Davide: 2016. Displacement Mapping As a Metric Tool for Optimizing Mesh Models Originated by 3D Digitization. J. Comput. Cult. Herit. 9, 2 (2016), 9:1–9:23. DOI:http://dx.doi.org/10.1145/2843947

[Guid13] Guidi, Gabriele: 2013. Metrological characterization of 3D imaging devices. In Proc. of SPIE – Videometrics, Range Imaging, and Applications XII; and Automated Visual Inspection. Bellingham, WA 98227-0010 – USA: SPIE, 87910M. DOI:http://dx.doi.org/10.1117/12.2021037

[Guid14] Guidi, Gabriele: 2014. Terrestrial optical active sensors – Theory & applications. In Stefano Campana & Fabio Remondino, eds. 3D Recording and Modelling in Archaeology and Cultural Heritage-Theory and best practices. Oxford: Archaeopress Publishers of British Archaeological, pp. 37–60.

[GuRB10] Guidi, Gabriele; Russo, Michele and Beraldin, Jean-Angelo: 2010. Acquisizione 3D e modellazione poligonale, Milan: Mcgraw Hill.

[Kald16] Kaldellis, Anthony: 2016, The Forum of Constantine in Constantinople: What do we know about its original architecture and adornment? in Greek, Roman, and Byzantine Studies 56 pp. 714–739

[Maca53] Macaulay, Rose: 1953, Pleasure Of Ruins, Publisher Walker And Company, New York, USA.

[Mang78] Mango, Cyril: 1978, Architettura Bizantina, Electa, Milano.

[MaPa15] Mancuso, Angela & Pasquali, Andrea: 2015, Different ways lead to different results? Experiences on modern photogrammetric surveying on cultural heritage subjects, in in Proceedings of the CHNT Conference 2014, Museen der Stadt Wien – Stadtarchäologie, Vienna.

[Onlu10] Önlü, Şehnaz: 2010, Analysis of Structural Elements of Basilica Cistern, Istanbul Technical University, Turkey

[Poll99] Pollione, Marco Vitruvio: Ed. 1999, L. Migotto (editor), De Architettura.

[Pucc13] Pucci, Mirco: 2013, Prima che appaia il "divieto di fotorilievo": considerazioni sulla fotomodellazione, in Disegnare

Con La Fotografia Digitale, Disegnarecon, September, ISSN 1828-5961

[Russ16] Russo, Eugenio: 2016, Costantino da Bisanzio a Costantinopoli.

[Rykw96] Rykwert: Joseph: 1996, La colonna danzante, Libri Scheiwiller.

[Sett84] Settis, Salvatore: 1984, Memoria dell'antico nell'arte italiana, Einaudi, Torino.

[Verd17] Verdiani, Giorgio: 2017. Retroprogettazione, DIDAPress, Firenze. Giorgio Verdiani, Ylenia Ricci, Andrea Pasquali. 2018, Collection of 3d models about the Medusa's heads in Istanbul, www.sketchfab.com

[Wilk00] Wilk, Stephen R.: 2000, Medusa, Solving the mystery of the gorgon, Oxford University Press.

Bali Temple VR: The Virtual Reality Based Application for the Digitalization of Balinese Temples

I Gede Mahendra Darmawiguna, Gede Aditra Pradnyana, I Gede Partha Sindu, I Putu Prayoga Susila Karimawan, Ni Kadek Risa Ariani Dwiasri
Laboratory of Cultural Informatics, Informatics Education Department, Universitas Pendidikan Ganesha
Singaraja, Bali, Indonesia
{mahendra.darmawiguna, gede.aditra, partha.sindu}@undiksha.ac.id, {yogasusila1996, risaariani01}@gmail.com

Abstract

The aim of this project is the development of a Virtual Reality Application in order to document one kind of Balinese cultural heritage which are Temples. The Bali Temple VR application will allow users to do a virtual tour and experience the landscape of the temples and all objects inside the temples. The application provides an on-site tour guide using virtual reality that allows users to experience the visualization of the Balinese cultural heritage, which in this case are temples. The users can walk through the temples and can see the 3D objects of temples and also there is narration of every object inside the temples with background music. Right now, the project has completed two temples for the virtual reality tour guide application. Those temples are Melanting Temples and Pulaki Temples. Based on the test results of its functional requirements, this virtual reality application has been able to run well as expected. All features that have been developed have been running well. Based on 20 respondents with various ages and backgrounds, our finding shows that The Bali Temple VR Application attracts people of all ages to use and experience it. They are eager to use it and hope that there will be more temples that they can experience to visit in this application.

1 Introduction

Bali is the smallest island and province of Indonesia. Bali, with its varied landscape of hills and mountains, rugged coastlines and sandy beaches, lush rice terraces and barren volcanic hillsides, all providing a picturesque backdrop to its colourful, deeply spiritual and unique culture, stakes a serious claim to be paradise on earth. Bali, the famed Island of the Gods has many cultural heritages, one of them are temples. Bali is known as an island of thousands temples. In every village in Bali, there are several temples and at least one small temple in each home of Balinese which reach to a total of 10.000. Balinese name of temple is pura. A pura is a Balinese Hindu temple and the place of worship for the adherents of Balinese Hinduism in Indonesia. Puras are built in accordance to rules, style, guidance and rituals found in Balinese architecture. Most of the puras are found on the island of Bali, as Hinduism is the predominant religion on it, however many puras exist in other parts of Indonesia where there are significant numbers of Balinese people. Puras are part of cultural heritages in Bali.

Cultural heritage is a cultural property that has an important value for understanding and developing history, science and culture in the framework of fostering the community and nation‘s personality [ThSR13]. Preservation of cultural heritage must continue to be carried out to preserve the culture that we have. Cultural heritage and natural resources are increasingly threatened by damage, not only by traditional causes, but because social change and socio-economic conditions are worsening the situation and as a great phenomenon of damage or destruction and awareness generally always comes too late for a cultural heritage, it‘s very important we take care.

Being located on the Pacific Ring of Fire (an area with a lot of tectonic activity), Indonesia has to cope with the constant risk of volcanic eruptions, earthquakes, floods and tsunamis. On several occasions during the last 15 years, Indonesia has made global headlines due to devastating natural disasters that resulted in the deaths of hundreds of thousands of human and animal lives, plus having a destructive effect on the land area (including infrastructure, and thus resulting in economic costs). The fact that Bali is part of Indonesia which is situated in the Pacific Ring of Fire, the efforts

to prevent damage to cultural heritages need to be proactively managed by means of preservation of cultural heritages. One way to preserve the cultural heritage which in this case are temples is to use virtual reality technology. One of the main advantages, in the fields of virtual realities is the complete virtual reconstruction of 3D environments, especially buildings in full detail. Even if the cultural heritage is physically damaged, it can be virtually reconstructed through probabilistic approximations.
This paper presents the project for the development of a virtual reality based application for the documenting the Balinese temples in Bali, Indonesia. By having such a kind of model, we can reconstruct the buildings based on the data that have been developed in the virtual reality application if, for example, things unexpected happen in the future. The Bali Temple VR application will allow users to do the virtual tour and experience the landscape of the temples and all objects inside the temples.

State of Arts: Laboratory of Cultural Informatics Augmented and Virtual Reality Projects.

This laboratory focuses on research related to culture. One focus of research at this laboratory is the use of augmented technology and virtual reality to document the culture, cultural heritage, arts, folklore in Bali. Augmented and virtual reality technology development began in 2013. We first developed an augmented reality book containing Balinese cultural heritage such as temples, dances, musical instruments, building ornaments, and others [DKCW14][KDCA14]. The working concept of augmented reality is that the application will detect images in books that will then bring up immovable objects. Then in 2015, we developed an augmented reality book containing legend and Balinese folklore. The object in the application is an animation of every Balinese folklore scene [DSKA15]. The augmented reality project continues with applications without books. The feature used in the application to get a marker is to use a user-defined target, where the user uses images that are nearby which are then made into markers so that they can display animations from each scene [WiDS17]. The development of culture-based virtual reality at LCI began in 2018. The first virtual reality application developed were games for Balinese folklores [KhAP18]. Then, it was continued with the development of virtual reality applications for temples in Bali that had previously

been developed using augmented reality on the augmented reality book project. The latest development of virtual reality application for Balinese temples is the development of a 3D 360° Virtual Reality Video Pura Besakih prototype [CrPW17].

Fig. 1: Augmented Reality projects in Laboratory of Cultural Informatics

2 Materials and Methods

2.1 Analysis and Design

Functional Requirements Analysis

After gathering and analyzing needs, there are some functional requirements that are used as a basis for designing Bali Temple VR applications, which are:

a. The application facilitates users to be able to take a tour in the temple area.
b. Applications can display temple objects and their landscapes in three dimensions.

c. The application can provide information in the form of audio and text about objects in the temples.

Tools and Materials

Based on the needs analysis carried out, the software that is needed for the development of virtual reality applications is:

- Blender is used to create Pulaki Temple objects
- Photoshop is used to edit temple object textures
- Unity3D with StemVR Library is used to create the virtual reality application
- Adobe Premiere is used to edit audio for temple object explanations.

The hardware that was used for the development and implementation of this application is:

- PCs for developing and implementing the application.
- HTC Vive

2.2 The Development Steps of Bali Temple VR Application

The steps in developing the Bali Temple VR consist of three main steps. First, taking real images of temples including the objects inside the temples by using a drone and perspective calculation in order to get the exact measurement. Second step is the development of 3D objects of the temples by using Blender. The third step is the development of VR application by using Unity3D and the library Stem VR. The VR tool that is used is HTC Vive.

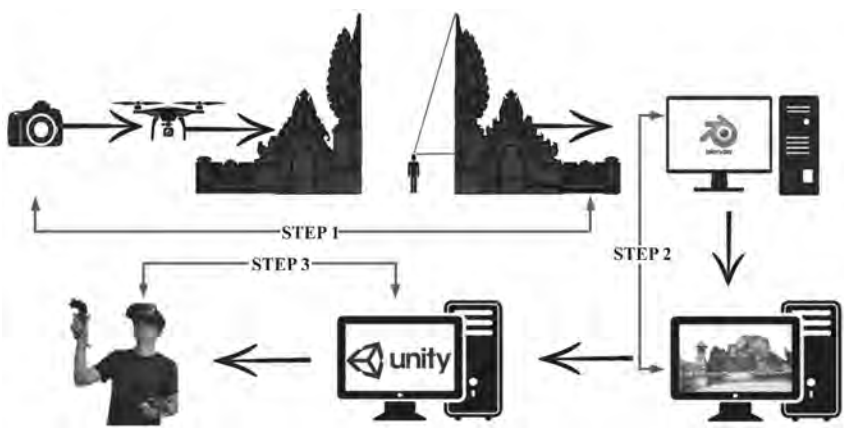


Fig. 2: The steps of Virtual Reality Application Development

3 Results

3.1 Implementation of 3-Dimensional Objects

The first stage in the development of the augmented reality story book is the creation of 3D objects and animations. The tool used is Blender version 2.70. The development of 3D objects and animation involves several steps:

a. ***Modeling.*** This is the process of creating 3D mesh (characters and other 3D objects) using some mesh tools such as plane, cube, circle, uv sphere, icosphere, cylinder, cond, grid, and torus. The techniques that were used were extrude technique and mirror modification.
b. ***Materials & Texturing.*** This process is used to simulate a surface color or property of 3D mesh. This is based on a photorealistic interpretation of a real material or any materials that can produce similar surface colors and textures.
c. After the objects and the landscapes are done they are exported to Unity3D.

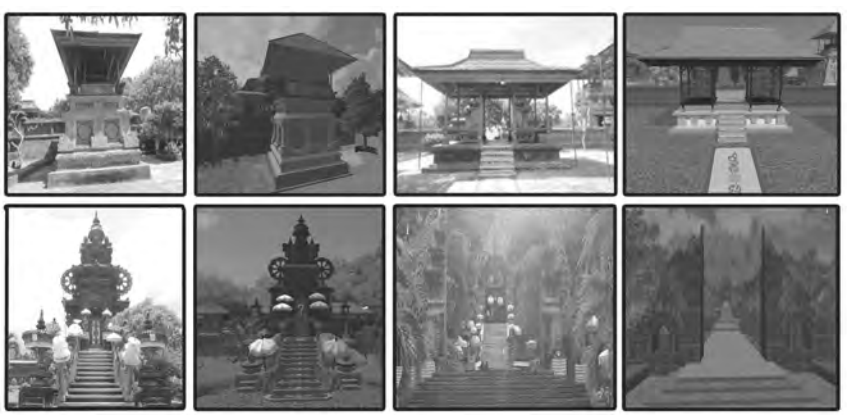


Fig. 3: Comparison between real Puras' objects and 3D Objects developed in Blender

3.2 Implementation of Virtual Reality Application

The development of the virtual reality application uses Unity3D. Before working with Unity3D, Steam VR has to be installed in order to use the virtual reality features. Steam VR can be downloaded on the Unity website, https://assetstore.unity.com/.

The steps for creating a virtual reality application are as follows:

a. Several files must be imported to Unity3D. The files are 3D objects with format (.fbx) and the texture files of the entire objects.
b. It is necessary to create a number of scenes in Unity3D, and then those scenes are stored in the Asset folder. The number of scenes depends on the number of temples. For example, the temple area is divided into five parts, meaning that five scenes are made. Every scene on Unity3D consists of Camera Righ, Directional Light, Steam VR Laser Pointer and Steam VR Teleporter.
c. To run the teleporter in Unity, a mesh collider is set on the object to be targeted by the teleporter. For example, in the VR application that was developed, the temple page was used as the teleport target so users could walk around the temple area by directing the controller to the temple page.
d. The final step is the process of building a Virtual Reality application. Application settings can be set in the build file menu settings. In this setting you can select the scene to be built and you can also add application icons. Then, the Virtual Reality application is ready to be built and run. The application results will be in the apk or exe format.

Fig. 4: The Bali Temple VR Application

4 Discussion

The application gives an on-site tour using virtual reality that allows users experience the visualization of the Balinese cultural heritage, which in this case are temples. The users can walk through the temples and can see the 3D objects of temples and also there is narration of every object inside the temples with background music.

There are several tests we have done. Based on the test results of its functional requirements (black box testing), this virtual reality application has been able to run well as expected. All features that have been developed have been running well. We also tested the application with a content expert to test the accuracy of the shape of each object temple created in the virtual reality application. The accuracy of the objects and landscapes are 90%. There are several objects that need to be polished.

In order to get the response from the people, the application is placed in the Museum Bali. The questionnaire that is used is a User Experience Questionnaire (UEQ). UEQ is used to measure the user experience of interactive products. The scale of the questionnaire cover both classical usability aspects (efficiency, perspicuity, dependability) and user experience aspects (originality, stimulation).

Item	Mean	Variance	Std. Dev.	No.	Left	Right	Scale
1	2.1	0.1	0.3	20	annoying	enjoyable	Attractiveness
2	2.1	0.1	0.2	20	not understandable	understandable	Perspicuity
3	2.1	0.1	0.3	20	creative	dull	Novelty
4	2.1	0.1	0.3	20	easy to learn	difficult to learn	Perspicuity
5	2.3	0.2	0.5	20	valuable	inferior	Stimulation
6	2.1	0.1	0.3	20	boring	exciting	Stimulation
7	2.5	0.3	0.5	20	not interesting	interesting	Stimulation
8	1.4	0.6	0.8	20	unpredictable	predictable	Dependability
9	1.9	0.1	0.3	20	fast	slow	Efficiency
10	2.1	0.1	0.2	20	inventive	conventional	Novelty

Item	Mean	Variance	Std. Dev.	No.	Left	Right	Scale
11	2.1	0.1	0.3	20	obstructive	supportive	Dependability
12	2.1	0.7	0.8	20	good	bad	Attractiveness
13	-0.1	0.7	0.9	20	complicated	easy	Perspicuity
14	2.0	0.0	0.0	20	unlikable	pleasing	Attractiveness
15	2.4	0.2	0.5	20	usual	leading edge	Novelty
16	2.1	0.1	0.2	20	unpleasant	pleasant	Attractiveness
17	2.1	0.1	0.3	20	secure	not secure	Dependability
18	2.1	0.1	0.3	20	motivating	demotivating	Stimulation
19	2.0	0.0	0.0	20	meets expectations	does not meet expectations	Dependability
20	2.1	0.1	0.3	20	inefficient	efficient	Efficiency
21	2.2	0.2	0.4	20	clear	confusing	Perspicuity
22	2.1	0.1	0.2	20	impractical	practical	Efficiency
23	2.1	0.1	0.2	20	organized	cluttered	Efficiency
24	2.1	0.1	0.2	20	attractive	unattractive	Attractiveness
25	2.2	0.1	0.4	20	friendly	unfriendly	Attractiveness
26	2.4	0.2	0.5	20	conservative	innovative	Novelty

Table 1: Result of UEQ for User Experience Test.

Based on 20 respondents with various ages and backgrounds, our finding shows that The Bali Temple VR Application has positive impressions in groups in Attractiveness, Clarity, Efficiency, Accuracy, Stimulation and Novelty. The Bali Temple VR Application attracts people of all ages to use and experience it. They gave a very positive response to the project that had been developed. They are eager to use it and hope that there will be more temples that they can experience to visit in this application.

5 Conclusion

The Bali Temple VR Project gives the opportunity to document cultural heritage in Bali where the main goal of this project is to preserve Balinese cultural heritage and to prevent loss of critical information when negative things like natural disasters occur in the future. In addition, this application can be used as a tool to introduce the culture of Bali to the people who are interested to know more. The Bali Temple VR application can help users to find information about Balinese temples as cultural heritage. This application can be used as a documentation for cultural heritage for the Bali Provincial Cultural Service. This application can also help to introduce Pura on Bali globally. Currently, only two temples have been digitized in the form of virtual reality applications and there are three temples that are under construction. This project is carried out with self funding from researchers. Hopefully, there will be a form of funding in the future that can help us develop virtual reality applications for digitally massive cultural heritage in Bali.

Literature

[CrPW17] Crisnapati, Padma Nyoman; Prihantana, Made Agus Suryadarma and Wijaya, Bagus Kusuma. "Pengembangan Prototipe 3D 360° Virtual Reality Video Pura Besakih Menggunakan Blender." E-Proceedings KNS&I STIKOM Bali (2017): pp. 437–440.

[DKCW14] Darmawiguna, I.G.M.; Kesiman, M.W.A.; Crisnapati, P.N.,; Wiartika, I.M.E.; Suparianta, K.D.; Susena, I.K.; Yudiantara, I.M.: Augmented Reality for the Documentation of Cultural Heritage Building Modelling in Bali, Indonesia. Kultur un Informatik: Reality and Virtuality, Proc of Culture and Computer Science Conf, Berlin, Germany, 2014, pp. 107–117.

[DSKA15] Darmawiguna, I. Gede Mahendra; Sunarya, I. Made Gede; Kesiman, Made Windu Antara; Arthana, Ketut Resika and Crisnapati, Padma Nyoman: The augmented reality story book project: A collection of balinese miths and legends. In International Conference on Augmented and Virtual Reality, pp. 71–88. Springer, Cham, 2015.

[KDCA14] Kesiman, M.W.A., Darmawiguna, I.G.M., Crisnapati, P.Y., Ardipa, G.S., Mariyantoni, I.K.Y., Nugraha, M.L., Prasetya, A.Y.R.A., Dewantara, I.M.A.Y. : The AR Book Project: Collection of Augmented Reality Application of Balinese Artistic and Cultural Objects. Kultur un Informatik: Reality and Virtuality, Proc of Culture and Computer Science Conf, Berlin, Germany, 2014, pp. 93–105.

[KhAP18] Khoerniawan, R.W., Agustini, K., Putrama., I. M : Game Edukasi Penjelajah berbasis Virtual Reality. Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika (KARMAPATI), Volume 7, No. 1, 2018.

[ThSR13] Threesiana, R.; Suwardhi, D.; Riyanto, S: Development Of Virtual Reality GIS For Cultural Heritage Conservation (Case Study: Sewu Temple). Indonesian Journal of Geospatial, ISSN: 2089-5054, Volume 2, No. 1, 2013.

[WiDS17] Wiradarma, I. Gusti Gede Raka; Darmawiguna, I. Gede Mahendra and Sunarya, I. Made Gede: Pengembangan Aplikasi Markerless Augmented Reality Balinese Story "I Gede Basur". Jurnal Nasional Pendidikan Teknik Informatika (JANAPATI) 6, no. 1 (2017): pp. 30–38.

Mobile Interactive Storytelling at the Ancient Agora of Athens: Exploring the Right Balance between the Site and the Digital Application

Akrivi Katifori, Maria Roussou,
Irene Kaklopoulou, Katerina Servi
Department of Informatics and Telecommunications,
National and Kapodistrian University of Athens
and ATHENA Research Center
{vivi, mroussou}@di.uoa.gr,
{eirini.kaklopoulou, katservi}@gmail.com

Abstract

Historical sites are places where the past and the present, the tangible and the intangible meet and offer visitors an opportunity to immerse themselves in history. The design of digital mobile applications for open-air archaeological sites presents specific challenges; however, it also has the potential to enhance visitor experience in unique ways. In this paper, we focus on the design and evaluation of a dramatized multimedia interactive story for the Ancient Agora (market) of Athens, with the objective to bring the site's function and essence to life. The iterative design and evaluation approach we have followed revealed elements concerning the effective balance between the characteristics of the site, the needs of the visitor and the possibilities offered by the technology, including the role and use of 3D and Augmented Reality (AR) technologies, the importance of sound and the level of interaction desired by the users.

1 Introduction

Digital multimedia mobile applications for cultural heritage are found nowadays in museums and cultural sites worldwide and are credited for ensuring access to information, and catering to differing visitor styles, interests and needs [McBB12]. Digital storytelling in cultural heritage contexts has been universally recognized as a direction that cultural heritage institutions, including museums and historical sites, need to invest in to attract and engage their audiences [TwFS08]. The CHESS project [RoKa18] explored different aspects of digital personalized storytelling and its successor, EMOTIVE (Emotive virtual cultural experiences through personalized storytelling), has been working towards the identification of a conceptual framework [PREY17] for the use of emotions in digital storytelling for heritage.

Historical sites, as places where the tangible and intangible meet, serve as living evidence of the sociopolitical and administrative functions of their era [DGLN08]. The experience takes place at the actual site where history happened, thus contributing towards enhancing the visitors' immersion. While engagement in a museum tends to be predominantly a visual affair, in an outdoor setting multiple senses are stimulated with the potential to place the visitor in direct connection with heritage, enabling engagement at an emotional, affective level rather than at a purely informational one [PDMP16].

Studies, including our previous work in the Ancient Agora [RoRS17], indicate that using mobile devices to support the visit in a cultural site, either indoor or outdoor, comes with a number of complex challenges that need to be addressed during design and/or deployment. These may include the design of the multimedia content delivery, balancing visitors' attention between the environment and the device, navigation, usability, social aspects, and personalization [RoKa18].

Outdoor settings can be really challenging also from a technical point of view, due to the possible lack of effective internet connectivity and issues such as intense sunlight that can also impede the presentation of visual material on screen.

In this paper, we present the design and development of an interactive digital storytelling experience for mobile devices for the archaeological

site of the Ancient Agora (market) of Athens, with the objective to explore the opportunities and challenges of mobile-mediated, digital storytelling in an outdoor setting. In Section 2, we discuss the story concept and objectives and how these inform the design and technical specifications of the digital experience. Section 3 presents the evaluation of the prototype experience and Section 4 draws together results and insights. Section 5 concludes the paper.

2 Designing a Digital Interactive Storytelling App for the Ancient Agora

The first step for the design of the experience was to clearly define its objectives in collaboration with the site's experts. The aim of the experience is to promote:

- emotional engagement and empathy of the visitor with the site and chosen historical period,
- a sense of the structure and complexity of the archaeological site and of the athenian society,
- reflection and perspective-taking about the people of the chosen historical period.

In this section we present the site's characteristics and how they informed design decisions about the concept and implementation of the storytelling experience, in relation to the aforementioned objectives. In each paragraph we discuss the interaction between the experience objectives and site needs, identifying concrete requirements and design decisions for the resulting experience (R1–R11).

2.1 The Site

The Ancient Agora of Athens is located in the northwest of the Acropolis. The Agora's initial use was that of a commercial and residential gathering place. The archaeological site is comprised of the outdoor site and a museum and it features multiple buildings from different eras, including 14 important monuments from the Classical period. The visitor wandering around the preserved outdoor site can mostly see only the foundations of these buildings and the well preserved Temple of Hephaestus. The site

is large, covering an area of roughly 20 acres. The site size and state of preservation implies the following two requirements:

- ***R1 – Guided navigation.*** The state of preservation of the monuments does not support visitor navigation by identifying concrete landmarks in space. GPS or another type of geo-localization technique is needed to support navigation from one point of interest to the other.
- ***R2 – Circular visitor path.*** The site is large and the walking distance between points of interest does not favor a free exploration experience. In this case, we designed the storytelling to be experienced at specific points of interest. These points are selected to be relatively close and consecutive in space, so as to minimize walking distance for the visitor in the large archaeological site, and to return with the visitor to the point where the experience started. When concluding the story part at a specific point and according to her choices, the user is guided towards the next point of interest.

The Agora was the center of Ancient Athens and most of its administrative and trading functions were located at this site, a place where notable historical figures, such as Pericles or Socrates, lived and orated. Hence, it is a place of the highest historical significance, visited by millions of tourists throughout the year. However, as is the case with most open-air archaeological sites, to the non experts, the value of what today remains of the site cannot be immediately perceived without a guide. This leads to the following requirement:

- ***R3 – Visual reconstruction.*** The state of preservation of the Agora monuments and buildings introduces the need for appropriate augmentations and reconstructions presented to the user, to better understand the features of the site.

2.2 Historical Setting and Period

Mainly focused around the trade and economical function of the Agora, the setting of the experience highlights this attractive aspect, rich in images and sounds – the crowded market with the traders benches not dissimilar to the markets and bazaars of the East, side by side with temples, altars and emblematic buildings of the classical antiquity.

- ***R4 – Audio reconstruction.*** Re-creating the sense of being in the market cannot be accomplished solely through visual augmentation (R3), but first and foremost with audio augmentations. Sound is key to reproduce the rich soundscape one would experience being present in the market in Ancient Athens.

The historical context of our story is the Ancient Agora of Athens during the classical period (480–323 BCE). The story unfolds at the beginning of the 4th century, one of the worst periods in the history of the city. Athens has been defeated in the recent Peloponnese War and faces a deep crisis. During this period the life status of many Athenians is shattered. People of previous affluence are ruined and now forced to manual labour to survive. In a society where manual labor is a major socio-economical differentiating factor and is in a sense frowned upon, these changes have had a significant impact. The financial aspects of the market become the incentive for deeper reflection on issues very much relevant also today: the financial crisis and its implications, ethical, political and social, issues of distribution of wealth, and more personal issues of coping in times of crisis.

- ***R5 – Digital storytelling***. Using digital storytelling as a tool to convey the historical context through the perspective of personal stories of inhabitants of that time.

2.3 Interactive Storytelling as the Experience Type

Interactive storytelling, is defined as a branching narrative where the user can directly influence the story plot and the characters' decisions, and in this way, create different story lines and alternative endings. This experience type is in fact a specialization of the wider concept of digital storytelling where the user is presented with narratives and stories related to the site; options, when available, allow the user to choose between different stories or to select additional informational content.

- ***R6 – Interactive digital storytelling.*** A key design choice for the experience was to employ interactive storytelling as the experience type.

Interaction and choices at the story plot level is the defining characteristic for the interactive storytelling literature genre. This approach is common in

the Interactive Fiction literature domain, and in gaming settings. However, this approach very rarely has been applied in the heritage domain, especially for on-site visits.

Why interactive storytelling?

Our initial approach for mobile digital storytelling in museums, in the context of the CHESS project and later, employed storytelling techniques where the user was guided around the galleries in a story-centric way. Characters of the past spoke to the user through the device, in some cases simply reminiscing personal stories, in others cases inviting the user to play a role and "help" them complete specific tasks. This approach aimed to engage the user through the illusion of being part of the story in some way and having direct interaction with the main character. As discussed in [RoKa18] and [KKKP18], although these experiences featured several branching and decisions points, they were consistently characterized by several users as "too guided" and "too linear", more so by those with experience in computer games. Users often referred to a "lack of interaction", which, when probing further, was in fact rooted in a sense of lack of actual control over the story plot. The mobile device and perceived nature of the storytelling experience, as a mobile app, created the preconception that the story would be "interactive". Moreover, this kind of interaction that offered only informational content selection and had no true effect over the story plot left the visitor with this sense of lack of control.

To address this finding we turned naturally to techniques established by interactive storytelling and its concrete premise that "story richness depends on the functional significance of each choice and the perceived completeness of choices offered" [Craw05].

- ***R7 – Interactive storytelling with meaningful decision points.*** Our interactive storytelling experience features 7 decision points at each story path and 9 alternate endings defined by combinations of these decision points. To address the issue of "functional significance" of the choices, some of the decision point, as it becomes evident, are later on decisive about how the story unfolds, whereas others are of an ethical or emotional nature. One of the paths, depending on the users' choices, leads to an "anticlimax" ending, similarly to what sometimes happens also in real life.

2.4 The Story Concept

The main character of the story is Hermias, a slave. Slavery in ancient Athens is a controversial institution in the "cradle of Democracy", as ancient Athens has been characterized throughout the ages. This interesting interaction between the political state of Athens and the established institution of slavery is by itself an incentive for reflection on the period.

What is the "truth" of the slave in ancient Athens and how can this be leveraged with the preconceptions of the audience? The divide between free citizens and slaves seems to be a simplistic view of this society. Things were more complex, with slaves becoming rich bankers, (as is the case with the main character of our story), citizens being accused of being descendants of slaves, etc. There are gaps in our knowledge and these offer an opportunity for interesting historical fiction.

- ***R8 – An Athenian slave as the main character.*** A slave, Hermias, has been chosen as the main character of the story, with the objective to promote the emotional engagement of the visitor. Hermias experiences concerns and feelings that are valid and timely also today, including financial insecurity, personal fear for the future of the individual and their family and loved ones, feelings of trust, or lack of, towards the others, etc.

2.5 The Story Plot

The story starts one early morning in 398 BCE by following around the main character, Hermias the slave, as he prepares to go to the market. He is wondering whether he should wear his amulet, which features the head of God Hermes, or leave it at home. Hermias was named after this amulet, with which he was found abandoned as a baby. This is the first decision the user is asked to make for Hermias: to wear the amulet or not? The user is addressed in first person when asked to make choices (Table 1).

The visitor then "follows" Hermias as he walks around the market, where he first meets his master Nicocles and then continues on to run errands. In the course of these interactions and according, again, to the user's choices, he speaks with different merchants and acquaintances, answering or not to their, sometimes, personal questions, about his origins. If the user, at the outset, chose that Hermias should wear his amulet while at the market, then the experience will include merchants asking Hermias about

his amulet; otherwise it will not. While at the market, Hermias hears news of a cargo ship sinking and realizes that his master Nicocles had invested heavily in this ship as a last attempt to recover financially. The story continues with Hermias in emotional distress about how to handle these news and with deep concern about how his master's financial disaster would affect him. The user then follows Hermias' exchanges with different characters in the story and is given the choice to affect his decisions and behavior. These choices define the ending of the story, which is also directly relevant to Hermias' initial choice to wear his amulet or not.

Nicocles is planning to ask Eucrates, a ruthless merchant of shields who accumulated his wealth during the war, for a loan. Eucrates is willing to give Nicocles the loan, but in exchange he asks for the ownership of Hermias. Eucrates' proposal came out of the blue. You… • are aware of your status and do not react... • forget your status and react with insolence...

Table 1: Example of a decision point.

2.6 The Storytelling App

To create and deliver the aforementioned experience, we used the *Narralive* authoring and experiencing tools, also employed within the EMOTIVE project [KKKP19]. Specifically, the experiences were created through the use of the Storyboard Editor, a web-based authoring tool for interactive digital storytelling which produces a mobile app for devices based on Android v4.1 (API 16) and later. More details about the app can be found in [KRPK19].

The story is divided into chapters related with the location and function of different buildings. The users are guided by the app to go to each of the points of interest and then access the relevant part of the experience. At certain points, visitors can have the possibility to access on-demand supplementary information about each specific point of interest (Fig. 1).

The story is implemented as a multimedia experience. Our previous work in the Agora [RoRS17] and other sites [RoKa18] clearly indicated that extensive use of visuals absorbs the user's attention on the screen and away from their surroundings. In this experience we opted for a predomi-

nantly audio based experience, with minimum visuals on screen. Initial formative design sessions led to the following design decisions for the prototype presented in this work:

- ***R9 – Audio based experience.*** The experience unfolds through audio segments, alternating a narrator with conversations between the story characters.
- ***R10 – Supporting use of visuals.*** Images are used sparingly, to (a) support navigation through maps and (b) show specific buildings or objects that are not currently identifiable on site (like the "Tholos" building, as reconstructions.
- ***R11 – Use of VR and AR.*** Tests on site as well as previous experience with mobile device mediated AR and VR outdoors revealed that issues such as sun glare and screen size can significantly diminish the added value of the use of these technologies. This issue is further discussed in Section 5.

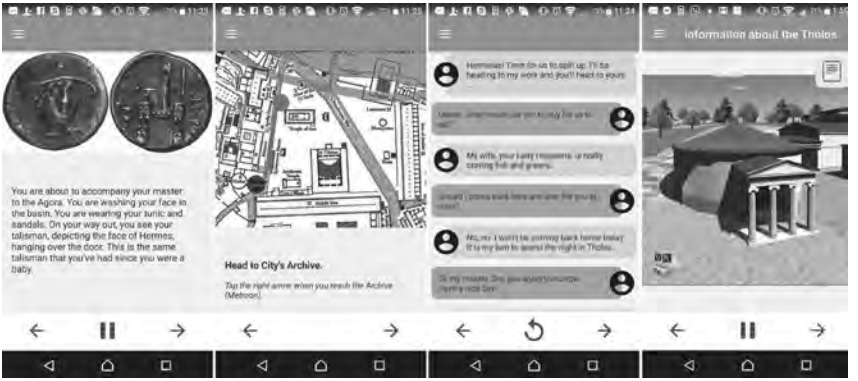


Fig. 1: Selected screenshots depicted aspects oft he story in the mobile app.

The next sections discuss the expert evaluation and its results for the prototype experience.

3 Expert Evaluation

After several iterations working with design ideas and prototypes on site, a first complete demo version of the experience was evaluated in November

2018 by 15 invited visitors from around the world who were selected according to their experience as domain experts, interpreters, and designers of similar experiences (e.g. archaeologists, museologists, experience designers and historians). These invited participants were asked to view the experience from the perspective of a visitor to the Agora, but also as experts, taking into account their experience on what works and what doesn't for visitors in similar contexts (Fig. 2).

Fig. 2: Users experiencing the interactive storytelling app

The participants were given the mobile device and were asked to follow the experience while being discreetly observed by the evaluators. Eight (8) of the participants experienced the story in pairs, using one device and headphone splitters. The reason for this was that we wished to examine the conversation between these pairs of users as they explored the site together.

4 Results and Discussion

In this section we discuss selected findings from the evaluation of the storytelling prototype.

4.1 Establishing Emotional Connection

The users agreed that the story was engaging and they felt immersed when having to make decisions; those in pairs discussed with their companions how to proceed and why at each decision point. As some users

commented, the experience helped them "imagine different aspects of life and social interaction in Athens".

An important comment, however, related to the believability of the character of the slave. In particular, it was suggested that those with no pre-existing knowledge of the role and status of slaves in the athenian society, and with specific preconceptions about slavery, felt that the character of the slave was not realistic, neither in attitude nor in the exchanges with his master. This lack of context and subsequent lack of believability about the character was decisive in breaking the engagement and immersion in the story.

Secondly, as also discussed in [KKKP18], interactive storytelling as an experience type in heritage also needs to take into consideration personalization in terms of the genre that the story belongs to. It is to be expected that this type of social drama may not be interesting or appealing as a genre for specific users, and indeed, there were those who found the story "only mildly interesting" or even "boring".

4.2 Understanding the Historical Context

One of the reported positive aspects of the experience was the fact that it helped the users "get a sense of what it was like to live in the past". However, as already discussed, the lack of historical contextualization about slavery at the beginning of the story seemed to affect emotional engagement. And, on the other hand, as some users commented, the availability of information in menus within the story flow was also considered confusing, or responsible for breaking immersion and engagement.

The challenge of the right balance between engaging storytelling and information delivery remains a strong one and in need of further exploration to identify the optimal techniques to combine both.

In relation to the site itself, again an interesting challenge emerged from the evaluation: on the one hand, some users reported that even though the visuals on-screen had been kept to a minimum, again their attention was frequently drawn to the device, hindering them from connecting with the physical site. They proposed pauses to the experience or prompts to look around in order to enhance their engagement with the surrounding physical world. However, at the same time they felt that the state of preservation of the site would benefit from a richer multimedia experience at

points. We are investigating the application of 3D soundscapes to enhance the visitor experience, as well as applications of VR or AR, which could be meaningful and effective taking into account the device size and sun glare.

4.3 Cultivating Reflection and Perspective Taking

Taking into account the conversation that sparked between visitors during and after the experience, we observed that, in some cases, the experience was successful in promoting reflection and perspective-taking. Users had a chance to experience the past through the perspective of one of its inhabitants. In fact, their disbelief about the character's status and behavior turned into a positive point as it triggered discussions about the role of slavery in the Athenian society, in comparison to other cultures and societies of that time but also later.

In the cases where the experience was shared between two visitors, perspective-taking and reflection seemed to be much more pronounced, attesting once again to the value of social interaction in heritage, as also discussed in [PRMK19].

5 Conclusions and Future Work

In this work, we presented the design and evaluation of a prototype interactive storytelling experience for the Ancient Agora of Athens. The iterative design and evaluation approach we have followed revealed elements and limitations concerning the effective balance between the characteristics of the site, the needs of the visitor and the possibilities offered by the technology. Based on the preliminary findings of our evaluation, we propose ways to address these challenges. As we work towards a newer version of the digital experience, we are looking further into the role and use of 3D and augmented technologies for the site, the importance of sound, and the level of interaction desired by the users.

Literature

[Craw05] Crawford, C.: On interactive storytelling. Berkeley, CA: New Riders, 2005

[DGLN08] Damiano, R.; Gena, C.; Lombardo, V.; Nunnari, F. and Pizzo, A.A stroll with Carletto: Adaptation in drama-based tours with virtual characters, vol. 18, no. 5. 2008.

[KKKP18] Katifori, A.; Karvounis, M.; Kourtis, V.; Perry, S.; Roussou, M. & Ioannidis, Y.: Applying true interactive storytelling in cultural heritage – Opportunities, challenges and lessons learnt," ICIDS 2018, Dublin.

[KRPD19] Katifori, A., Roussou, M., Perry, S., Drettakis, G,. Vizcay, S., Philip, J. (2019). "The EMOTIVE Project – Emotive Virtual Cultural Experiences through Personalized Storytelling," CIRA@EuroMed 2018, pp. 11–20. Ireland: IEEE

[KRPK19] Katifori, A.; Restrepo Lopez, K. M.; Petousi, D.; Karvounis, M.; Kourtis, V.; Roussou, M. and Ioannidis, Y. „Approaching "Dark Heritage" Through Essential Questions: An Interactive Digital Storytelling Museum Experience." MW19: MW 2019. Published January 13, 2019.

[McBB12] Mcgookin, D.; Brewster, S. and Bergstrom-lehtovirta, J.: Shaking the Dead : Multimodal Location Based Experiences for Un-Stewarded Archaeological Sites, Nord. Conf. Human-Computer Interact., 2012, pp. 199–208.

[PDMP16] Petrelli, D.; Dulake, N.; Marshall, M. T.; Pisetti, A. and Not, E.: Voices from the War: Design As a Means of Understanding the Experience of Visiting Heritage, Proc. 2016 CHI Conf. Hum. Factors Comput. Syst., 2016, pp. 1033–1044.

[PREY17] Perry, S.; Roussou, M.; Economou, M.; Young, H. & Pujol, L.: Moving Beyond the Virtual Museum: Engaging Visitors Emotionally. In Proceedings of 23rd Int'l Conference on Virtual Systems and Multimedia -VSMM 2017. Dublin.

[PRMK19] Perry, S.; Roussou, M.; Mirashrafi, S. S.; Katifori, A. & McKinney, S.: Collaborative, Shared Digital Experiences Supporting Sites, Meaning-Making at Heritage Sites. In H. Lewi, W. Smith, S. Cooke, & D. vom Lehn (Eds.), The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums and Heritage Sites. Routledge International Handbook. Routledge. 2019 (In press)

[RoKa18] Roussou, M. and Katifori, A.: Flow, Staging, Wayfinding, Personalization: Evaluating User Experience with Mobile Museum

Narratives, Multimodal Technol. Interact., vol. 2, no. 2, 2018, 32. http://www.mdpi.com/2414-4088/2/2/32/pdf

[RoRS17] Roussou, M.; Ripanti, F. & Servi, K.: Engaging Visitors of Archaeological Sites through "EMOTIVE" Storytelling Experiences: A Pilot at the Ancient Agora of Athens. Journal of Archeologia E Calcolatori, 28(2), pp. 405–420. (PDF) CM., June 2017, London. pp. 373–379.

[TwFS08] Twiss-Garrity, B. A.; Fisher, M. & Sastre, A.: The art of storytelling: enriching art museum exhibits and education through visitor narratives. In J. Trant & D. Bearman (Eds.), Museums and the Web 2008. Montreal, Quebec, Canada: Archives & Museum Informatics.

Virtual History – Forum Romanum

Reconstructing an Archaeological Site for Research and Science Communication

Sylvius Lack, Beate Hetényi
Filmuniversity Babelsberg *KONRAD WOLF*
14482 Potsdam
{s.lack, b.hetenyi}@filmuniversitaet.de

Abstract

The main goal of the project "Virtual History – Forum Romanum" is to let people see, hear and experience the ancient Forum Romanum during the times of Julius Caesar. It thrives to be a contemporary scientific-artistic edit of current research data in the interactive immersive 3D space. The reconstruction of this historic space serves as a pilot project for the future of virtual and augmented reality spaces and for an experience based access to scientific data. Since this project is still under development the scope of this paper is to highlight the artistic challenges we are facing and to elaborate on the methods used during our design process.

1 Introduction

"Virtual History – Forum Romanum" is an interdisciplinary scientific-artistic research project led by Beate Hetényi at the Filmuniversity Babelsberg KONRAD WOLF. It is financed by the European Regional Development Fund (ERDF) and based on the findings of the research and teaching project "Digital Forum Romanum/Analogue Storage Media II – Auralisation of Archaeological Spaces" led by Prof. Dr. Susanne Muth at the Winckelmann-Institute of the Humboldt-University of Berlin in cooperation with the Excellence Cluster TOPOI.
In this project we are using the technology of virtual reality to create an immersive and interactive experience of the ancient Forum Romanum during the times of Julius Caesar. To achieve this goal we identified three main working areas:

1.1 Reconstructing the Forum Romanum as a Real-time VR Experience

As a first step it is necessary to adapt the previous work done by Prof. Dr. Susanne Muth et al. to work in a real-time rendering environment for virtual reality. Due to the inherent technological limitations of VR our 3D models need to be optimised as well as sound and lighting to be tailored to be calculated in the time-frame of just about 11 milliseconds per single picture frame.[1] But this is not only a technological problem since the possibilities of artistic expression rely directly on the means of producing the content. Therefore a constant exchange between the artistic and technological departments seems necessary. To accommodate this we decided to use an iterative and agile approach to design and development which is well established in the software industry, especially in the development of computer games.

1.2 Adding a Layer of Emotion and Atmosphere

To complement the proven archaeological "raw" data and to add a sense of "what could have been" this project calls for an experience layer which reaches out to human emotion and intuition. As opposed to film and

1 To achieve a framerate of 90 Hz it is necessary to render a new frame every 11,11 milliseconds

games we are not striving to tell a story or guide our audience in a certain direction through some sort of "level-design". Nevertheless our goal is to communicate a feeling of "being there" – more of a holistic reconstruction of this ancient site as opposed to the presentation of a distinct sequence of events. The main challenge here is to find a well tuned balance between proven and established scientific procedures and findings and the necessity of adding elements which are not preserved or need to be faithfully reconstructed. Finding a solution to this problem is one of the main focus points of our work and is described in more detail in chapter 3 "Telling the unknown".

1.3 Developing an Example for Science Communication

Our third working area is to find a way to communicate to interested laymen how archaeological findings are realised. This goal is reflected in the overall dramaturgy of this project and will be described in greater detail in chapter 5 of this paper.

2 Scientific-artistic Research Questions

The main research question of this project is how to construct the illusion of an historical space based on scientific data. To achieve this goal we identified three main working areas from the context of traditional cinematic experiences. These well establish processes will need to be adapted and transformed to work with non-linear immersive digital media such as virtual and augmented reality. Our main scientific-artistic research questions based on three traditional disciplines of film production are:

2.1 Script and Dramaturgy

- How to develop a cinematic script for VR?
- How does the interaction between the audience and the experience influences the overall dramaturgy and storyline?
- To which extent does the audience itself plays a part in the dramaturgy?

2.2 Scenography

- How to develop plausible models and props for 3D?
- Which forms of hybrid solutions are possible in VR?
- How to develop a spatial layout in 3D interactive spaces?

2.3 Sound

- How to establish a 360° soundscape in an historic context?
- To which extend is it possible to use algorithmic procedures instead of surround sound mixing?
- How to guide the audience's attention and create impact in sound for VR?

3 Telling the Unknown

As mentioned in 1.2 we need to add elements which we can not be sure of or which simply are impossible to reconstruct on a purely scientific basis. This need arises from our project's goal to create a holistic and credible reconstruction of the ancient Forum Romanum. Therefore we need to find a solution of how to tell the unknown. We need to establish a way of telling the audience when and where we are not sure without breaking the illusion. When approaching this problem from a traditional point of view during the production a fictional movie we always have a story to tell. In this case we may well be able to circumvent this problem by subjugating historic accuracy to the needs of telling a plausible story. But from a cinematic storytellers perspective this project lies somewhere between a fictional movie and a documentary with an added demand for not imparting a distorted historical picture.
This may possibly add up to the single most prominent challenge in this project and may be the most difficult to find an answer to that satisfies scientists, artists and the general audience alike.

4 Dramaturgical Elements

To examine the different artistic and technological questions we are working on three different scenarios inside the reconstruction of the Forum Romanum. These will serve as templates for the future development of a more complex nature. These three basic scenarios are as follows:

1. The reconstruction of elements of everyday life based on the research done during a joint seminar between the department of scenography of the Filmuniversity Babelsberg and the department of archaeology of the Humboldt University Berlin.
2. A political speech of Cicero as recorded by his secretary, re-enacted by an actor and recorded using volumetric video technology.
3. A dramaturgical enactment of a scene of importance on the Forum Romanum, such as a ritual performed by the vestal virgins or a public trial.

5 Structure of the VR Experience

The VR experience itself will be produced as an intertwined orchestration of three planes of representation of the Forum Romanum itself. These three planes represent how we can see and understand the Forum Romanum today. First we have the "real" Forum Romanum in it's current state, i.e. the archaeological site that can be visited in Rome today. Second we have the 3D reconstruction of the Forum Romanum during the times of Julius Caesar based on proven scientific knowledge. Third we have an artistic interpretation of the archaeological findings and other relevant sources to fill in the gaps of the unknown.

The planes themselves will be designed to be self sustained, i.e. the should convey information and meaning on their own accord. But together they should also complement each other to paint a bigger picture of the Forum Romanum and how we came to understand it's history and socio-political structure.

These planes could be thought of as existing in parallel during the whole VR experience. They could be navigated using different interaction methods and viewers could switch between those planes at certain times

and locations. This approach is used to further the understanding of how our current understanding of the Forum Romanum developed and to differentiate between the scientific facts and the artistic interpretation.

6 Methods and Resources Used

6.1 Field Research

During several field trips we collected extensive visual and geometrical data. We scanned the current state of the Forum Romanum using a LIDAR scanner at several positions and did numerous photogrammetric captures of different historic artefacts. We captured materials, such as floors and pavements, while using colour-boards to get a professional grade colour reference and shot several 360° panoramas on location.

6.2 Scenography Seminar

During the winter semester 2018/19 a joint seminar between the department of scenography of the Filmuniversity Babelsberg and the department of archaeology of the Humboldt University Berlin had been held. The goal was to develop an interdisciplinary approach to research of how simple everyday life could have been in ancient Rome.

6.3 Sound Seminar

During the winter semester 2017/18 a joint seminar between the department of sound of the Filmuniversity Babelsberg and the department of archaeology of the Humboldt University Berlin had been held. The goal was to examine the possible auralisation of a 3D representation of the Forum Romanum.

6.4 Interacting with Fellow Artists and Researchers

Apart from daily lively discussions in our interdisciplinary team we actively search to exchange techniques and methods with other disciplines and fellow artists. In the context of the scenography seminar we invited Yadegar Asisi to the Filmuniversity Babelsberg to talk about his large scale panoramic pictures.

7 Conclusion

Since this project is just running for a bit over six months with it's full team on board, we are just putting the final touches to concept, design and technical layout. We are well aware that at this stage we have more questions than answers. While striving to show a world from over two thousand years ago to an audience of today we have to deal with modern viewing conventions without sacrificing scientific honesty. Our hope is that in the tension between proven factual data and the necessity of filling the gaps with artistic content new perspectives for scientists and artists alike will arise.

Making the Absent Present

Virtual Remapping of Jerusalem's Past in the Interactive Documentary *Jerusalem, We Are Here*

Anna Wiehl
University of Bayreuth
95440 Bayreuth
anna.wiehl@uni-bayreuth.de

Abstract

Jerusalem, We Are Here is a co-creative interactive virtual new media tour and remapping project which emerges at the intersection of critical historiography, new media art and documentary making. At the centre of the project stands the creation of a virtual space that does not only document a past *status quo* but that also opens the possibility for negotiating future options of living together in a Jerusalem neighbourhood from which, after 1948, most non-Jewish inhabitants have been expelled.

Key concepts to discuss the complex media assemblage are polyphony, open space documentary as well as Foucault's notion of heterotopia. The leading hypothesis of this contribution is that we are currently witnessing a shift in 'doing documentary': a shift from a representational to a performative paradigm, from an authorial vision to a plurality of perspectives, and from a temporal to a spatial notion of media configurations.

1 New Media Assemblages and Transdisciplinary Approaches to a Facetted Notion of Temporalities and Spatialities

Jerusalem, We Are Here opens quite startlingly: The user-interactor finds himself in a dark room. Then, a lavish red curtain opens to reveal a blank cinema screen. We are inside the Lev Smadar Theater, once named *The Oriental*. As a voice from the off explains, the former owner of the cinema, Ferdinand (Nado) Schtakleff, was a fervent amateur filmmaker himself. He possessed a camera and a tripod, and shot many short films documenting his family life in the 1940s. And: without knowing it, he shot the beginning of what ended up as the expulsion of Palestinian Arabs, Armenians, Greeks and other non-Jewish citizens from Palestine after 1948. Between 750,000 and one million people lost their homes and were never allowed to return. Some of them documented their lives before these days – and these audiovisual documents build the centre of the virtual mapping project *Jerusalem, We Are Here*.

As the project's "About" page notes, the goal of the collaborative interactive documentary is to enable people who otherwise are not able to come and visit the places in which their families used to live, to go there virtually: "there is a need to bring the space to them". Moreover, due to the co-creative character of the transmedia configuration, former non-Jewish residents who are seldom heard are given a voice to pass on their perspective on a contested chapter of history. However, *Jerusalem, We Are Here* is not only of interest for those who lived there, but for user-interactors all over the globe as the project discusses issues of media ethics such as questions of self-representation and the transformative potential of media configuration in an innovative way.

This contribution takes a paradigmatic case of what can be called "new media open space documentary" – a term coined by Zimmermann and de Michiel [ZiDe13] – and approaches issues of media aesthetics but also media ethics from a transdisciplinary perspective. As a theoretical frame, key concepts such as polyphony, critical historiography and emplaced interaction will be introduced as well as Foucault's heterotopia [Fouc84]. The concepts will be then applied to *Jerusalem, We Are Here* in order to analyse in how far the layering of temporalities and the reconstruction

of micro-histories potentially allow user-interactors to catch glimpses at multiple histories and how they enable, at the same, those concerned by the politically motivated displacement to create a mosaic of counter-narratives to mainstream Israeli nationalist historiography. A special focus will be set on the possibilities offered by emerging technologies for the mapping of actual spaces to create virtual spaces and augment physical space to enable a renegotiation of notions of home and socio-cultural belonging.

2 *Jerusalem, We Are Here* as Open Space Documentary – Rendering Polyphony and Heterotopia Experiential

2.1 The Concept of Open Space Documentary and Working Principles of Co-creative New Media Design

A powerful metaphor for describing how interactive new media assemblages such as *Jerusalem, We Are Here* can achieve a nuanced superposition of multiple perspectives and temporalities, plurivocal narratives and the creation of intermingling virtual and physical spatialities is the concept of the 'open space' as it is developed by Zimmermann and de Michiel for the field of documentary [ZiDe13; 18]. Open space new media projects employ working principles from various disciplines, among others literature, music, environmentalism, urban planning, landscape design, literary theory, relational aesthetics, design theory, social practice art, political theory and new media theory. Notwithstanding differences in the theoretical approaches to openness in this context, what unites most conceptualizations of open space is that they try to balance the relationships between natural and built ecologies, between enclosure and access, naturally growing and pre-constructed, virtual and physical. Open space documentaries are built on "ideas of collaboration, micro-territories, contingency, horizontality, bottom up, multiple agency, decentralization, migration across media platforms and through different communities; permeability and mutability are key" [ZiDe13; 356]. Ehrlich speaks in *The Solace of Open Spaces* of "a geography of possibility" [Ehrl85; 9] – i.e.

dynamic environments which are open for development, surprise, inspiration, change, which allow to imagine possible futures, and which potentially become the site where transcultural communication can emerge.
In open space documentary, what has been described as the documentary triangle of subject, filmmaker, and audience [Nich01] – a paradigm that has informed traditional documentary studies for decades – is replaced by a circularity to 'doing documentary'. Those formerly known as documentary 'authors' become place-based designers or 'context-providers' [Dani08]; those formerly known as 'subjects' become active participants in creation, bringing in their own stories, telling them in their own words and co-authoring the medial work; and those formerly known as audiences become engaged interactors or even participants in ongoing discourses. In this sense, open space projects "explore the terrain where technologies meet places and people in new and unpredictable ways, carving out spaces for dialogue, history, and action" [ZiDe18].
New media open space documentary projects are based on an ethos of collaboration and networking; they try to promote dialogue and debate and response to urgent social and political issues. Often, open space documentaries are adapted to the specific need of physical sites as well as particular media environments. In order to reach out, they "migrate across archives, dialogues, essays, live media events, performances, websites, and video" [ZiDe18].
Jerusalem, We Are Here [Heli18] can be considered as such a co-creative interactive and participatory open space new media virtual tour in this sense. It is a collaboration between former citizens of the Jerusalem quarter Katamon, historians, new media designers and documentary makers. Working closely together, the participating families contributed their personal stories and views as they provided insight into their family's personal media archives. Together with media professionals and scholars, the former residents of the Katamon neighbourhood engaged in a dialogue to arrange the material and to create a web as well as an AR interface through which these memories can be accessed. And – what adds a further facet of openness to the project: *Jerusalem, We Are Here* is open-ended. Via social media (as well as on the website itself), the initiators encourage the submission of material; they encourage people who once lived in Katamon or visited the place to contribute photographs or films and

to share their memories connected with sites in the quarter. Due to this embrace of co-creation, the database of material keeps growing, archiving not only official accounts but also very personal stories.

2.2 Polyvocality and the Contextualizing Embeddedness of Micro-histories

During the primary iterative design process, the mixed team of professional media makers and participating subjects decided to map Katamon not street by street but house by house, story by story. 360° images from streets and houses are superimposed with interactive maps of the quarter and amateur-produced images from the past – most of them shot before 1948, i.e. before the Palestine war and the expulsion of non-Jewish residents.

Jerusalem, We Are Here plurivocal, collective as well as individual remembering takes place in form of fifteen short poetic *cinema verité* documentaries and fifteen audio segments spread across three neighbourhood tours. Some of the videos feature original material from the 1940s – home videos as well pieces of what can be characterized as citizen journalism in modern terms; some clips present interviews with former residents; and in others, the user-interactor accompanies their children or grandchildren who are going back to Katamon and who try to remember the memories handed to them by their family when encountering the places in which their relatives used to live – most often places which have radically changed.

Featuring google streetviews and embedding material and stories from former residents or tour guides, the user-interactor is invited into the families' lives and into their past – as well as into a speculative future, because also the hopes and fears of those who used to live in the quarter are addressed: issues such as the dying of the generation who lived there before the war and the menace of the loss of many stories connected with the places, as well as current problems as e.g. gentrification. Discourses past and present fuse, and public and private spaces are intermingled and enhanced with meaning – multiple meanings brought forward through collaborative storytelling.

Fig. 1: Screenshot of the interactive interface of the web-documentary version of *Jerusalem, We Are Here,* featuring a google streetview of a site on the tour superimposed by additional information – both textual and audio – and an original photograph from the 1940s. The small interactive map at the bottom of the screen allows situating oneself within in the tour and navigating to other spots which are enhanced by collaboratively collected material.

One spot, for example is the site where Count Bernadotte, former UN Security Council Mediator, has been assassinated. Embedded into a google streetview of today are audio segments as well as textual information. The present view of the house is superimposed with a portrait of the Bernadotte, and if one clicks on the headphone-icon, one can listen to the memories of a historian who shortly characterizes Bernadotte's role in international politics in the 1930s and 1940s. During World War II, Bernadotte arranged a deal to enable the rescue of about 31,000 prisoners from German concentration camps, among them 450 Danish Jews who had been deported to Theresienstadt. After the war, Bernadotte was unanimously assigned mediator in the Arab–Israeli conflict. However, he was killed in 1948 by members from a paramilitary Zionist group. In this sense, the info-box contextualizes these micro-narratives into the larger history of settlement policy and thus relates it not only to the history of the quarter but to socio-political issues at large of that time as well as current issues. At the same time, the layering of material – including private photographs

– adds a more personal facet and brings in micro-histories that one does not find in this way in official history books.

Fig. 2: Screenshot of the navigation mode which allows to access material through interactive maps superimposing modern cartography of the neighbourhood with original municipal survey drawings and aerial photography. Sites are tagged with keywords, a short informational text tells the story of the place and additionally brings in the personal memories which are connected to the spot by private photographs.

A second navigation mode allows to gain an overview over the spots which serve as anchors for the micro-stories connected to them. In an overhead view, buildings to which various material could be collected are marked in red. Contemporary street maps are combined with reconstructed overlays of old municipal survey drawings, post-war aerial photography and modern satellite and balloon photography. A column at the left hand side presents sources regarding the edifices – ranging from official documents to photographs from the private archives of residents and pictures which show how the place has changed over time. Due to the still expanding database of material, the many socio-cultural strata of Katamon can be explored; what has vanished or has been extinct is brought back, and different temporalities are co-present in one multi-layered interface. As Dorit Naaman, initiator and producer of *Jerusalem, We Are Here,* explains, "the present dominates our sense of space, but the past is always enduring

under the surface, even when it has been socially, politically and economically concealed" [Naam18]. This impetus to make the absent present underlies the global design of the project – not only the interface and interaction design but also the working principles of collaboration and the ethics of representation.

2.3 Emplaced Interaction and the Dynamic Layering of Virtual and Physical Space Past and Present

One challenge in telling moving stories through archives, databases and maps is that these forms of visualizing tend to favour the cognitive at the expense of the emotional. Through the combination and layering of factual information, private images and sometime very personal memories, *Jerusalem, We Are Here* tries to overcome this gap – an effect which is even stronger when experiencing the interactive remapping project *in situ*. Thus, all material can either be accessed online in form of an interactive webdocumentary or by really going to the physical spaces in Jerusalem, using one's smartphone to access material. Hence, the hybrid media project creates a both a virtual space with not necessarily physical checkpoints and it allows for an embodied and emplaced experience if one accesses the material 'on the spot'.

Drawing on the work of Dourish [Dour01] on embodied interaction, the work of Howes [Howe04] and Pink [Pink09] on the emerging paradigm of 'emplacement', Aston introduces the concept of "emplaced interaction", which "marries the digital with the analogue to create shared experiences with elements of face-to-face and sitespecific experience at their core" [Asto17; 222]. Whereas Dourish defines embodied interaction as a way of approaching human computer interaction which privileges engaged action over disembodied cognition, Howes suggested that a new paradigm is emerging – one which adds environment into the equation of 'body *plus* cognition'. He refers to this paradigm by calling it 'emplacement', putting emphasis on the fact that one should be aware of the cognitive, emotional and sensuous interrelationship of body, mind and place. Pink adds a perspective which builds on the working principles of 'emplaced ethnography' as in which the documenting scientist 'attends to the question of experience by accounting for the relationship between bodies, minds and the materiality and sensoriality of the environment' [Pink09; 7].

At the core of the theoretical concept as well as its realization in open space new media projects and interactive documentary stands the endeavour to engage user-interactors beyond "clictivism" [Asto17; 222], thus stimulating the renegotiation of issues and create a feeling of belonging to one community with sometimes different perspectives yet a shared agenda and an interest to overcome former conflict. An example of the potential of such emplaced interaction and the attentiveness to the specificity of places with their different layers of history and micro-histories is the so-called 'Greek Club', one sites on the tours through Katamon. Founded in 1902, the Greek Club was the centre of the Greek community's social life. It was a place dedicated to meetings and discussions, cultural performances, dance the celebration of religious feasts and national holidays. As the majority of the community was expelled or fled in the course of the war of 1948, the Greek Club fell into disuse and decay. However, in recent years, it has been refounded as a place for transcultural community life and proves how inspiring exchange can be – especially if one is aware of the many socio-cultural layers which vibrate in one site.
This evolution despite the turbulent past of the site is not only documented through the participatory collection of photographs and memories; this material is sensitively interrelated and embedded into the interactive interface and thus renders the micro-histories connected with the site experiential. And finally – what gives also hope with regard to the transformative impetus of *Jerusalem, We Are Here* and the goal to contribute to breaking up boundaries: user-interactors who are experiencing the assemblage *in situ* are invited to join the community and bring in their perspectives into ongoing discussion.

2.4 Heterotopia, the Fragmentation and Multiplicity of History and Mosaic Narration

In *Jerusalem, We Are Here*, the authorial vision which still characterizes many linear documentary productions is replaced by a mosaic of voices and viewpoints which do not necessarily have to be in consonance only. The plurality of voices offers multiple viewpoints on complex political and social matters and it allows a co-presence of perspectives instead of a contraposition of argument. This also signals a shift from a linear, temporal to a spatial paradigm of documentary making and historiography: due

to this nuanced interface and interaction design, sometimes simplifying chains of cause and effect are countered. This approach to render realities past and present experiential (and please mind the plural!) relates to Foucault's concept of heterotopia which is based on the assumption that it is necessary to juxtapose "in a single real place several spaces, several sites, that are in themselves incompatible" [Fouc84; 6–7] in order to get a deep understanding of this site.

This co-existence of various, sometime contradictory perspectives challenges central premises of most traditional approaches to historiography – axioms such as the confidence on evidence-based argument and causality. In this sense, *Jerusalem, We Are Here* is rather indebted in poststructuralist and postcolonial understanding of historiography – i.e. strands that embrace polyphony as an opportunity to turn historiography away from causality, linearity and unity which are elements that are often linked to a hegemonic exertion of power that silences opposing voices and minimizes difference. These master-narratives which are most often in service of nationalist goals, structural domination and totalizing viewpoints thus simplify complexity. Both heterotopia and polyphony present alternatives to those models as they expand the quantity and – what is even more important – the quality of experiences, histories, connectivities and voices: "A polyphonic history breaks a single historical event into pieces, and then builds interpretation through a mosaic of arranged and contrasting fragments and routes" [ZiDe18; 60]. Such post-structuralist perspectives on history invoke dialogic configurations and the co-existence of multiple pasts, and they imply new contextualizations. The awareness of ruptures, fragmentation and a mosaic notion of history as well as the attentiveness for differentiation, multiplicity and simultaneity disengage linear master-narratives. Localized and situated notions of layering micro-narratives replaces a unified, universalized story and replaces it with multiple pasts. In *Jerusalem, We Are Here,* it is the often polarizing coverage of mainstream media of the Palestinian-Israeli conflict, dichotomist narratives and the mere focus on current incidents – most often military conflicts – that is challenged with alternative narratives. These are sometimes memories of vernacular life, other cinematic vignettes are poetic, some are touching upon current issues. As they are embedded within one densely networked media assemblage which can be procedurally explored, they dynamically

created something greater than the mere sum of the single 'parts' of this configuration – an effect that is certainly also due to the deliberate interface and interaction design.

The historiographic model that underlies *Jerusalem, We Are Here* conceives of the past as a dynamic nexus of assumptions, interpretations, contestations, modifications, struggles and uncertainties. What is essential to note in this context is the fact that a polyvocal, facetted understanding of history does not denote a conflict-free liberal utopia; however, social and political domination as well as the power over discourses becomes challenged and the encounter of contesting standpoints becomes the locus for potential problem solving due to the embrace of heterotopia and multiplicity and the open negotiation of conflict. In *Jerusalem, We Are Here* – and here we come circle round in this analysis – this takes place through the openness of the configuration: theoretical concepts are filled with life in the actual spaces which invite exchange and the virtual spaces such as social media which accompany the project; with regard to ethics of representation, they are realized through the open space documentary approach and the collaborative design of the project which includes various voices and perspectives; and they are aesthetically rendered experiential through the different interfaces though which material can be accessed.

3 Remapping Vanished Places, Bringing Back the Lost Past and Negotiating Potential Futures

As has been shown, at the centre of the project stands the creation of a virtual space that does not only document a past *status quo* but that also opens the possibility for discussion for future options of living together. In this sense, *Jerusalem, We Are Here* makes the past present and points at the same time at potential future developments.

The polyphonic collaborative working principles that underlie the configuration as well as the interface and interaction design which render the multimedia, deeply networked material experiential mirror the global impetus of the work: the assumption that one can break open dichotomist thinking by layering various versions of memories, by being aware of the fragmentation of history and at the same time by being sensitive

for a comprehensive visions of contested pasts, still remaining open for potential futures.

In this sense, the overall-design of *Jerusalem, We Are Here* and the ethos that characterize the configuration can be seen as part of the argument: they reflect the idea that polyphony is one key to a better understanding of current socio-cultural issues, and they transport the hope that a multi-facetted virtual renegotiation of pressing concerns and an awareness of multiplicity of perspectives, a co-presence of different temporalities and different conceptualization of space can help to promote conflict solving. Thus, the new media documentary project is far more than a database of material: it opens virtual dialogic space to experiment with solutions to the aesthetic, ethical, political, historical and social challenges of uneven power relations. It embraces complexity, heterogeneity and multiplicity of material, narratives, voices, perspectives, authors, screens, realities, places and temporalities. By doing so, the project tries to overcome thinking of the past in terms of linear chains of cause and effect that typically characterize especially nationalist narratives of the Israeli-Palestinian conflict. Rather, concerns past and present are opened for discussion in their interdependent, complex layering. Hence, *Jerusalem, We Are Here* does not only challenge distinctions between public and private, inside and outside, past and present, but also between the presumably known and the speculative.

This supports the hypothesis that we are currently witnessing a shift in 'doing documentary': a shift from a representational to a performative paradigm, from an authorial vision to a plurality of perspectives, and from a temporal to a spatial notion of media configurations. Open space new media configurations bear the potential for the productive juxtaposition and intermingling of different angles and invite the user-interactor to 'dive deep' into heterogeneous material. As we have seen, *Jerusalem, We Are Here* offers an oscillation between the past and present, one's own preformed opinion and new takes on issues – and thus inspires a potentially transformative shift of perspectives – "a movement between the self and other, and between the subjective and the objective" [AsOd18: 72], as Aston and Odorico postulate.

Due to the interdependent, multi-layered complexity of the narratives and the dynamic networkedness of the micro-histories, manifold spaces

for negotiation are opened. In this environment, all agents – the initiators of projects, professional media maker, creatively participating subjects as well as user-interactors are pushed to more performative engagement. Within this process, they all become "cowriters, coauthors, cocreators, comakers, coeditors and, in the end, coresearchers" [AsOd18: 73]. In this regard, projects such as *Jerusalem, We Are Here* push the boundaries of historiography, mapping projects and interactive documentary into new directions and inspire fresh takes on both theory and practice.

Literature

[Asto17] Aston, Judith: Interactive documentary and live performance: From embodied to emplaced interaction. In Rose, M.; Gaudenzi, S.; Aston, J. (Hrsg): The Evolving Practices of Interactive Documentary. Wallflower Columbia University Press, New York 2017, pp. 222–36.

[AsOd18] Aston, Judith; Odorico, Stefano: The Poetics and Politics of Polyphony: Towards a Research Method for Interactive Documentary. alphaville 15, 2018, pp. 63–93.

[Dour01] Dourish, Paul: Where the Action Is. The Foundations of Embodied Interaction. MIT Press, Cambridge 2001.

[Fouc84] Foucault, Michel: Of Other Spaces: Utopias and Heterotopias (Des Espace Autres, March 1967), trans. by Jay Misckowiec, *Architecture/Mouvement/Continuité*, 1984, pp. 6–7.

[Ehrl85] Ehrlich, Gretel: The Solace of Open Spaces. Viking Books, New York,1985.

[Heli18] Jerusalem, We Are Here. 2018. Collaborative interactive documentary. Initiated by Naamann, D., produced by Helios Design Lab. https://jerusalemwearehere.com/#/. Accessed 12.02.2019.

[Howe04] Howes, David (Hrsg): Empire of the Senses: The Sensual Culture Reader. Berg: Oxford 2004.

[Naam18] Naaman, Dorit, quoted on https://docubase.mit.edu/project/jerusalem-we-are-here/. Accessed 13.02.2019.

[Nich01] Nichols, Bill: Introduction to documentary. Indiana University Press, Bloomington 2001.

[Pink09] Pink, Sarah: Doing Sensory Ethnography. Sage, London 2009.

[ZiDe13] Zimmermann, Patricia; de Michiel, Helen: Documentary as Open Space. In: Winston, B.: The documentary film book. Palgrave, Basingstoke, pp. 355–365.

[ZiDe18] Zimmermann, Patricia; de Michiel, Helen: Open space new media documentary: A toolkit for theory and practice. Routledge, New York 2018.

Combining Visualization of World Heritage and Applied Research

Johanna Leissner
Fraunhofer-Gesellschaft for the advancement of applied research
Brussels office · Rue Royale 94 · B-1000 Bruxelles
johanna.leissner@zv.fraunhofer.de

Martin Papirowski
men@work Media Services S.R.L. · Sperantei 28 · 020994 Bucharest
papirowski@menatworkmedia.com

Ralf Schäfer, Oliver Schreer, Christian Weißig
Fraunhofer Heinrich Hertz Institute · Einsteinufer 37 · 10587 Berlin
{ralf.schaefer, oliver.schreer, christian.weissig}@hhi.fraunhofer.de

Abstract

Fraunhofer-Gesellschaft for the advancement of applied research has created a "Virtual Heritage Expo" as a contribution to the European Year of Cultural Heritage 2018: It consists of several virtual exhibition halls presenting the research and cutting edge technology development performed at Fraunhofer-Gesellschaft for the protection of historic monuments and artefacts. Over hundred individual objects, 3D models of significant artefacts from 20,000 years of human history, virtual projection screens and complex installations are used in this exhibition. The Virtual Heritage Expo can be visited in two ways: By individual visits using Virtual Reality glasses or as a multi-user experience, by watching a virtual tour on an ultra-high resolution (2000 x 7000 pixel) curved screen. Different technologies have been used to create the content for these virtual experiences: Render engines for high resolution CGI, Lidar and 3D scanners for scanning 3D objects, 360° cameras with up to 10.000 x 3.500 pixel resolution and a volumetric studio, to create dynamic 3D models of persons.

1 Introduction

Already a quarter of a century ago, Manfred Koob, architect and university teacher at TU Darmstadt recognized one of the greatest dangers to the World Heritage: People! Cultural mass tourism represents a great threat to the most important monuments of humanity from a conservation perspective. But how can we strategically address this decay of the world cultural heritage and protect it from people without excluding them? An unsolvable task - at a first glance. The Fraunhofer-Gesellschaft, Europe's largest organisation for applied research with over 70 institutes and 27,000 scientists is proposing an innovative solution: We call it the Virtual Heritage Expo. It is the world's first virtual exhibition of applied research dedicated to the world heritage. We have created a complex of exhibition halls in which we present our research and development work together with historic monuments and artefacts as a virtual exhibition. We use multimedia, over hundred individual objects, 3D models of significant artefacts from 20,000 years of human history, virtual projection screens and complex installations. This expo combines virtual 3D worlds in a breathtaking architecture with stereoscopic 360° expeditions to important monuments such as the Green Vault in Dresden, the ancient city of ruins in Pompeii, the Cologne Cathedral or Göbekli Tepe, the first temple of humankind.

The Virtual Heritage Expo can be visited in two ways: By using Virtual Reality glasses, for which a special exhibition booth for four visitors has been constructed and as a multi user experience, an ultra-high resolution (2000 x 7000 pixel) projection on a curved 180° screen, which transports the viewer into the virtual world without wearing glasses.

2 Combining New Technologies and Cultural Heritage

The construction and design of virtual spaces for Virtual Reality experiences is still a pioneering technology. There is no empiricism that has grown over decades, most approaches of VR creators are still quite experimental. Although there is a number of examples of virtual museums

such as “The Kremer Museum” [Krem], there is no installation known to the authors, where both new technologies and cultural heritage are on exhibition together in a virtual environment, therefore a new concept was required. The primary task of Virtual Heritage Expo is to communicate didactically technologies and scientific developments in the service of the preservation of the world cultural heritage on one hand and to raise awareness for the topic and its problems on the other hand.

2.1 The Immersive Experience

The goal of the VR experience is to illustrate comprehensibly that cultural heritage protection needs innovative research and technology development while also entertaining the recipient, offering him a strong immersive experience, unforgettable minutes in a virtual world.

These two requirements have to be considered and implemented in the concept, which however creates a problem: Many museum curators subordinate the space to the exhibits. The architecture of the museum space, the lighting design and the public guidance are exclusively oriented towards the exhibits, the artefacts. An extreme example is the concept of the „Dark Room“, in which the showcases look like islands of light in a nocturnal sea. This philosophy is in contrast to the idea of the Wilhelmine or Victorian museum palaces, enormous domed buildings in which the exhibits degenerate into miniaturized decorative objects.

VR has the potential to combine these two philosophies. However, one has to consider that Virtual Reality is not a copy of reality, but it creates its own reality. The virtual space is by no means constrained by the architecture of the real world. It has no static, economic or scientific limitation in size, form or design, which is one of the reasons, why VR is so overwhelming for the user.

Similarly there is no need for fully realistic representations, explanatory pieces, exhibits and artefacts have to be comprehensible, they must beguile the recipient. Therefore, we combined video shots and 360° video with virtual spaces, 3D models of scanned objects and persons in order to put reality and virtual reality on a par.

2.2 Designing the Virtual Exhibition

The exhibition halls are grouped around a central hall building, the Big Hall. The architecture of the interiors of the Virtual Heritage Expo is not a copy of an existing architectural concept, but rather a reminiscent of computer-generated film backdrops of science fiction productions. Measured in terms of the size of the human being, the exhibition halls correspond to the size of Gothic cathedrals. The BIG HALL, with a floor area of around 20,000 square meters, corresponds to the floor area of the Basilica of Saint Peter, after all one of the largest and most important churches in the world.

An exception is the so-called Roggersdorf Hall, which represents a fully simulated church in Upper Bavaria. The church building is surrounded by a real landscape with sea cliffs, low mountain ranges, lakes and forests. A biotope with an area of perhaps eight square kilometers in the real world, where this biotope occupies only part of the hall area.

Much bigger than in reality are also the historical artefacts that dominate the exhibition concept. Examples are a Chinese terracotta soldier, an Egyptian pharaoh bust (see Fig. 1) or the Venus of Willendorf, which dates back to more than 20,000 years and represents one of the oldest art objects of mankind. In the BIG HALL more than 40 exhibits with dimensions of over 40 meters height can be seen.

Fig. 1: Egyptian pharaoh bust

In the CultLab 3D hall, which represents the automated 3D scanning technology, the recipient himself becomes a scan object. The recipient is following the procedural steps of the world's only fully automatic scanning line from the subjective perspective of an artefact.

3 Production Methods

The advantage of Virtual Reality is that multiple sources of 2D and 3D information can be combined in a highly creative way. Therefore, various content production technologies have been used ranging from classical 3D modelling and 2D footage integration towards much more advanced techniques such as ultra-high-resolution panoramic video capture and volumetric video.

3.1 Scanning of 3D Objects

The high quality 3D reconstruction of cultural heritage artefacts has been performed with the CultLab 3D Scanner by Fraunhofer IGD [Cult]. CultLab3D is an extendable, multi-modular scanning facility using the next generation of autonomous and compliant robots as well as optical scanning technologies. The system consists of two scanning units (CultArc3D, CultArm3D) connected by a tray conveyor system. The entire acquisition process for geometry and texture of an object takes less than ten minutes on average, at a resolution in the sub-millimeter range. CultLab3D is currently designed for high-precision 3D acquisition of objects with up to 50 kg in weight and up to 60 cm in length, width and height. Some other high quality 3D models have been received from other Fraunhofer institutes, which used laser scanning methods.

3.2 3D Reconstruction of Sites

Some elements in the Virtual Heritage Expo are modelled in 3D in high detail and texture using standard 3D modelling tools. For example, the Roggersdorf Hall, in which a simulated historic building is surrounded by a real landscape with sea cliffs, low mountain ranges, lakes and forests, was modelled manually. The user can fly across this miniaturized lands-

cape and experience Roggersdorf at different weather conditions in future time periods.

3.3 360-degree Video

360-degree video is an adequate technology to allow the viewer to experience historic sites virtually. It can be used for both presentation forms, VR-glasses and immersive panoramic cinemas. Compared to photogrammetric reconstructions, 360-degree video allows the reproduction of dynamic scenes. It is obvious that this possibility can provide a higher authenticity, however it causes a higher technical effort for content generation.

For applications demanding high quality, Fraunhofer HHI developed a whole family of 2D and 3D omnidirectional cameras called OmniCam360. The OmniCam360 is a mirror-based multi-camera system that allows the recording in a 360° panoramic format. The sophisticated segment-wise combination of mirrors and cameras enables a parallax-free setup, which allows perfectly stitched images even for live applications.

The OmniCam-version used for the productions in the context of the Virtual Heritage Expo is using a combination of 11 HD respective UHD-cameras and provides a resolution of 10.000 by 3.500 pixels at a frame rate of up to 60 Hz. The field of view covers 360 by 120 degrees.

Fraunhofer HHI has developed a Real Time Stitching Engine (RTSE) for the processing of the individual image segments to generate a seamless overall panoramic image. The RTSE supports all the processing steps needed, including warping, stitching, blending and colour matching. Since the RTSE provides outputs of the stitched panorama in different formats and resolutions, it can also be used for the live preview during the film production.

The OmniCam-360 has already been used for various panorama productions over the last years. In the context of the Virtual Heritage Expo, the first series of productions has been done in the Green Vault in Dresden, the ancient city of Pompeii (see Fig. 2) and the historical optical Fraunhofer glass workshop at Benediktbeuern.

Fig. 2: OmniCam production in Pompeii

3.4 Volumetric Video

Volumetric video is another element used in the Virtual Heritage Expo in order to provide a realistic and convincing representation of humans in the virtual world. Volumetric video is regarded worldwide as the next important development step in the field of media production. The main concept is to capture real persons with multiple cameras simultaneously and create naturally moving dynamic 3D models, which can be observed from arbitrary viewpoints in the virtual scene. Fraunhofer HHI has developed a novel capture system, which is based on 32 high-resolution cameras arranged as stereo pairs capturing a moving person in 360 degree (see Fig. 3). A complex 3D video processing software for volumetric video, the so-called 3D Human Body Reconstruction (3DHBR), finally produces a sequence of meshes as dynamic 3D models that can then be integrated into common render engines such as Unity or Unreal. In Fig. 4, left, a sample mesh is shown, which is then integrated in a virtual reality scene as shown in Fig. 4, right. In contrast to classical animation of virtual characters, facial expressions as well as moving clothes are captured from video information and reconstructed at high geometrical detail and texture quality [SFER16].

Fig. 3: Drawing of the capture and light stage (left) and first prototype (right)

Fig. 4: Resulting 3D model (left) and integrated model in virtual reality scene (right)

4 Compositing the VR Experience

Originally, the Virtual Heritage Expo was designed as an interactive VR experience to allow the user to walk around in the virtual space and explore the different halls. The experience was developed in Unreal and targeted for Oculus Rift as one of the standard head mounted displays for VR. However, the complexity of the complete Virtual Heritage Expo becomes too high for an interactive experience due to the large number of 3D elements. Therefore, a guided 360 degree stereoscopic 3D video based

VR experience has been derived from the available 3D models. As Unreal cannot provide the necessary rendering quality for 360 degree video, the big halls have been imported to Houdini and high quality ray tracing is used to achieve best possible video quality. However, the interactive VR experience is still under consideration, but the overall concept needs to be further developed in order to allow a fluent interaction with minimized re-loading of 3D data.

For the VR experience, the 3D models are rendered with Houdini in a resolution of 3840 x 1920 for the left and right eye. Similar holds for the panoramic video content. The resulting MPEG-video can be experienced in any capable player for stereoscopic 360 video. For demonstration purposes, a movable cube has been designed that allows parallel viewing experience for four users (see Fig. 5). At each side, an Oculus Rift is available to watch the VR experience. Four state-of the art gaming PCs support fluent display and high quality graphics rendering. The whole cube can be easily transported and therefore shown in different locations and events of the Fraunhofer-Gesellschaft.

Fig. 5: VR presentation cube

5 Compositing the Immersive Room Experience

A further option to present virtual objects, historic monuments and artefacts in a realistic manner the usage of immersive rooms, where the audience is surrounded by the scene. Such panorama presentations have a long tradition, panorama paintings in huge rotundas have already been used in the 18th and 19th century for spectacular presentations of scenes of war, religion or landscape. An authentic experience, in which the audience feels immersed into the virtual scenes, requires reproduction technologies for both, acoustic and visual presentation, that support quality features similar to those which are used to in real life. With these requirements, Fraunhofer HHI developed an immersive presentation platform called "Tomorrow's immersive Media Experience (TiME) Lab". It is a panoramic cinema with a footprint of 8m by 8m, equipped with a 180-degree curved screen with a width of 12m and a height of 3,4m. A multi-projection system using 14 HD projectors provides 2D and 3D images with a resolution of 7,000 x 2,000 pixels [ScKW16].
The TiME-Lab is also equipped with a spatial sound system in order to provide an authentic immersive audio presentation. It works as a wave field synthesis system (WFS) using 140 loudspeakers. WFS is an object-based sound system, which enables audio reproductions with a precise mapping of the sound objects to their visual sources to avoid perception conflicts. In addition, the acoustic characteristics of rooms or environments such as churches or concert halls, can be realistically reproduced.
In comparison to VR glasses, immersive rooms as the TiME-Lab provide a more natural multi-user experiences, because people can see each other while communicating. It is obvious that such kind of natural communication during the experience provides an additional benefit especially for education and training purposes.

6 Summary

The Fraunhofer Gesellschaft has developed a virtual exhibition, in which applied research dedicated to the world heritage is presented together with important artefacts of world heritage. This exhibition combines video

shots, 360° video, virtual spaces and 3D models of scanned objects and persons. Cultural Heritage Expo is based on the artistic concept developed by Martin Papirowski, but technologies of different Fraunhofer institutes have been used to create this virtual exhibition. It can be experienced either on VR glasses or in an immersive viewing room, called the TiME Lab.

The final composition of the content has been coordinated by Fraunhofer Brussels and by Fraunhofer HHI, which also provides the viewing facilities.

Literature

[Cult] www.cultlab3d.de

[Krem] http://www.thekremercollection.com/the-kremer-museum/

[ScKW16] Schäfer, R., Kauff, P., Weißig, C. (2016): The Potential of Panorama Technologies for Cultural Applications, Kultur und Informatik: Augmented Reality, Hrsg.: C. Busch, J. Sieck, Verlag Werner Hülsbusch, ISBN: 978-3-86488-103-9, 2016, pp. 17–28

[SFER18] Schreer, O., Feldmann, I.; Ebner, T.; Renault, S.; Weissig, Ch.; Tatzelt, D.; Kauff, P. (2018): Advanced Volumetric Capture and Processing, Proc. of International Broadcasting Convention, Amsterdam, The Netherlands, September 2018.

From Ruins to Glory: The Recreation of Ancient Greece in Assassin's Creed Odyssey

Stéphanie-Anne Ruatta & Jonathan Dumont
Ubisoft Canada
250 rue Saint-Antoine Ouest
Montréal, QC H2Y 0A3, Canada

Abstract

The Assassin's Creed series takes imagination and ingenuity to new heights by placing a sense of historical authenticity at the heart of its gaming environments. Developed by Ubisoft Quebec, the latest instalment, Assassin's Creed Odyssey, sets its stage in Ancient Greece at the height of the Peloponnesian War.

This presentation focuses on the procedures by which the Assassin's Creed Odyssey team establishes a sense of historical authenticity in the game. It explores the interactions between the research and the historical references, the creative process and the procedures used in the reconstruction of the world in game. In the context of video game production, some compromises must be made between historical re-enactment and technical and creative parameters, such as technological conventions, scientific information and requirements for diversity, space-time and game mechanics. An analysis of these conditions establishes how the relationships between digital technology, the legacy of the past and the world of video games, contributes to a shift in perspective when showcasing history.

Images

Fig. 1: A Reconstruction of the City of Athens

Fig. 2: Objects and Artifacts of an Ancient Workshop

Fig. 3: Stone Textures for Reconstructions from Vincent Dérozier

Fig. 4: Simulation of the Marketplace in Ancient Athens

Wadi Al Helo VR – A Virtual Visit to a Cultural Heritage Site

Showcasing a Virtual Reality Storytelling Framework

Zlatan Filipovic[1], Pablo Dornhege[2], Felix H. Beck[3]
[1] College of Architecture, Art and Design,
American University of Sharjah
26666 Sharjah, United Arab Emirates
zfilipovic@aus.edu

[2] Studio 105106
Alt-Moabit 109, 10559 Berlin
info@105106.net

[3] Lab for Narrative Technologies and Spatial Installations
New York University Abu Dhabi
United Arab Emirates/Germany
felix.beck@nyu.edu, www.felix-beck.de

Abstract

This paper showcases a prototype virtual reality storytelling framework built around the Wadi Al Helo project, a collaboration between the Sharjah Gateway to Trucial States (Government of Sharjah entity), American University of Sharjah, New York University Abu Dhabi, and the research studio 105106, in support of Sharjah's UNESCO World Heritage application. The framework is used to tell the remarkable story of Wadi Al Helo, its historical development, and its significance for the formation of the Trucial States, and allows for a virtual tour of the valley and its historical sites at their actual scale. The creation of this prototype allowed us to incorporate and test, in a museum context, a variety of technologies and methods, which we describe in this paper.

1 Introduction

We live and create in a pivotal moment at which VR technology is no longer available exclusively at leading academic institutions and specialized research institutes or corporate labs developing the technology themselves. Recent mass production of a range of VR-enabled products empowers a growing community of engineers, computer scientists, artists, game and simulation designers, cultural heritage and museum professionals, and finally educators and students to develop experiences using these platforms. [RoBa17]

At the same time, the *"focus in museums is shifting towards the use of artifacts for providing an interactive experience to visitors, in contrast to the traditional museum approach, where the focus was on the collection, display and storage of objects. [...] Digital technologies, in particular interactive storytelling and gaming, have a great potential for assisting both the education and entertainment of visitors in museums. This is because they can communicate the heritage of societies in an interactive way, overcoming some of the problems presented by more traditional means, such as text."* [DGRA07]

Those two developments form the basis for our creation of an interactive VR experience to assess the use of a VR storytelling framework in a museum context and its potential to extend the physical exhibition space and serve as a more accessible research and educational platform.

2 Hard- and Software Architecture

2.1 Hardware Architecture: HTC Vive in Combination with TPCast Wireless Adapter

After comparing different available VR Systems, analysing their advantages and disadvantages we matched them according to our requirements: free movement and tracking inside a play area of 4 by 4 meters, integration of physical objects in the play area and the ability of rendering detailed photogrammetry models in real time. Based on those parameters we went for the HTC Vive in combination with the TPCAST Wireless Adapter. This

solution combines the computing power of a room-scaled, tethered 6 DOF-VR System with the benefits of a wireless HMD, allowing for free movement.

2.2 Software Architecture: Unity3D as Development Environment for the Software

Using Unity3D gives student collaborators with no prior knowledge in software development, coding or game design the possibility for a quick start into building VR experiences, while still being extremely versatile and allowing for scalable results. This allows for a fluent collaboration between participants of varying skills and backgrounds.

2.3 Object Acquisition, 3D Modelling

There were various strategies considered related to recreation of the architectural structures at the site. Initial visits have also included students from the NYUAD and AUS. In order to generate detailed and to scale representation we have tested a number of software technologies and platforms. Objects of interest are recreated to real scale based on drone footage photogrammetry (Fig.01), satellite terrain data and GPS info. The software Reality Capture in combination with Pix4D were our platforms of choice. Output in forms of point cloud data and textured meshes was furthermore optimized with MeshLab in order to meet the requirements and capabilities of the Unity3D game engine where everything was integrated. Working with high density mesh data required making strategic decisions about creating a number of meshes for each object, differing in their Level of Detail (LOD). These were dynamically loaded to the Unity 3D engine relative to the vantage point users will have and their interaction (proximity) to the models as they explored the set. Additional objects were built in Cinema 4D and Maya.

Fig. 1: Drone capturing photographic data of the Burj Um Al Nar

3 Physical Setup and Software Design

3.1 Installation Elements: VR in Combination with 3D-printed Elements

A low resolution 3D-printed model mounted on laser-cut cardboard panels is placed onto a pedestal (Fig. 02A). This relief model serves for the user as a point of reference in two ways. On the one hand, the model introduces the broader context of the narrative theme to incoming spectators. On the other hand, the model and pedestal serve as a *marker*, a fixed position in real and virtual world, to help the user orient themselves in the virtual realm. When one looks through the HMD a virtual version of the model is rendered seamlessly to match the exact size and location of the physical 3D-printed architectural model (Fig. 02). Here we define a tactile experience which allows the user to explore and sense a physical object. Simultaneously the user observes a high resolution virtual version mapped with colourful textures. As the narration progresses the pedestal serves as the fixpoint and as carrier of the interface.

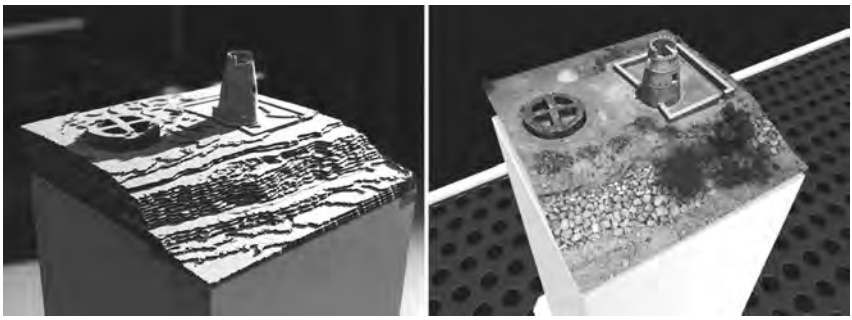


Fig. 2a: View onto Physical Relief Model with Watch Tower (3D print, PLA/wood filament) and surrounding heritage site (sliced cardboard), Fig. 2b: VR view onto model.

3.2 Interface Design: Simple 'One-Click' Interface

A simple touch button is the interface element that becomes easily identified via the precise augmentation of the physical and virtual model. Departing from a premise that: "Tangible interfaces offer a way to simplify the control of a device. The direct and physical nature of manipulation can be easier to learn and understand than abstracted menu structures or conceptual mappings of controls." [Char15]

Our interaction interface consists of one physical button mounted on the pedestal that also exists in the virtual world. Once the position of the button is identified in the virtual space it can be easily remembered, and used in the tangible world. Each push triggers the beginning of a new chapter in the application.

4 Storytelling Method

"Whoever, in whichever medium, starts to impart knowledge must become a storyteller, because we open up the world through stories." [HeKa12]

Creating a Virtual Reality experience with a complex Game Engine at its core gives us a variety of storytelling methods, ranging from classic, film-like linear and non-interactive narratives to the extreme opposite: a non-linear interactive environment, providing the user with an extensive decision space. For this particular prototype we decided on taking the

middle ground by using a linear interactive approach. This allows for a much clearer and structured narration and gives us more control over the time spent in the experience. At the same it creates pockets of free will, giving the illusion of a more non-linear environment.

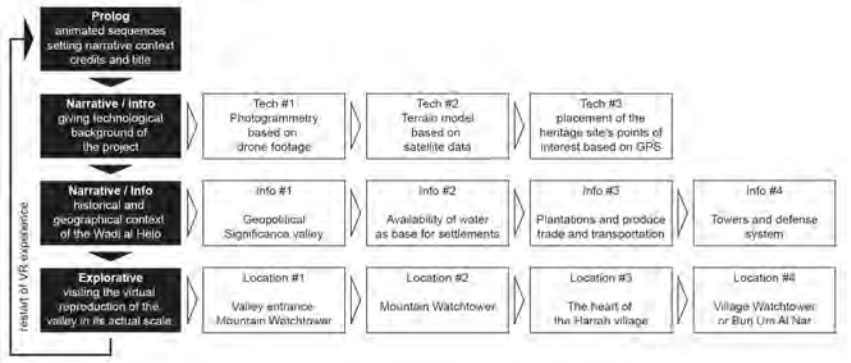


Fig. 3: Storytelling Structure

4.1 Epilog/Prolog Chapter

A combined epilog/prolog chapter functions as narrative bracket, start and end point of the virtual journey, and provides – in more spatial terms – an anteroom for ending one user's visit and welcoming a new one. It credits the participants involved in creating the experience while at the same time giving context and prevailing tone by showing animations and sound samples illustrating historic everyday life in the Emirate of Sharjah and Wadi Al Helo.

4.2 Didactic/Step-By-Step-Narrative Chapters

The didactic chapters first introduce the technical background of the experience and then via the narrative describe the historical development of the Wadi Al Helo and its significance for the formation of the Trucial States. Spatial elements combined with graphical overlays coupled with voice over narration form a Hybrid Medial Narrative Space inside the Virtual Reality. This form of transmedia storytelling allows for dispersed delivery channels creating a unified educational experience, where each medium makes its contribution. [Jenk07]

A virtual 1:1000 scale model is used to explain the broader context of the Wadi and the surrounding valleys. Cardinal points, trade routes, and surrounding villages are shown. Additionally there is detailed information highlighted through visual layers (Fig. 04). Each themed layer sum up on top of each-other and create one information map.

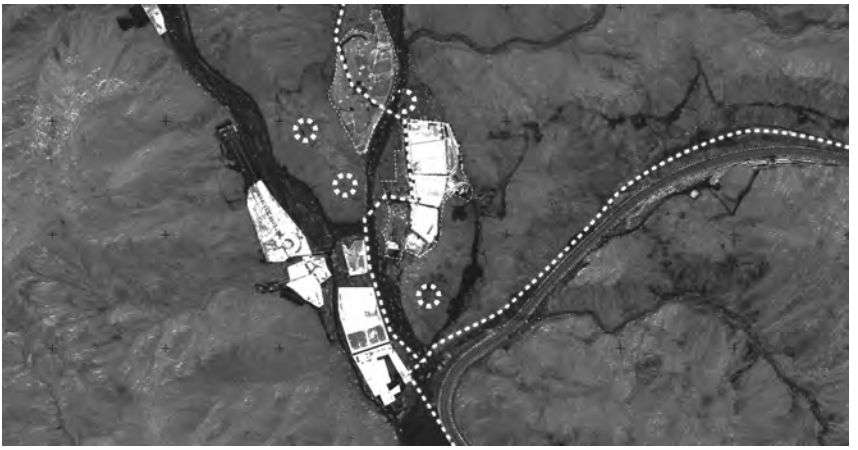


Fig. 4: All information layers: Water ways, farms, village, trade routes, locations of several watch towers.

4.3 Explorative Chapters

The experiential highlight of the experience is a tour through the Wadi and its historical sites in their actual scale. The use of a "modern magic carpet" grants the possibility to move quickly between the far apart sites while giving an overview of the valleys geographical structure and creates a sense of scale. The voice over narrator from the previous chapter functions as a tour guide giving background information on the different sites.
Using VR to visit the cultural heritage sites in this form offers the general public the possibility to reach places that under normal circumstances are inaccessible to them due to their remote location or because they are in hard or impossible to reach areas (for example on top of a steep mountain) while at the same time protecting the archaeological sites from the side effects of uncontrolled tourist visits.

5 User Testing, Experience

A group of ten students from College of Architecture, Art and Design's (CAAD) with no prior VR experience was our primary user group. Their feedback was used to decide upon the fundamental storytelling method and fine-tune details like the path, pace and speed of the flying platform.
In later, more public, presentations we observed two different types of user experiences: The first type is experiencing storytelling as principal user of the VR prototype – We call him **FPV – First Person Viewer**. The second type, we refer to as **Spectators,** is observing the large scale mirrored screen projection of the FPV experience. We noticed quite an interesting interaction between the FPV and the Spectators: At many instances Spectators guided and navigated the FPV in to performing specific tasks (i.e. controlling the vantage point, asking for particular type of action and/or framing of the VR world, exploring the soundscape [also mirrored in the studio space] via controlling FPV user position in physical/VR space).
This was enabled due to a specific setup we created in Media Lab of CAAD.

Fig. 5: Student user testing the VR experience

6 Further Directions and Conclusions

Based on the user testing and our observations we plan on further researching the increased integration of the Spectators into the virtual experience. Using asynchronous interfaces to create a collaborative environment for larger groups of visitors we plan to test establish guidelines for a more participatory rather than isolated single user VR storytelling design methodology. Another area that needs to be explored is the increased gamification and use of non-linear interactive elements to more thoroughly activate the user in the experience.

Using these innovative methods of research and dissemination we can capture the imagination of the general public and generate interest not only in the historical aspect of archaeology but also in the work and expertise that goes into supporting these archaeological surveys. [...] The base idea behind using VR and AR techniques is to offer archaeologists and the general public new insights into the reconstructed archaeological sites, allowing archaeologists to study directly from within the virtual site and allowing the general public to immersively explore a realistic reconstruction of the sites. [HRDM11]

Authors

Zlatan Filipovic is Associate Professor of Art and Design at the American University of Sharjah, where he teaches multimedia design and animation. His research and teaching interest include animation, film and video in linear and interactive forms, VR prototyping, and art/design pedagogy. Filipovic holds an MFA in Electronic Integrated Arts from NYSCC at Alfred University and a BA in Painting from the Academy of Fine Arts in Sarajevo. He has exhibited widely in solo and group exhibitions internationally at venues such as Manifesta 4 in Frankfurt; Gallery Almine Rech in Paris; European Media Art Festival, Osnabrueck; Siemens art Lab in Vienna; Art Museum of UNM, Albuquerque; National Gallery of Bosnia and Herzegovina, Sarajevo; Sharjah Art Museum and Maraya Art Center, Sharjah UAE; and Biennale of Contemporary Arts in Thessaloniki, Greece.

Pablo Dornhege researches, develops and designs real and virtual narrative spaces in his design studio 105106. During his studies at the Berlin University of the Arts, he focused on exhibition design and digital/analog spatial systems. In 2006 he co-founded the independent design group "Laborrotwang" and founded studio 105106 in 2018. In addition to his work as a designer and his research activities, he teaches among other universities at the Berlin University of the Arts, where he was visiting professor for exhibition design from 2017 to 2018. www.virtualspatialsystems.com – www.105106.net

Felix Hardmood Beck is Assistant Professor of Practice of Design at the New York University Abu Dhabi. He leads the Research Lab for Narrative Technologies and Spatial Installations (NTSI-Lab, www.ntsi.info) in which he envisions systems and spaces, and creates and deploys innovative objects and installations through design and engineering tools. Before entering academia he has gathered practical experience working as media designer and user-experience professional for several renowned design and architectural studios and clients in business and cultural institutions from 2001 on. His work has been featured in a range of art and design publications and has gone on to several exhibitions and international design festivals. www.felix-beck.de

Literature

[Char15] Charlier, Martin: Interface and interaction design. In: Claire Rowland, Elizabeth Goodman, Martin Charlier, Ann Light & Alfred Lui (Hrsg.): Designing Connected Products: UX for the Consumer Internet of Things, O'Reilly Media 2015, p. 298

[DGRA07] Danks, M.; Goodchild, M.; Rodriguez-Echavarria, K.; Arnold, D.B.; Griffiths R. (2007) Interactive Storytelling and Gaming Environments for Museums: The Interactive Storytelling Exhibition Project. In: Hui K. et al. (eds) Technologies for E-Learning and Digital Entertainment. Edutainment 2007. Lecture Notes in Computer Science, vol 4469. Springer, Berlin, Heidelberg

[HeKa12] Herrmann, Alexander and Kapsner, Andreas: Wissenschaftsvermittlung und transmediales Geschichtenerzählen. In: Caroline Y. Robertson-von Trotha Jesús Muñoz Morcillo (Hrsg.):

Öffentliche Wissenschaft und Neue Medien, Karlsruher Institut für Technologie (KIT), Karlsruhe 2012, p. 81

[HRDM11] Haydar, Mahmoud; Roussel, David; Maidi, Madjid; Otmane, Samir; Mallem, Malik: Virtual and augmented Reality for Cultural Computing and Heritage. In: Virtual Reality – Issue 4, Cultural Technology, Springer 2011, p. 311

[Jenk07] Jenkins, Henry: Transmedia Storytelling 101; http://www.henryjenkins.org/2007/03/transmedia_storytelling_101.html, [12.07.2012]. Visited: 2019/03/04

[RoBa17] Rouse, Rebecca & Barba, Evan: Design for Emerging Media: How MR Designers Think About Storytelling, Process, and Defining the Field. In: Interactive storytelling : 10th International Conference on Interactive Digital Storytelling, ICIDS 2017 Funchal, Madeira, Portugal. Springer International Publishing AG, Cham, 2017, p. 245

The AURORA School for ARtists

Artistic Augmented Reality Applications in Cooperation with the Independent Arts & Culture Scene in Berlin

Maja Stark
AURORA School for ARtists
http://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
maja.stark@htw-berlin.de

From 2018 to 2021, the INKA-project AURORA School for ARtists at HTW Berlin offers artists and other creative minds in Berlin the opportunity to educate themselves about Augmented Reality (AR) and digital media. In addition, they can apply for a place at the AURORA Production Lab in order to implement their own artistic AR apps in cooperation with the interdisciplinary AURORA project staff.

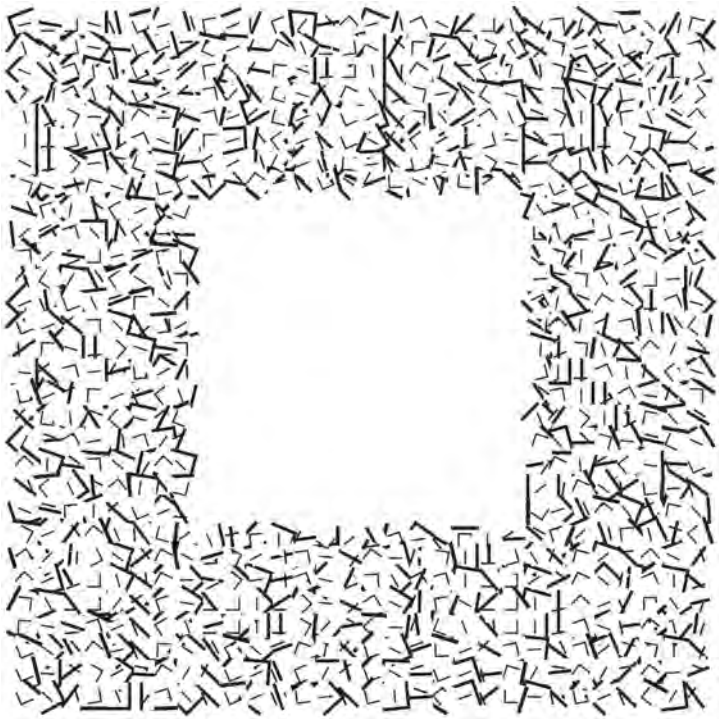
In the coming two years, the central research interest of the AURORA School for Artists will be the mutual influence between art and computer science on cooperative creative processes and results.

On the following pages you will find the first AR(t) results from the AURORA Production Lab produced with the support of the AURORA team by Banz & Bowinkel, Bianca Kennedy, Felix Kraus, Phyllis Lembert, Dani Ploeger, Theresa Reiwer, Dagmar Schürrer and Ulrike Schmitz. Each image serves as an AR marker – please download the app INKA AR and scan the markers to experience both the analog and the digital art through Augmented Reality.

1. Download the **INKA-AR-App** for free.

2. Look for images marked with the **AR-Symbol.**

3. Hold your **smartphone over the image.**



Banz & Bowinkel, *Untitled (Augmented Carpet)*

2019, Vinyl Print, 3 x 3 m

Banz & Bowinkel, André Selmanagic, Maja Stark
AURORA School for ARtists
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

Not least in the shape of their own avatars, Friedemann Banz and Giulia Bowinkel have been moving in computer-generated parallel worlds for quite some time. Their own body movements in space – recorded and transformed into fluid simulations using suitable software – provide input to computers for the calculation of the artists' digital twins, which can be moved back and forth along these colour traces. Banz & Bowinkel transfer the digitally manipulated simulations as renderings from the virtual to the analog reality, but they also produce virtual reality art and have already used augmented reality as a tool to show supplementary content-related aspects and details in selected works on a virtual layer.

In their latest series, augmented reality is in focus of Banz & Bowinkel's artistic work for the first time. Now everything revolves around the question of how AR can be understood as an independent art form. For this purpose, one of the avatars from a previous project was revised and equipped with an independent behavior. His decisions are now simulated live. In a structure of meta rules created by the artists, he now has to orientate himself, but inevitably acts in a play that is directed by them. A sharp-edged patterned carpet on the floor – implemented as a vinyl print of 3 x 3 meters in size – is used as a marker. Here, multiple avatars 'exist' and can be made visible using the AR app by Banz & Bowinkel.

Like real human beings the avatars are driven by internal needs. While hunger, tiredness and hygiene lead us to active action, the avatars' action is determined by mathematical formulas using a so-called *Utility AI*: potential behaviour like "seek company" or "avoid more than three neighbours" have scores, which are constantly recalculated based on the avatars' ever-changing needs and environmental factors. The behaviour with the highest score wins; triggering a new set of animations as well as updating the needs accordingly. While this underlying concept seems simple, breaking down human behaviour into numbers and formulas was a time-consuming process, albeit giving insights into our own human decision-making processes.

Some of the animations – e.g. communicative gestures – are pre-recorded using motion-capturing (e.g. taken from the online-tool Mixamo) and will play out in the same manner every time. Others combine pre-recorded walking animations with Unity's pathfinding algorithms, allowing the avatar to roam freely and interact more closely with the viewer.

As a supposedly self-determined machine an avatar is dependent on its creators – us humans. Contrary to the current great enthusiasm for machine-based decision-making, Banz & Bowinkel believe the focus should rather be on who animates these machines and on which types of orders are implemented.

About the Artists

Giulia Bowinkel, together with Friedemann Banz, forms the Berlin based artist duo Banz & Bowinkel. In their work, Banz & Bowinkel focus on the computer as an every day device and its influence on human culture. The focus here is on the perception of the world, which people understand as reality and is now simulated via the computer. With their work, Banz & Bowinkel question the concept of simulated reality and thereby human perception of the world in virtual space. The multiple award-winning works of Giulia Bowinkel and Friedemann Banz have been exhibited at the Museum Abteiberg in Mönchengladbach, the House of Electronic Arts in Basel as well as the Zeppelin Museum in Friedrichshafen.

www.banzbowinkel.de

Bianca Kennedy, *Swimming with the Lovers*

2019, Augmented Fineliner and Watercolour on Paper, 27.7 x 55.4 cm

Maja Stark, Leonid Barsht
AURORA School for ARtists
https://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

The bathtub is a central theme in Bianca Kennedy's œuvre: in 2016 she began a thorough exploration of this intimate place of human existence in film, and in the following years she created a comprehensive series of coloured drawings based on a kaleidoscope of found bathing scenes. On them, the tub is never empty, but always filled with liquid and more or less lively populated by one or more characters of different ages in diverse situations. The true life out there is now and then reflected, reduced to a

few square meters, bundled, bared, dissolved and heated in the tub water. Whether boredom or passion: both are intensified in the tub.
Drawings in the same style also form the basis of Kennedy's virtual reality work VR all in this together of 2018, in which she catapults the viewer into the tiled retreat of two self-absorbed bathers and exposes him/her to a truly emotional roller coaster: on the one hand you can enjoy the scene of peaceful intimacy accompanied by the sound of the softly splashing tubwater, on the other hand you can not help but feel as an intruder or voyeur, caught in a spectacle not intended for one's own perception.
In contrast, the bather on the artist's augmented drawing of 2019 looks out of the picture: Relaxed she twirls a strand of hair between her fingers and makes eye contact, as if she were familiar with her real counterpart. Six differently shaped noses in the washed lemonade-orange coloured bathing water render the scene surreal and at the same time more sensuous, but inevitably raise the question, whose olfactory organs the female nude allows near her, and why – or are they even representations of our own sense of smell creeping up on the woman?
The augmented reality app INKA AR, which is linked to the drawing, continues the game of closeness and distance: Just when you believed yourself to be only a few steps away from the image of the bathing figure, the application pampers a whole forest of potted paper plants behind a closed door, their spatial dimension moving you far away from the scene.

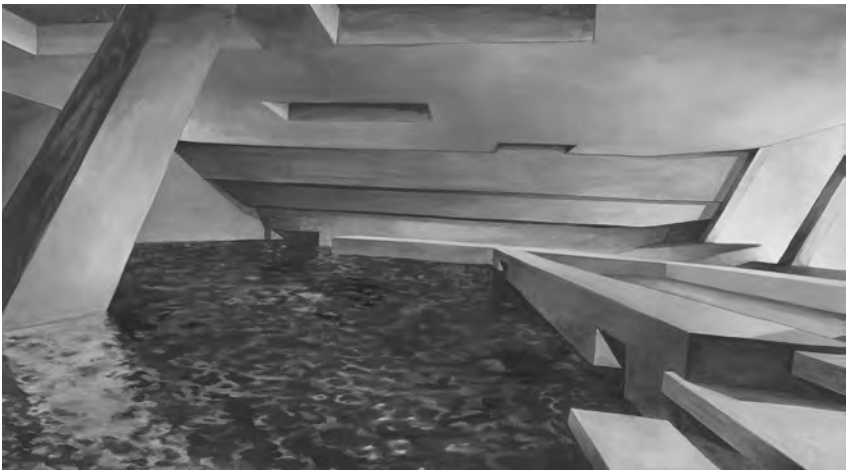
An additional element on the right-hand side is a room corner that continues the waldmeister-green bathroom tiling and shows a wash-basin, bathrobe and towel. And that's not all: The face of the protagonist is suddenly distorted into a one-eyed grin, which evokes an additional level of (emotional) distance through its deterrent effect. All displayed elements are analogue drawings, but the digital augmented reality technology allows their spatial arrangement and a playful interaction: You can remove almost all components of the extended reality by simply touching the screen accompanied by a clear splash sound – only the room corner stays persistent. Each tap also leads to another surreal metamorphosis of the protagonist, with her familiar face reappearing only occasionally, like an ephemeral vision.

For the augmentation of *Swimming with the lovers*, Bianca Kennedy separated her ideas into useful subtasks, enabling a structured and efficient approach. Parallel to the actual implementation, this enabled the deepening into individual subareas of the development of augmented reality applications, and gave the artist the knowledge and the necessary tools to independently realize similar projects in the future. One of the key points of her AR work was the interaction as different events are triggered when touching the smartphone screen. In implementation, this required various sorts of queries in the program, for instance where the screen has been touched, whether it is a single click etc. Likewise, further code was needed to test the touches on a computer during development. To simplify all this, the tool Lean Touch was imported into the project, which already handles many of the basic queries internally.

About the Artist

Bianca Kennedy studied Fine Arts at the Academy of Fine Arts in Munich, where she graduated as Meisterschülerin from the class of Professor Klaus vom Bruch. Scholarships have taken her to North America, Barcelona, Athens and Tokyo. Her animations, drawings and site-specific installations have been exhibited at the Kunstverein München, the Centro Cultural Banco do Brasil in São Paulo, the C-Gallery Milan and at the Colombo Art Biennale in Sri Lanka. In addition to analytical stop-motion animations, in which Bianca Kennedy reveals human abysses, the artist regularly works on photo and drawing series for which she stages her own spatial room-models.

www.biancakennedy.com



Felix Kraus, *Cutting Sunday*

2016/18, 3D Augmented Acrylic Painting, 100 x 180 cm

Maja Stark, Elisabeth Thielen
AURORA School for ARtists
https://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

The large-format acrylic painting *Cutting Sunday* by Felix Kraus is part of a whole series of contemporary interiors, reduced in colour and sometimes so boldly shaped in their composition that they recall the artistic cosmos of M. C. Escher. Kraus is always showing only a part of a world, which is deserted of humans and furniture alike, and in which sharp-edged concrete, shivering water surfaces and intentionally set light sources evoke a Kafka-like mood. The skilful naturalistic reproduction of the only supposedly really existing interiors, stands in a long art-historical

tradition. In the work of media artist Felix Kraus, who often appears as an incarnation of his own Swan Collective, it is however not the end result, but rather the starting point of a multi-layered creative process using digital tools. Recently this process culminated in the virtual reality work *Here we are* from 2018: elements of his analogue paintings, which are simultaneously restricting and spacious, are condensed into an appealing and disturbing 360° interior architecture, in which you have to find your way around – a casual yet convincing voice from the off does not necessarily contribute to finding orientation. The voice suggests that you are nothing more than the intellectual creation of the speaker, an artificial intelligence. The art of deception is operated on a high literary-philosophical level – the virtual space mutates into Plato's cave.

It is difficult to adequately represent movements, and, as a result, the temporal dimension in painting – *The Act Descending a Staircase No. 2* by Marcel Duchamp from 1912 is probably the most famous testimony to an artistic examination of this problem: the painter dismembers the movement into static sequences, which are simultaneously present on the canvas. Just over one hundred years later, digital technology offers new possibilities: using Augmented Reality, Felix Kraus extends his acrylic painting *Cutting Sunday* and adds a temporal layer by superimposing the interior architecture with light and shadow movements.

In order to achieve this effect Felix Kraus recreated one of his paintings as a 3D scene with the help of image-based modelling in Cinema4D. After importing it to Unity, this scene now appears whenever users scan his painting with the matching AR application. The almost ghostly effect of lights and shadows moving over the walls of the 3D scene is achieved by using a Unity shader that simulates the movements of light sources outside of the rooms. These light sources then either lighten up or darken the respective textures of the inner walls.

About the Artist

Felix Kraus is the initiator of the Swan Collective and studied at the Academy of Fine Arts in Munich and the Karlsruhe School of Design. He received the scholarship of the Studienstiftung des deutschen Volkes.

The Swan Collective mixes different techniques such as virtual and augmented reality, painting, paper embossing, literature and performance. Works of the collective have been exhibited in institutions such as the Stuttgart Art Museum, the Centro Cultural Banco do Brasil in São Paulo, W139 in Amsterdam, the Kunstmuseum Aalen, the Kunsthalle Schweinfurt or the Goethe Institut in Toronto. In addition, Felix Kraus has participated in various screenings and exhibitions as a member of the Swan Collective, including London, Berlin, Hamburg, Bolzano, Athens and Tokyo. He was awarded the first prize for his films at the LOOP Festival Barcelona and the Ludwigsburg Film Festival.

www.felixkraus.com

Phyllis Josefine, *dvvvdvvv (XR re-vived clothingpieces)*

AR

2019, Reflective Colour on Cloth

Maja Stark, Denise Bischof
AURORA School for ARtists
https://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

Graphics, electronic music, singing, media art, painted clothing – the multifaceted artistic work of Phyllis Josefine alias dvdv (pronounced "dada") merges to its own synaesthetic and interactive cosmos, in which one can start to immersive himself by visiting her self-programmed website. Through her love of experimentation between the analog and the digital world, the artist is effectively predestined for augmented reality, through which she can bundle all her creative output in a multi-layered work.

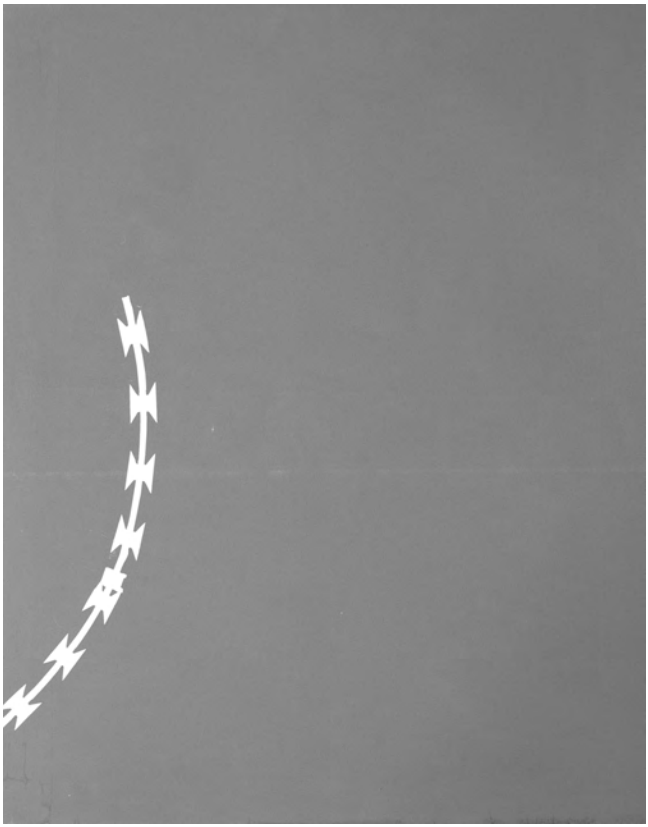
Clothing worn in the dark plays a key role in Josefine's AR art. It makes you think of dance floors, club armchairs and bars, in the shade of which you can be as good as you are or how you want to be, where freedom and individualism manifest not least in the form of – sometimes extravagant or even artistic – clothing. At the same time, shadows blur contours and facial features, the analog reality becomes visually more difficult to detect. In this context, Josefine brings clothes to a new, virtual life. She paints two to three coats with specially developed reflective textile paint. Since AR works only in good light conditions, the smartphone-internal flashlight is turned on with the help of a script and is held onto the painting. The marker then reflects the incident light into the dark environment – an effect that is superimposed in the AR application by particle effects and shapes that can be created and adapted in Unity. In addition, the markers trigger large-scale animations and sounds. To trigger different events, a timer has been programmed, which records the duration and the position of the marker and displays different virtual elements accordingly. Likewise, various simultaneously detected markers may interact to trigger different events, giving a playful form of interactivity.

Reinforced by the darkness, which literally absorbs the real space, the clothing unfolds through AR to another, but now virtual shell, partly surrounding the human beings wearing them, partly floating along like a shell of individual visuals and tracks from the artist's unpublished EP *What is the opposite of ambivalence*. But it also seems as if the artist's cosmos is being transferred to the three-dimensional, in order to play on an infinite digital space and share it with those present. Materiality takes a step back in favor of Josephine's intellectual creation, which appears as an ephemeral spectacle, putting viewers in a trance of light and music.

About the Artist

Phyllis Josefine aka dvdv is a media-artist, musician and autodidact who seldom limits herself to one medium. Initially focusing on experimental video and graphics, she began producing and singing music in 2014 and designing her own clothes-paintings. In 2017 she developed her own interactive website for her debut album with the alias *dvdv*. She was involved in the creation of the smart movie *The Future Is Not Unwritten* by Susanne Steinmassl, an endless, self-generating film about transhumanism and artificial intelligence. Phyllis' works have been published in numerous online magazines including NOWNESS, The Creators, FELT ZINE, AQNB and *The Golden Boy Press*. *The Future Is Not Unwritten* was exhibited at the Goethe Institute in Japan, SXSW in Texas and the MCBW – Munich Creative Business Week.

www.dvdv.space



Dani Ploeger, *Smart Fence*

2019, Augmented Silkscreen, 42 x 59 cm

Maja Stark, Elisabeth Thielen
AURORA School for ARtists
https://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

Smartphone, Smart Home, Smart Clothes, Smart Water. The term smart has become the omnipresent buzzword in marketing jargon and paints the image of artificially intelligent high-tech products for everyday relief and health-enhancing nutrition of the advanced human. He wears smart objects in his pocket and on his skin, they enter our bedroom and are even physically consumed. But how does the progressive human proceed if he wants to keep someone off his back?

Smart Fence is the title of a multi-part work by Dani Ploeger – and this title is not a cynical exaggeration of the marketing trend described, but the actual name of high-tech border fences, which are located on parts of the external borders of Europe, to deter and keep away immigrants. Smart Fences are equipped with 'smart' technologies such as heat and motion sensors and night vision cameras. The high-tech equipment of the fence stands in stark contrast to its archaic purpose of fearful separation. Ploeger wrote in an interview with *We make money not art*: "[T]heir framing as supposedly clean and precise technologies is symptomatic of a broader cultural practice that uses narratives of technology to justify means of violence".[1] Ploeger does not accept the argument that the use of Smart Fences has been operated only by Hungary and is due to the 'uneuropean' policy of Hungarian President Victor Orban, because: "This perspective ignores that Frontex, the European Border and Coast Guard Agency, is also active at the Hungarian border fence and that Greece, Spain and Latvia, among others, have built or are building similar fences, although these have not received as much media attention. In the end, these fences are quite convenient to many governments across the EU that want to restrict immigration."[2]

In the centre of Ploeger's *Smart Fence* exhibition at Belgian Bruthaus Gallery 2019 was an original piece of smart fence from the border between Hungary and Serbia – it is the trophy of a quite hazardous surprise attack by the artist on this fence, documented on video and published online. In his AR work, a piece of this barbed wire is set as a paper-colored cut-out in front of the lead-gray background of a screen print. In Unity, it is not represented as a 3D object but as a two-dimensional graphic and is transparent at the beginning of the augmentation. As soon as one scans the

1 http://we-make-money-not-art.com/cutting-through-the-smart-walls-and-fences-of-fortress-europe/ (last access: 29.03.2019).

2 Ibid.

screen print, which serves as the marker, the texture's alpha channel and thus the opacity are slowly increased to the maximum value, whereby the fence moves towards the camera and thus the user. While the fence piece swings, the accelerometer value of the smartphone is constantly retrieved. By rotating the smartphone the user is now able to give a short angular momentum to the object, based on the rotation angle of the phone. After creeping up slowly, the barbed wire swings past the camera and finally disappears.

About the Artist

Dani Ploeger combines performance, video, computer programming and electronics hacking to investigate and subvert the spectacles of techno-consumer culture. Re-purposing, mis-using, and at times destroying everyday devices, his work exposes seemingly banal and taken-for-granted aspects of digital culture as objects of both physical beauty and political power.
Among others, he has worked with traditional metal workers in the old city of Cairo to encase tablet computers in plate steel, attended firearms training in Poland to shoot an iPad with an AK47, made a VR installation while embedded with frontline troops in the Donbass War, and travelled to dump sites in Nigeria to collect electronic waste originating from Europe.

www.daniploeger.org

Theresa Reiwer, TOVIAS

2018/19, Augmented Room Installation, 500 x 325 cm

Theresa Reiwer, Maja Stark, Elisabeth Thielen
AURORA School for ARtists
https://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

Theresa Reiwer's AR work TOVIAS is part of a narrative space specially built by the artist. The narrative of the immersive installation is advertised by the fictitious WELCOME HOME company in painfully sharpened marketing jargon as a smart home prototype of the SLOW ROOMS series. The fiction is accredited by a differentiated corporate identity, website and social media appearances as well as by print brochures in which one reads: „It does not matter whether it is about the choice of the music during dinner, the picture hanging in the hall or the right light mood: your Ambience Enhancer already knows what you need before you know it."
The theatre guest is invited to live in this story for a trial: for 20 to 30 minutes, the Smart Home may be tested in absolute isolation. The fact that the apartment is entered alone intensifies the entire experience and the „certified relaxation tools" of the new home can be highly individualized. The latest feature of SLOW ROOMS is the TOVIAS package. The name stands for „Tool for Virtual Associate", an add-on that should breathe life into the Smart Home. Experienced with appropriate technology, TOVIAS ensures that you never feel alone in a SLOW ROOM – unless you want to. It can be switched on and off at the push of a button, and adds, so the brochure, all the positive effects of huan company, without the disadvantages. Within Reiwer's installation the viewer can empirically explore, whether the basic human need for society is really this easily satisfied: using a HoloLens the viewer perceives a ghost-like AR avatar, that goes about his everyday occupations in the apartment as matter of fact.
The pastel colours of the corporate design of WELCOME HOME can only superficially whitewash a dystopia, in which self-optimization constraints and an unreflective enthusiasm for technology are the focus, and in which the supposedly trusted home mutates into an externally determined isolation cell. The work of Theresa Reiwer thus stands in a long tradition of not that unrealistic visions of the future, ranging from George Orwell's 1984, to July Zeh's Corpus Delicti, to the television series Black Mirror. Technological progress in the course of digitalisation is breathtaking – and this can, in the case of a lack of reflection and feedback within the values of a free society and as illustrated by Reiwer's Narrative Space, be understood quite literally.
Theresa Reiwers application was realized using a *Microsoft Hololens* which allows for a way higher degree of immersion and hands-free AR.

The virtual humanoid flatmate was modelled in 3D using *Adobe Fuse* and animated with a few basic animations (such as walking, sitting, typing on a smartphone) using the online tool *Mixamo*. The different animations and thus the different actions of the virtual flatmate are controlled by a utility-based artificial intelligence, known from computer games like *The Sims*. The flatmate has a set of different needs (hunger, fatigue, boredom, ...) represented by variables that are constantly changing due to the passing of time and other actions. The humanoid character always acts on its most prominent need while moving throughout the flat.
From 02.05. to 16.05.2019, Theresa Reiwer's narrative space could be tested in a dwelling near metro station Samariterstraße in Berlin. At the same time, its inhabitants were fighting against against the modernisation of the very same building which would have lead to displacement through an increase in rent – a side scene conciously chosen by the artist.

About the Artist

Theresa Reiwer studied theatre and film at Freie Universität Berlin and the Bilgi Üniversitesi in Istanbul. She received the Mart Stam scholarship for a subsequent study in stage and costume design at the Kunsthochschule Berlin Weißensee. She worked for the performance group *Showcase Beat Le Mot* and realized several of her own projects in cooperation with Theaterakademie Hamburg and Hochschule für Schauspielkunst Ernst Busch, for example at the bat-Studiotheater in Berlin and the Gauß Theater Hamburg. The feature film Jibril, for which she made the production design, was shown as part of the official selection of the Berlinale in 2018 and received the Studio Hamburg Award for "Best Film". As a photographer, she has shown her work in group exhibitions and designed music artwork. As a lighting designer, she realized several multimedia installations. Currently she is engaged in digital media art including augmented reality.

www.theresareiwer.de

Ulrike Schmitz, *The lizards are not what they seem*

2019, Augmented Ink Jet Print, 60 x 40 cm

Maja Stark, Leonid Barsht
AURORA School for ARtists
https://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

Since the dawn of science man has been using images, graphics and models to underpin theories and propose theses. Not only since the perfection of digital image processing are "fake views"[1] powerful tools for inadvertent as well as purposeful construction of reality. In the visual

1 A. Beltin et al. (eds.) (2018): Lust der Täuschung. Von antiker Kunst bis zur Virtual Reality, exh. cat. Munich/Aachen. Munich: Hirmer, cover text.

arts, this construction has been deliberately pursued since antiquity, for example to demonstrate the technical virtuosity of artists and the deceptiveness of the human eye. In science, however, every graphically proven thesis is accompanied by a claim to truth that is in strong contradiction to deliberate deception. Here, this is not a well-prized trick, but a taboo that violates the ethic of science and falsifies the search for truth up to its ideological concealment.

The artist Ulrike Schmitz deals with the boundaries between scientific and ideological visualizations in her AR work The lizards are not what they seem. In the work she draws on two very different reality narrators, whose theses both revolve around the question of the genetic determination of the human: On the one hand the Viennese zoologist Paul Kammerer (1880–1926), who at the beginning of the 20th century conducted research on the feuersalamander and ultimately wanted to prove with manipulated photographs, that our genes can be changed by social circumstances. On the other hand the British conspiracy theorist David Icke (* 1952), who tries to underpin the existence of so-called Lizard People using questionable footage. According to Icke, humanity is a subjugated breed of these reptilian aliens. Celebrities such as Queen Elizabeth, George W. Bush or the Clintons are, according to Icke, all Lizard People – a theory that 4% of the population believe in the US.

As if contrasted in a Petri dish and magnified microscopically, the artist shows two mask-like human head models that seem to float away from a blue-washed solution. A cell-like structure on the lower right edge of the picture reinforces the impression of a sinister microbiological experiment. The greenish fluorescent profile in the background seems to be undergoing a metamorphosis to the lizard – the outline is as though drawn by an invisible hand, but not yet completely filled. Or is the subsequently supplemented line only the manipulated proof of lizard-being? Anyone who researches the Lizard People Theory of David Icke and its references to the surroundings of Barack Obama will find the outlined profile in the accompanying iconography.

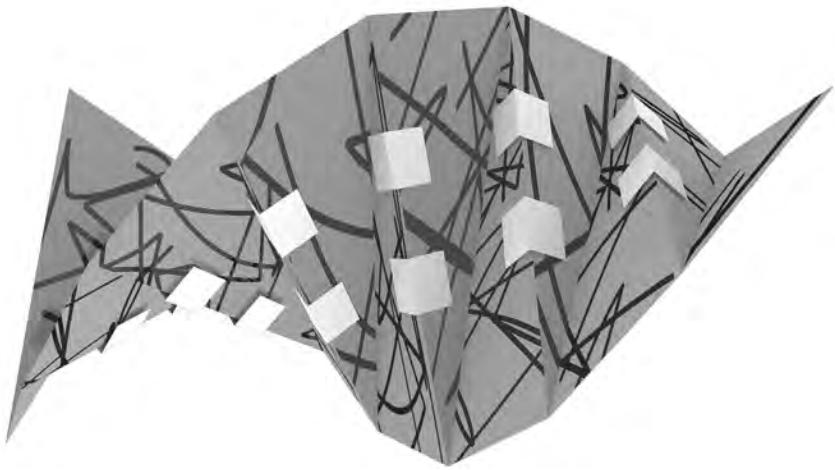
Through AR, the front mask is set in motion and shows up like a 3D-sculpture seen from different perspectives. It seems as if it were the modelled precursor of a scientific breeding or even a mutation to – to quote Icke – a "reptilian race". Not least, a proven rule of thumb can be derived with

regard to the central issue: Supposed racial characteristics will always remain an unmistakable feature for distinguishing between deception and truth, between ideology and science.
Of particular importance in the context of technical AR development was the constant change of the elements to be augmented with regard to their position, rotation and size. Initially, animation within Unity seemed to be the best solution. Ultimately, however, it was more useful to implement reusable code to modify the named properties. In the form of various scripts, this code is assigned to the individual elements to be augmented. For instance, this makes it possible to quickly set which axis and how fast an element should rotate.

About the Artist

Ulrike Schmitz lives in Berlin. After completing her law degree and doctorate, she graduated from the Ostkreuzschule für Fotografie in Berlin in 2012. She is currently working on her thesis in the postgraduate Master's program Art in Context under Prof. Dr. Heiser at the University of the Arts Berlin. In her artistic works she deals with phenomena of science and their interaction with social structures and valuations.
In 2015 she was invited to the five-year global exhibition project reGeneration3 of the Musée de l'Elysée, Lausanne, Switzerland and in 2016 to PLAT(T)FORM of the Fotomuseum Winterthur, Switzerland. In 2018 she participated in the residency program of WINZAVOD Centre for Contemporary Art in Moscow. In 2019, she was part of The Unlearning Place during the opening days of The New Alphabet at HKW in Berlin. Her works have been exhibited extensively in Germany and internationally, such as the Benaki Museum in Athens, the Centro Nacional de las Artes in Mexico City, Lishui Art Museum galleries in China, Art Foundation metamatic: taf in Athens and the Museum De Buitenplaats in Groningen, Netherlands.

www.ulrike-schmitz.com



Dagmar Schürrer, *Untitled (Von der Fläche zur Form)*

AR

2019, Augmented Sculpture, 40 x 25 x 20 cm

Dagmar Schürrer, Maja Stark, Leonid Barsht
AURORA School for ARtists
https://aurora.htw-berlin.de
HTW Berlin (University of Applied Sciences) · 12459 Berlin
aurora@htw-berlin.de

A futuristic and yet enigmatic aesthetics emanates from Dagmar Schürrer's origami-like object made of acrylic glass – it looks almost as if it had been thrown through the window of a screen as an encrypted message of the digital to the analog world to be decrypted by its rhythmic hatching. Its delicate crease pattern stands in contrast to its solid materiality, and yet the edges of the silver terminals reveal that is not simply 3D print, but a precisely handcrafted artwork. Undoubtedly, with its purist aesthetic this

rhythmically shaped object already functions as an independent work in itself. But that's not all: In addition, it serves as a 3D screen specially developed by Dagmar Schürrer, which, caused by AR in conjunction with its aforementioned hatching, reveals the reproduction of parts of her ten-minute video work *Seeking Patterns* (2019), driven by the rhythm of electronic music. However, this reproduction is by no means limited to the screens, but dissolves from them and expands pulsing into the three-dimensional space.

With her work on AR, Schürrer takes up the idea of Expanded Cinema, which from the 1960s merged forms and contents into flowing pictorial worlds in order to make the medium of film tangible in a new, sensual-aesthetic way.[1] At the same time, the artist addresses the question of how far this intention can be realized with the new technical possibilities of object recognition and extension by means of AR. In this context the transformation into the three-dimensional shows itself in both the video and the analog object.

In this cooperation of art and computer science, a number of laboratory tests on object recognition and augmentation were carried out in advance. The most important question was, if the artwork to be recognized as a marker should be first created digitally and then – for example, with a 3D printer – be transferred to the analog world or if it should be the other way around. Both methods were tested for Dagmar Schürrer's AR project and each entailed specific challenges. Thus, it is hardly possible to replicate a digital model so precisely in the analog world that it is easily recognized by the relatively strict AR algorithm. On the other hand, when scanning an analog object, the recognition of it is more accurate, but it lacks its digital reference in order to be able to augment it only at selected locations. Ultimately Dagmar Schürrer's solution was to scan the work and digitally create a reference model on that basis.

Also on the aesthetic level, decisions and the development of the sculpture were strongly influenced by the capability of the application to recognize objects as marker. The original idea of a monochrome white sculpture had to be discarded because it had too few recognition points (feature points) and Vuforia therefore did not register the sculpture as a marker. The

1 See https://www.schirn.de/magazin/kontext/doug_aitken_im_kontext_des_expanded_cinema/ (last access: 02.04.2019).

interaction of artistic work and technical feasibility resulted in a singular sculptural work that was co-formed by the technology of the AR application. The result of this process is a hybrid, expansive work that reveals numerous reciprocal relationships between object and video in terms of rhythm, structure, color and form, and will attract attention as a novel AR art form at the interface between analog and digital creation.

About the Artist

Dagmar Schürrer is an artist working with the moving image. She assembles found footage, digitally generated objects and animations, text, drawings and sound to form intricate video montages, evocative of painting, collage and poetry. She holds a degree in Fine Art from Central Saint Martins College of Art and Design in London, UK. Her work has been exhibited internationally, amongst others at the *New Contemporaries* at the ICA London, the *Impakt Festival* in Utrecht, NL, the *Moscow Biennale for Young Art* and the *Transmediale Vorspiel* in Berlin. Her videos have been screened at numerous festivals: SUPERNOVA in Denver, the *Seattle Film Festival*, the *Horn Experimental Film Festival* in Israel, *Tricky Women Festival* in Vienna, or the *Diagonale Film Festival* in Graz. In recent years she received the Goldrausch Scholarship of the Senate of Berlin, and was shortlisted for the Berlin Art Prize and the Tenderpixel Award in London.

www.dagmarschuerrer.com

The Digital Exhibition at the Konzerthaus Berlin

Cultural Participation through Digitalisation

Michael Droste
INKA Research Group
HTW Berlin University of Applied Sciences
12459 Berlin
michael.droste@htw-berlin.de

Annette Thoma
Project "Virtual Konzerthaus"
Konzerthaus Berlin
Gendarmenmarkt, 10117 Berlin
a.thoma@konzerthaus.de

Abstract

Music for Everyone! This is not a platitude, but rather a living motto for the Konzerthaus Berlin: bringing music to a broader public is paramount. The Konzerthaus Berlin aims to provide new approaches to classical music and to promote broader participation in culture. For this purpose it has initiated the APOLLO project in conjunction with University of Applied Science (HTW) Berlin to develop innovative ways of communicating music in digital space.

Some results of this cooperation are part of the digital exhibition that was opened in May 2018 and is presented in the vestibule of the Konzerthaus Berlin. Visitors can experience classical music at the Konzerthaus Berlin through five interactive augmented and virtual reality applications. The different parts of the exhibition feature among other things the building and history of the Konzerthaus as well more educational topics as the typical structure of a symphony orchestra.

1 Objective and Motivation of the Exhibition

Besides its efforts for innovative concert experiences, the Konzerthaus Berlin is convinced that participation in the modern Internet culture and media is an important step to facilitate the access to classical music. Especially when targeting younger audiences, institutions like the Konzerthaus Berlin need to be poised to experiment with innovative approaches to impart information through digital media and digitalisation in general. Successful utilisation of social media and recently trending technologies like Augmented and Virtual Reality allows for cultural participation in a modern and often interactive way. Furthermore, the digitalisation allows for an easy, democratic access to knowledge and cultural content regardless of one's social or ethical background.

1.1 Cooperation with the HTW

Since August 2016, the Konzerthaus Berlin is working with the University of Applied Sciences Berlin (HTW) in a joint project named APOLLO ("Applikationslabor für Onlinemedien, Virtual Reality und Location Based Services") and together they develop innovative concepts that aim at imparting knowledge surrounding the field of classical music through digital media. The primarily focus are Augmented and Virtual Reality applications. Over its three-year runtime, APOLLO is funded by the European Regional Development Fund (ERDF).

In May 2017, the AR app "Konzerthaus Plus" was released, featuring a collection of augmentations for the seasonal brochure of the Konzerthaus Berlin. The app is regularly updated with new augmentations for other printed publications of the Konzerthaus Berlin, e.g. the current iteration of the seasonal brochure or postcards. Temporary content was also added to support installations for festivals with augmentations. The augmentations featured in the "Konzerthaus Plus" app consist of a wide range of digital media, ranging from simple audio or video players, to interactive games and 3D models.

1.2 The Digital Exhibition

Continuing the development of "Konzerthaus Plus" the Konzerthaus Berlin opend a digital exhibition in May 2018, featuring multiple Augmented and

Virtual Reality applications. The exhibition is presented in the vestibule of the Konzerthaus Berlin and is open to the public free of charge from spring to fall. In this timeframe the exhibition is visited by up to 10,000 visitors per month. For people that are unable to visit the Konzerthaus Berlin or that want to explore the exhibition again from home the AR applications of the exhibition were integrated into the existing "Konzerthaus Plus" application, that is available for Android and iOS for free.
In the vestibule of the Konzerthaus, the Augmented Reality applications of the exhibition can be experienced using the tablets that are mounted on the exhibits. Qualified volunteers guide visitors in their usage of the exhibits and facilitate the access for first-time users of this new technology.

2 The Content of the Digital Exhibition

The five steles of the digital exhibition try to impart knowledge of classical music by enabling the user to view or hear the music in innovative ways and convey information about the history of the Konzerthaus Berlin and its orchestra. Four of the steles utilize Augmented Reality and one is using Virtual Reality.

2.1 The Konzerthaus Berlin as a 3D Model

One of the AR steles shows a high-resolution 3D model of the Konzerthaus Berlin. The application starts in an exterior view, but users are able to interactively explore the five most important halls. The halls each feature fitting background music as well as some additional text information that summarizes architectural and historical trivia regarding the currently visible room. As only the vestibule is open to the public, the application aims at users that want to get a glimpse at the different halls but will most likely not have the chance to visit a concert.
The model will be used for an upcoming update to the Virtual Reality application of the exhibition described below. There, the model will be the basis for a guided audio tour through the building.

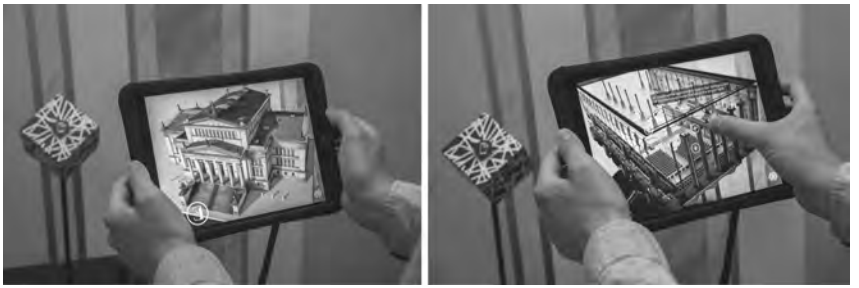


Fig. 1: The Konzerthaus Berlin and the Great Hall in Augmented Reality. Credit: Konzerthaus Berlin/Pablo Castagnola

2.2 The Virtual Quartet

The "Virtual Quartet" is an AR application that aims to show the structure and interplay of a string quartet by allowing the user to deconstruct it at will. Therefore, the musicians of the Konzerthaus Quartett where filmed in front of a green screen and their audio recorded individually. The application uses multiple markers that are styled as playing cards; one card per musician.

The user can decide which musicians play at any moment by either scanning only a subset of the cards or by flipping over the ones he does not want to hear. The application allows the user to interactively explore the impact each musician has on the overall sound of a string quartet.

Fig. 2: The "Virtual Quartet" in Augmented Reality.
Credit: Konzerthaus Berlin/Pablo Castagnola

2.3 The Virtual Timeline

The AR application named "Virtual Timeline" was updated in May 2019 and is now the first application of the exhibition to utilize markerless Augmented Reality based on ARKit. The new technology allows augmentations to be placed relatively freely in space. The new timeline's augmentation is therefore allowing the user to spatially explore the history of the Konzerthaus Berlin and its orchestra by spreading a line with the most important events around the stele that reveal further information upon closer inspection.

2.4 The Orchestra Puzzle

The orchestra puzzle is an AR application that tries to educate users about the general structure of a symphony orchestra. The user is presented with an empty schematic of an orchestra and has to assign 3D models of instruments to their respective seats. This is done using drag-and-drop. The game aspect is strengthened through additional game mechanics, e.g. sound based success or failure feedback and a limited number of tries before the game is reset and the user has to start over again. The application is aimed at a younger target audience.

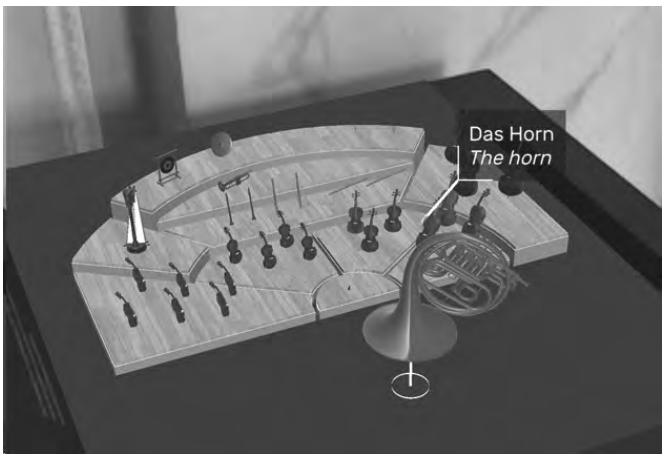


Fig. 3: Screenshot of the orchestra puzzle.
Credit: Konzerthaus Berlin/Pablo Castagnola

2.5 The Konzerthausorchester Berlin in VR

The application aims to give the user a whole new perspective on a classical concert by enabling him to switch his viewpoint at runtime as well as allowing three points of view that are not accessible during a regular performance, e.g. on stage right next to the conductor. To achieve this goal a concert was filmed using multiple full-sphere 360-degree cameras in conjunction with spatial microphone technology. The latter allows the user to also experience the correct sound impression for each of the points of view he can occupy.

Overall this highly immersive concert experience of Felix Mendelssohn Bartholdy's final movement of his fourth symphony offers innovative and new impressions for regular concertgoers as well as laymen of classical music.

Fig. 4: The Virtual Reality headset in the vestibule of the Konzerthaus Berlin. Credit: Konzerthaus Berlin/Pablo Castagnola

3 Conclusion

Music and the way it is consumed is, just as most aspects of life, heavily influenced by technological change. The sound experience is not bound to the concert hall any more, but is saved and multiplied as vinyl records and CDs, transmitted over radio and is by now most prevalently stored digitalised. Music is almost everywhere and anytime available. Classical music and its institutions should embrace this change and use it to their advantage. Institutions must not be afraid and realise that digital content is not meant to and will never replace the live experience of a concert and that utilising new media and technologies does not contradict the focus on live concerts.

The interplay between classical music and technology is still a novelty and its potential widely unused. However, the Konzerthaus Berlin is confident that cultural institutions can increase cultural participation and education by investing into trending technologies like AR and VR. The Konzerthaus Berlin is treating digital music education as a central part of their agenda and is working on cross-media concepts fit for the task.

Overall, the greatest potential of digital cultural education is the ability to use its media to create new access points to cultural knowledge. Its primary attributes, namely immersion, interactivity and participation, will supplement older, linear approaches to imparting knowledge in the future even further.

Namibia Living Books

Barbara Liebel
Language & Literature Studies · University of Namibia · Windhoek
daad.namibia@gmail.com

Detlef Pfeifer
Goethe-Institut Namibia · Windhoek
Detlef.Pfeifer@goethe.de

Jürgen Sieck
Hochschule für Technik und Wirtschaft Berlin · 12459 Berlin &
Namibia University of Science and Technology Windhoek
juergensieck@acm.org

Abstract

The concept of Augmented Reality is not new, but has become very popular in recent years with the introduction of wireless networks, new sensor systems and high-performance mobile devices. These powerful handheld devices allow us to see the real world enhanced with computer generated content anywhere at anytime. This has led to a massive rise of Augmented and Virtual Reality. Universities, large and small companies as well as start-ups are adding new AR hard- and software components, products and services to their product portfolios and increase the possibilities and fields of applications of Augmented and Virtual Reality.

In this paper, we describe a joint project between students from HTW Berlin, NUST Windhoek and UNAM Windhoek to use Augmented Reality to enrich children's books. With the aid of Augmented Reality, the readers of the augmented books are given the opportunity to access additional content complementing the books. These contents include images, illustrations, audio, video, simple animations, 3D objects, interactive media as well as games. The prototypes were implemented using Vuforia and Unity during a coding week in Namibia.

1 Introduction

The development of information technologies in the last decade was able to bring new possibilities and challenges into many aspects of life. This is especially true for cultural aspects such as art, music, games, entertainment and literature, where the introduction of information technologies attracts newer and wider audiences.

The paper presents the results of a coding week in Windhoek Namibia with Namibian and German students. The project's goal was the development of various Augmented Reality (AR) applications for a selection of Namibian children's books.

The augmentations of the Namibian children's books are included in the "Goethe-AR" App. In all subprojects the printed children's book will be augmented with digital content. In order to not disturb the layout and design of the books, markerless tracking was used. The opened page of the selected book is used in the same way as the traditional AR markers for the identification and registration of the corresponding contents. Our long-term goal is to provide a single application that integrates a wide range of mixed reality applications that can be used by the authors themselves for each of their books.

2 Related Work

Early developments in the field of Virtual and Augmented Reality had mostly been driven by military, architecture, industrial maintenance and gaming. Especially U.S. Air Force, NASA and researchers at the MIT have built the basis for AR and VR in the 70s and 80s of the last century [KrPo10]. Heads-up-display (HUD) systems or simulations with HMDs were especially used in these areas. The first appearance of the concept of augmented reality is attributed to Caudell and Mizell [CaMi92] in the early 1990s. The two Boeing scientists developed an experimental AR system to help workers assemble wiring harnesses [KrPo10].

Particularly in recent years it can be observed that VR and AR applications extend to many other fields. This may be due to the fact that display technologies such as HMDs have changed from professional and very expensive

equipment to consumer electronics. Display devices such as the Oculus Rift, the Samsung Gear VR or Epson AR Glasses bring this technology to many areas of life. Additionally, a huge increase of AR and VR based applications can be observed in art and culture. As described in [Isea12] AR contains potentials for teaching, learning and pleasure in culture and art and can be used in interactive entertainment, interactive storytelling, visual art, sound art, interactive opera or digital archives. Opera visits can also be unique experiences for visitors; examples are Mozart's "Zauberflöte" at the Komische Oper Berlin[1] [Barr13] or the augmentation with live video mapping of a traditional Chinese opera "Havoc the Dragon Place" [Huan14]. As described in [Huan14], "no translation is needed, and people who don't have any background in Chinese opera can also easily experience the performance".

The content in print media, however, is based on the presentation of text and images. New media, such as audio, video and various interactive media formats, cannot be integrated directly into a printed book, newspaper or magazine. Classical print media consist of static content and offer poor or no interactivity [Pere11]. Different approaches such as printing internet links, printing QR-codes or adding additional media such as CD and DVD were used to solve this problem in the past. The user is provided further digital and interactive information. However, the user has to switch from the actual medium, which provides the content and information, to a new medium to retrieve the additional information. The connection of the user to the print medium can therefore quickly be lost. With the use of AR, print media can be enriched with digital interactive and non-static information. This means AR allows the user to view the real world with superimposed computer-generated content.

Many advances were made in the main research areas of AR: visualisation, tracking and registration, as well as interaction and media integration. All these areas must be addressed by the use of AR for print media. Tracking is necessary to identify the printed content to be enriched and to register the digital content geometrically correct. Visualisation techniques are required to present the additional content to the user. Interactive access gives the user the possibility to control the additional content.

1 https://www.komische-oper-berlin.de

Registration is the process of overlaying the virtual objects in the real scene and is one of the most important research topics in AR [Azum97, ABBF01]. The required information for registration is extracted from the real objects (in our case from the page of the book). This is the basis for feature points of the real scene [PYNO06]. The authors in [PYNO06] define two categories of registration approaches:

a. The sensor-based approach, where mechanical, magnetic, ultrasonic or optic sensors are used to gather the information for registration from the real scene. Often a calibration of the sensors is necessary. Many applications use specialised sensors, and they could be expensive and the levels of accuracy [PYNO06], especially when external sensors are used, is not good enough.
b. The second approach is computer vision with image recognition. This approach does need no external devices, and there is no need to calibrate external sensors. Computer vision offers the potential for accurate tracking without the use of additional sensors. Different approaches for camera-based tracking are named in [PYNO06].

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 [LiSD15]. The simplicity and accuracy is based on the design of the markers. A predefined shape and the high contrast of the embedded pattern make them easily recognisable in most setups [LiSD15]. Another approach can be found in [YoSm16], where the authors use ARToolkit[2] marker in an interactive AR system to place furniture in a room. In this system, markers are used to define the spatial position of the furniture to be placed. Dibidogs children storybook[3] also contains AR markers to enrich the user experience.

Markerless augmented reality techniques allow the use of natural images as targets for the placement of augmentation information. The natural images correspond to parts of the real world, which are captured by the camera of the AR-system and are examined for specific natural features such as edges, corners or texture patches [BaPG09]. The authors in [KaSh13] describe a markerless AR application for picture books with the

2 https://artoolkit.org
3 http://www.dibidogs.com/files/3113/9323/2202/DIBIDOGS_BROCHURE_EN.pdf

usage of the scale-invariant feature transform (SIFT). The use of SIFT-based algorithms calculates feature points of an image and uses the pictures as AR markers and enriches them with virtual 3D-objects [KaSh13].
For a long time, most AR interfaces were based on the desktop metaphor and used designs from Virtual Environments Research. A major trend in interaction research, especially for AR systems, is the use of heterogeneous designs, tangible interfaces [ABBF01], and multimodal interaction methods. Heterogeneous approaches blur the boundaries between reality and virtuality and take parts from both worlds. Tangible interfaces emphasise the use of real, physical objects and tools. Similar to AR systems, the user is able to see the real world and can interact with real objects. In this mode, the AR interface is a real component [ABBF01]. A major focus in interaction research is the development of mobile AR System (MARS). With the increasing sales of smartphones and their increasing technical features and technical possibilities, smartphones seem to be the ideal platform for AR. A classic example for this kind of application is the mobile AR browser. However, interacting with virtual objects is one of the biggest challenge. The interaction with virtual objects is described in [TUNH15]. One approach is tangible user interfaces for real object-based interaction. A user can handle, rotate or manipulate virtual objects by handling and rotating the real object [TUNH15].
Another approach is to track the user's hand to interact with virtual objects [TUNH15]. With the aid of computer vision, the user's hand is recognised by a camera-mapped AR system. [KoAS16] describe in their work a system based on a normal RGB camera to recognise the user's hand and gestures. [TeKI09] tracks fingers to realise in-air typing. In [HBEB09] hand-drawn shapes are used to create AR objects, and in [HüVa13], a system is presented in which the user's fingertips are equipped with AR markers.

3 System Description

The most important components of children's book are text and images. Interaction is also very important. There are many approaches with analogue interactions, i.e. children can open and close doors, have handles to do animations and could watch from different sides to see diffe-

rent images. Modern AR systems offer many more possibilities. The typical age of readers of children's books is between 4 and 10. Many children already have experience with smartphones and are able to use them. This knowledge influenced the general concept of the AR application and led to a cautious approach. First of all, the AR application should only extend the existing content of the books and not replace it. Furthermore, the AR application's handling needed to be as intuitive and easy as possible to enable the children to use the application.

While widely used across mobile applications, we do not want to integrate a manual to teach the user the interface and the operation of this application. Ideally any augmentation should only need to be viewed through the mobile devices' camera and if interactivity is desired, can be activated using a simple tap (see Fig. 1).

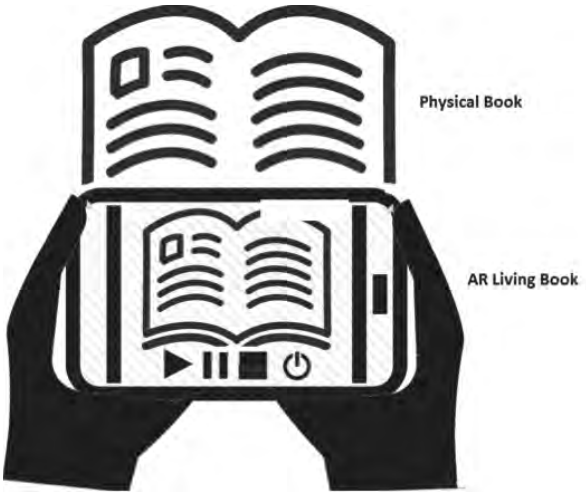


Fig.1: User Interface, Real Book and the Attached Living Book Idea

For the content and the possibilities for interactivity this meant slight limitations, but we were able to use images, drawings, audio, video, simple 2D and 3D animations, and 3D models.

Finally, we decided to use a markerless AR approach. This enables us to use the non-augmented content of the printed book to position our augmented content. The printed content is not obscured with typical QR-code-like markers.

The main components of the authoring system and the system architecture are Vuforia and Unity3D, described in Fig. 2.

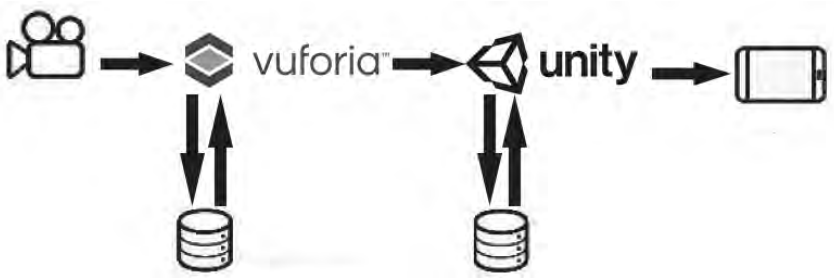


Fig. 2: System Architecture

4 Prototypes

The participants of Coding Week were divided into six groups. Each group was assigned a children's book, for each of which an AR app was developed. These six apps were finally integrated into the Goethe-AR app.

Mina and the Magic Baobab Tree

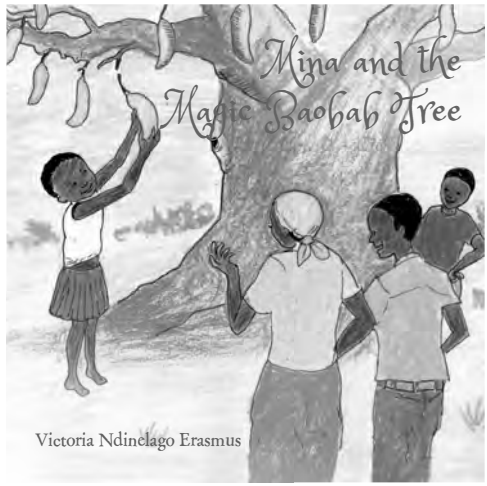


Fig. 3: Cover of the Children's Book "Mina and the Magic Baobab Tree", Image Source: Kuisebbooks

The subproject Mina and The Magic Baobab Tree creates some animations to enhance the story of the book. The pages of the book are the markers and augmented with the animation. In addition the group produced some audio files in English and some in German, based on the story line. This give the users the possibility to switch between English and German.
The most interesting feature of the AR app is the ability to tell the story from the perspective of different characters: Mina, the old lady or the aunt.

The Dancing Tortoise and the San Hunters of the Kalahari

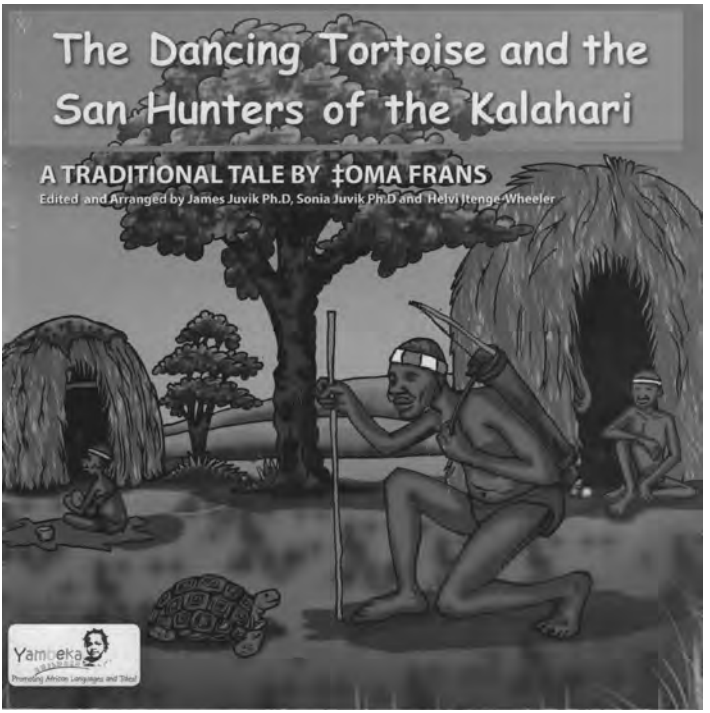


Fig. 4: Cover of the Children's Book "The Dancing Tortoise and the San Hunters of the Kalahari", Image Source: Yambeka

AR

The AR application is targeting primary school learners and also adults such as foreigners who are curious about the culture of San people. The AR app is able to tell the story from three different perspectives; from the hunters', tortoise's or granny's perspective. The characters will be identified by additional markers to be placed on the pages of the book.

The characters will tell the story from their own special perspective. The characters will not be talking at the same time. Each character starts 2D animations, audios and will change the environment. If a person is angry the animation will change the surroundings in an angry manner.
Furthermore, the application will be made for edutainment to entertain the user of the application while educating about the way of living of San people and their culture. Overall, this will benefit the users by giving them a new experience in addition to the written message and will attract more people to the museum or the library.

The Little Weaver Bird

The main focus of this children's Book is "The Little Weaver Bird" narrating the story. The weaver bird book could be used in education to raise awareness of the bird and give users more information about the bird and the bird's live. In addition, the book and the AR app could be used to teach languages by narrating in three different languages, Oshiwambo, German and English. This project is also based on the idea of being able to teach children word associations and spelling by creating simple puzzle and quizzes about the weaver bird.

"The little Wildebeest may not die."

AR Fig. 5: Covers of the Children's Book "Benni 3" and "Benni 4", Image Source: Kuisebbooks AR

The aim of this subproject is to make reading and drawing a fun experience for children aged 5 and up. The front covers of the books are markers and are augmented with a movie and gives an overview of what the book is about in three different languages, namely German, English and Oshi-

wambo. There are subtitles of the main story. The user could choose a specific colour for the colouring pages of the books. This will select the language preference of the user. An example of this would be that by colouring the Elephant blue, the user would select the rest of the story to be in English. Green could be used for German and red for Oshiwambo.
As the user progresses through the book, there are puzzles to fill in with keywords from the text. In addition to this there is one animation where the grass gets greener, the land wetter and the river flowing as it rains by tapping on the screen. There will be several animations of animals dancing during and after the rainfall. Children can be kept occupied by coloring in the digital images found on some pages of the book. Many animals featured in the book will have information about them as an added augmentation.
On the final page of the book is a little quiz, which randomises questions, which come from the book and will test the child's comprehension of the story.

Namibian Magic

The Namibian Magic book is about little children enjoying the great outdoors of the Namibian wild. The application is enhanced audio sounds when a specific page is open and identified by the application. The user will have the option to select from three different languages in which the story can be presented, English, German and Oshiwambo. When the audio is playing there are also 2D and 3D models for the augmentation of the pages of the book.

Acknowledgment

This paper describes the work undertaken in the context of the coding week "Augmented Reality" hosted by the Goethe-Institut Windhoek and is generously funded by the Goethe Institute Windhoek and the HTW Berlin.

Literature

[ABBF01] 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), pp. 34–47. http://doi.org/10.1109/38.963459

[Azum97] Azuma, R. T. (1997). A Survey of Augmented Reality. Presence Teleoperators and Virtual Environments, 6(4), pp. 355–385. http://doi.org/10.1162/pres.1997.6.4.355

[BaPG09] Barandiaran, I., Paloc, C., & Graña, M. (2009). Real-time optical markerless tracking for augmented reality applications. Journal of Real-Time Image Processing, 5(2), pp. 129–138. http://doi.org/10.1007/s11554-009-0140-2

[Barr13] Barritt, P.: Banging My Head Against the Table, in: Proceedings of Culture and Computer Science: Visual Worlds and Interactive Spaces, Berlin, 2013, vwh Verlag, 2013, ISBN 978-3-864880-045-2

[CaMi92] Caudell, T.P.; Mizell, D.W.: Augmented reality: An application of heads-up display technology to manual manufacturing processes. In Proc. Hawaii Int'l Conf. on Systems Sciences, pp. 659–669, Kauai, HI, USA, 1992. IEEE CS Press. ISBN 0-8186-2420-5

[HBEB09] Hagbi, N., Bergig, O., El-Sana, J., & Billinghurst, M. (2009). Shape recognition and pose estimation for mobile augmented reality. Proceedings of the 2009 8th IEEE International Symposium on Mixed and Augmented Reality.

[Henr05] Henrysson, A., Billinghurst, M., & Ollila, M. (2005). Virtual object manipulation using a mobile phone. Proceedings of the International Conference on Augmented Tele-Existence, pp. 164–171. http://doi.org/10.1145/1152399.1152430

[Huan14] Huang, X.; Lee, B.; Kim, H.; Lee, J.: An Experience-Based Chinese Opera Using Live Video Mapping, In: 6th International Conference, VAMR 2014, Held as Part of HCI International 2014, Heraklion, Crete, Greece, June 22–27, 2014, Proceedings, Part II, pp. 178–189, Springer, ISBN: 978-3-319-07463-4

[HüVa13] Hürst, W., & Van Wezel, C. (2013). Gesture-based interaction via finger tracking for mobile augmented reality. Multimedia Tools and Applications, 62(1), pp. 233–258. http://doi.org/10.1007/s11042-011-0983-y

[Isea12] https://isea2011.sabanciuniv.edu/paper/digital-re-presentation-and-simulacrum-augmented-reality

[KaSh13] Kao, T. W. & Shih, H. C. (2013). A study on the markerless augmented reality for picture books. IEEE International Symposium on Consumer Electronics (ISCE), pp. 197–198. http://doi.org/10.1109/ISCE.2013.6570182

[KoAS16] Kovalenko, M., Antoshchuk, S. & Sieck, J. (2016). Visual hand tracking and gesture recognition for human-computer interaction. Proceedings of International Conference on Culture & Computer Science ICCCS'16

[KrPo10] van Krevelen, D. & Poelman, R. (2010). A Survey of Augmented Reality Technologies, Applications and Limitations. The International Journal of Virtual Reality, 9(2).

[LiSD15] 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

[Pere11] Perey, C. (2011). Print and publishing and the future of Augmented Reality. Inf. Services and Use, 31(1-2), pp. 31–38. http://doi.org/10.3233/ISU-2011-0625

[PYNO06] 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

[TeKI09] Terajima, K., Komuro, T. & Ishikawa, M. (2009). Fast finger tracking system for in-air typing interface. (pp. 3739–3744). Presented at the CHI ,09 Extended Abstracts on Human Factors in Computing Systems, New York, New York, USA: ACM. http://doi.org/10.1145/1520340.1520564

[TUNH15] Tanikawa, T., Uzuka, H., Narumi, T. & Hirose, M. (2015). Integrated view-input AR interaction for virtual object manipulation using tablets and smartphones. Proceedings of the 12th International Conference on Advances in Computer Entertainment Technology – ACE '15. http://doi.org/10.1145/2832932.2832956

[YaCh12] Yang, X. & Cheng, K.-T. T. (2012). Accelerating SURF detector on mobile devices. ACM International Conference on Multimedia, pp. 569–578. http://doi.org/10.1145/2393347.2393427

[YoSm16] Young, T. C. & Smith, S. (2016). An Interactive Augmented Reality Furniture Customization System. International Conference on Virtual, Augmented and Mixed Reality, pp. 662–668. http://doi.org/10.1007/978-3-319-39907-2_63

SmartSquare (Smart Culture in Smart Cities)

Jens Bley
eCultureLab@HCU c/o CityScienceLab HafenCity University
20457 Hamburg

Martin Niggemann
SmartSquare · CityScienceLab HafenCity University
20457 Hamburg

Anais Wiedenhöfer

Abstract

The federally funded project SmartSquare develops innovative service models for the revitalisation of a public space, which is currently used mainly as a transit zone, by means of digital cultural storytelling, data analytics, simulation and service scenarios. The focus is on Hamburg's Domplatz, the former location of the Hammaburg castle and the intellectual and cultural centre of the city for centuries. However, the site offers no physical artefacts and insufficient information to do justice to its cultural-historical significance. The cultural services and installations make this place visible by providing access to a digital storytelling dimension.

The first step will be a data-oriented inventory of the currently practiced uses and, in addition, further future uses. For the analysis of the collected data, a digital, interactive surface model is used. Jointly with various actors, neighbours, users and service providers, different space scenarios are being developed. On this basis, integrated digital service scenarios from the fields of culture, tourism, mobility and retail will be developed, which in turn will be included in the space analysis. The various measures and their evaluation are included in a method box.

Smart services enrich public spaces: the Domplatz will be revitalized by intelligent offers that connect the interests of visitors and residents. “Cultural injections”, which take up the specific history of the square and make it tangible, enrich the square. These include purely digital offerings, such as apps, as well as digital-physical installations, such as displays, steles or interactive objects. Central locations with a cultural anchor point, analogous to Hamburg‘s Domplatz, can be found in many cities and regions.

The method box is made accessible for the analysis and systematic revitalization of public spaces and small-scale neighbourhoods. The urban society benefits from new forms of public space design.

Hamburg as a living laboratory for digital urbanization is the object of cooperation between the HafenCity University Hamburg (HCU) and the Changing Places Group of the Media Lab at the Massachusetts Institute of Technology (MIT). The CityScienceLab at HCU (CSL@ HCU) is a research unit exploring processes of urbanization in the digital age. Smart Cities urban testbeds and cultural perspectives are at the core of the eCultureLab@HCU, running the nationally funded multiple stakeholder SmartSquare project. SmartSquare is one of five European projects exploring the impact assessment model with Europeana, the EU digital platform and network for cultural heritage.

The Future of Classical Music

Is 3D-Sound Giving Music Back its "Soul"?

Stephan Frucht
Siemens Arts Program
Siemens AG
Charlottenstr. 57, 10117 Berlin

Abstract

Siemens Arts Program, together with the Orchestra Academy of the Bayerisches Staatsorchester, has recorded works by Peter Tchaikovsky and Friedrich Gulda and produced them in several immersive sound formats. In collaboration with the Immersive Audio Network IAN, a completely new sound experience has been created, combining traditional cello repertoire with a technically innovative audio process. Immersive 3D sound reproduces all three spatial dimensions. The recipient is in the middle of the sound space and can experience the quality of the sounds three-dimensionally. To go one step further, Siemens Arts Program has combined the 3D audio recordings with an augmented reality application. A virtual avatar orchestra plays Friedrich Gulda's concert in 3D sound. Viewers can choose their own viewing and listening position while moving through the musicians' "digital twins" with a touchpad.

Fig. 1: Orchestra Academy of the Bayerisches Staatsorchester in Siemens' Munich headquarters during a Siemens Arts Program music production in (immersive) 3D-sound

Background

Siemens AG enjoys long-established and sustainable partnerships with a large number of cultural institutions such as the Orchestra Academy of the Bayerisches Staatsorchester (Bavarian State Orchestra). However the Siemens Arts Program also ventures beyond traditional sponsorship-based partnerships by initiating its own innovative projects, in which it joins partners from the world of art and culture to produce new creations.

1 About the 3D Audio Project

During the 2017/18 season, the Siemens Arts Program joined forces with the Orchestra Academy of the Bayerisches Staatsorchester and specialists from the Immersive Audio Network IAN to record cello works by Peter

Tchaikovsky and Friedrich Gulda at Siemens AG's Munich headquarters and the Bruno-Walter-Saal of the Bavarian State Opera, and produce these in a number of "Immersive-Sound-Formats".
The 3D production is the first joint artistic project involving young scholarship students of the Orchestra Academy. The recordings made in collaboration with the Immersive Audio Network IAN resulted in both an audio-CD and a Pure Audio Blu-ray with two immersive audio formats and high-resolution stereo sound.

- The recording was produced at the IAN Studios in Munich, in the following formats:
- **CD:** 2.0 PCM Stereo 44.1 kHz/16 bit
- **Pure Audio Blu-ray**:
- 11.1 Auro 3-D 96 kHz/24 bit (immersive)
- Dolby Atmos (immersive)
- 2.0 Stereo High-Resolution (96 kHz/24 bit)

To take things a stage further, the 3D-audio recordings were linked with an Augmented Reality application. A virtual avatar orchestra plays Friedrich Gulda's concerto in 3D-sound. Viewers can themselves choose where to view and listen to the performance, while moving among the musicians' "digital twins", using a touchpad.

A music video clip has also been produced featuring the "Overture" (1st movement) from Gulda's cello concerto, in which Siemens has placed the Orchestra Academy's musicians within an artistic context at the company's headquarters premises. The video is presented in the form of a bonus track on the Blu-ray release.

2 The Technical Background

What is 3D-immersive audio?
3D/immersive audio formats are not in themselves new: however, they are only very rarely used in an everyday music context since they place high demands on hardware and software. With immersive audio formats, it is no longer necessary for the music to be split between fixed, discrete chan-

nels, but instead it can be reproduced as an integrated whole in individually defined sound sources within the space. Here, the sound is no longer reliant on stereo acoustic sources within the customary environment on our right and left, but can be perceived in its entirety as a natural aural experience above and below us within the room too.

What is the difference between 3D-audio and conventional surround-sound?

With the 3D immersive sound, the X and Y axes – familiar from so-called surround sound – are joined by a third dimension: the Z level. Your hearing turns into a true 3D experience, similar to what you hear in nature: hence, the technology used in the Siemens auditorium can enable the positioning of any number of sounds anywhere in the room.

Each sound object has its own volume, as well as a stable room position which can be changed dynamically. It is for this reason that it is also referred to as "object-based listening". The listener is right in the middle of the musical happenings. You experience the spatial quality of the sounds up close; you can move freely between them and discover the sound space independently – as if you are sitting in the middle of the orchestra or in a seat of your choice in the concert hall.

What equipment is required to play 3D-recordings?

- There are many systems on the market which support immersive audio in Dolby Atmos or Auro 3D.
- An AV-receiver system with a multichannel loudspeaker setup capable of reproducing immersive 3-D sound offers the best acoustic experience.
- In addition, a whole series of manufacturers are now offering soundbars suitable for the purpose. Even some modern TV sets feature integrated loudspeakers for immersive audio reproduction.

The technology in the Siemens Auditorium
Siemens Real Estate has fitted out the auditorium of the new Siemens Headquarters in Munich with the latest audio playback technology able to reproduce this 3D sound. This audio system is based on a technical solution devised by the Fraunhofer Institute for Digital Media Technology (IDMT) for which the Siemens Arts Program, working with the Immersive Audio Network (IAN), created high-resolution immersive content in its own building.

3 The Pieces Recorded on CD and Blu-ray

The session offered the young scholarship students of the Orchestra Academy of the Bayerisches Staatsorchester the opportunity to make a recording, under exceptional production conditions, that unites chamber music and a concert-style repertoire with innovative audio technology. The 3D-sound album "Cellokonzerte" was issued in May 2018 as a Pure Audio Blu-ray recording and CD on the Hänssler Classic label.

The following works were recorded on CD and Blu-ray:

Peter Tchaikovsky (1840–1893)

- Tchaikovsky's **Variations on a Rococo Theme, Op. 33**, originally written for violoncello and orchestra, was reinterpreted for the recordings with the rare instrumentation featuring cello and wind quintet, and recorded for probably only the second time using this orchestration. The recording was arranged by cellist David Stromberg. The work consists of seven variations on a theme, preceded by a brief introduction (Moderato quasi andante). The theme (Moderato semplice) is carried by the solo instrument and features an unpretentiously cantabile, but appealing melody.
- Tchaikovsky's **Andante Cantabile** from the String Quartet No. 1, Op. 11, No. 2. The chamber music-like movement is taken from a Ukrainian folk song ("Vanya sat on the divan"). The arrangement for solo violoncello and string trio is the work of cellist David Geringas.

Friedrich Gulda (1930–2000)

- Gulda's **Concerto for Cello and Wind Orchestra** in five movements was recorded with an unusual combination of instruments: alongside the cello and wind orchestra the instrumentation also features guitar, double bass and bass guitar, plus percussion. The concerto was premiered to great acclaim in 1981, and was recorded on vinyl in the same year with cellist Heinrich Schiff and the Vienna Wind Ensemble, conducted by Gulda himself.
- The introductory overture featuring rock- and funk-style jazz elements is followed by the second movement (Idyll), evoking Austrian Alpine music. The third movement (Cadenza, cello solo) offers the solo cellist two opportunities to improvise, and leads *quasi attacca* into the fourth movement (Minuet), which is reminiscent of a medieval dance. The jazz-rock inflected closing movement (Finale alla marcia) sees Gulda refer back to the opening movement, leaving the listener with idiosyncratic associations to the traditional wind music of his Austrian homeland, studded with jazz-style interludes that are marked by a bass-ostinato, drum passages and raucous interjections from the brass section.

4 The Artistic Concept

The Siemens Arts Program believes that the magnificent works of the traditional music repertoire must be carried along within and alongside the contemporary events which they themselves regularly outlive. This encompasses not only the development of new instruments, musico-historical discoveries, different modes of interpretation, but also new technologies.

Accordingly, the Siemens Arts Program, under the leadership of its artistic director Stephan Frucht, has set itself the task of bringing unusual repertoires, new forms of instrumentation and cutting-edge technologies together into a project. With the present recording and the different forms of presentation, an artistic creation far removed from the well-trodden paths of the classical music business has here developed in collaboration with Jakob Spahn and the Orchestra Academy of the Bayerisches Staatsorche-

ster. The recording that emerged from these endeavors can here offer an experience of undreamed-of quality compared with an Mp3/Mp4 version. Where music reproduced from Mp3/Mp4 recordings is effectively reduced to its basic component parts due to the extreme compression of the source data, it is entirely possible that immersive 3D-sound gives music back its "soul".

Gleisdreieck Online – An Interactive WebGIS System for Exploring Berlin's Industrial Heritage

Jens-Martin Loebel
bitGilde IT Solutions UG (haftungsbeschränkt)
13127 Berlin
loebel@bitgilde.de

Nico Kupfer
Berlin Center for Industrial Heritage (bzi)
12459 Berlin
kupfer@industriekultur.berlin

Abstract

Egon Erwin Kisch once described the areas of the Anhalter and Potsdamer train stations around the Gleisdreieck as a "sea of railway tracks". Based on georeferenced data and six years of research work, it is now possible for everyone to trace the development of the area from the beginning of the 19th century to the present day online. Developed by industrial partner bitGilde IT Solutions UG in collaboration with the Foundation of the German Museum of Technology and the Berlin Center for Industrial Heritage (Berliner Zentrum Industriekultur), we created a location-aware, context-sensitive, interactive browser-based WebGIS application which allows for the virtual reconstruction of the Gleisdreieck area and provides support for digital storytelling in the form of guided tours. The application not only presents the compiled geodata, but also provides an overview of the development of the area by means of interactive queries and provides information on individual historic settlements and objects. Therefore, the WebGIS application allows for dynamic queries for specific criteria. Results are displayed in real-time, as over 7.000 WebGIS features are rendered dynamically and projected across multiple scale-accurate maps.

1 Project Background

Industrial buildings and other remnants of the industrial age shape the character of Berlin's cityscape. In fact, Berlin's rise to become a metropolis was determined by industrial progress and the implementation of innovative technologies. Around 1900, Berlin was the largest industrial city on the European continent. Its economic, technical and architectural innovative capacity set global standards and high-tech products "Made in Berlin" for example from Siemens or AEG conquered the world market. However, this part of Berlin's history was overshadowed by historical events in the course of the 20th century and the subsequent decline of the industry. Today Berlin is perhaps better known as the formerly divided city and a focal point of the Cold War, but not for its rich and important industrial past, which can be found all over the city.

The Berlin Center for Industrial Heritage (bzi), a joint project of the University of Applied Sciences HTW Berlin and the Foundation of the German Museum of Technology, was established in 2011 to unveil this essential part of Berlin's history and rise an awareness in the broad public for its industrial heritage and the potentials that lie within it for the future development of the city. In cooperation with Berlin's Senate Departments and private and public initiatives, bzi elaborates concepts and strategies, networks the sites and stakeholders both internally and externally, organizes public events and does basic scientific research. It takes an unusual approach to the concept of tourism and employs the new media.

As part of the scientific research of the bzi, an industrial archaeological research project on the history and development of the area around the elevated railway station Gleisdreieck began in mid-2012. Today also the home of the German Museum of Technology, the development of the area dates back to the beginnings of the Industrial Revolution in Prussia.

1.1 Location

The area around Gleisdreieck is part of the Kreuzberg district at the boundary of Schöneberg and comprises the former Anhalter and Potsdamer Bahnhof as well as their surrounding areas. Located on an artificial plateau, this former railroad site, which has now been converted into a series of parks, is bordered to the east by Möckernstraße and to the west by

Flottwellstraße. Today part of the city center, the area was just outside the city wall at the opening of the first railroad in Prussia in 1838, the Berlin-Potsdamer-Eisenbahngesellschaft. Three years later, the Berlin-Anhaltische Eisenbahngesellschaft opened its Berlin terminus, the Anhalter Bahnhof, just nearby. From that time on, all subsequent building and development in that area was substantially influenced by the development of the railroads and the expansion of the stations to the south. Even the Hobrecht land-use plan for Berlin from 1862 had to take this development into account and be revised accordingly. Between 1869 and 1880, the two stations where totally rebuilt und enlarged to accomplish the increasing traffic demand. The Potsdamer Bahnhof became afterwards more important for regional connections, whereas the Anhalter Bahnhof developed into one of Berlins greatest and most bustling railroad stations with connection as far as southern Italy. Because of its destinations and the famous architecture of the new station building from Franz Schwechten, the Anhalter Bahnhof also became known by the Berlin residents as “gate to the south”.

Fig. 1: The new Anhalter Bahnhof by Franz Schwechten, completed in 1880. Photo: Museum of Architecture TU Berlin, Inv. No. BZ-F 08,016.

In addition to the railroads, there were other important parties in terms of industrial history. Werner Siemens opened his first backyard factory in

1847 right behind to the Anhalter Bahnhof. Also Orenstein & Koppel, later an internationally active mechanical engineering group, started their business next to the Anhalter Bahnhof. Their first production facilities were later replaced by new representative company headquarters, which still exist today, albeit with new uses. After the nationalization of the railroad companies, the newly formed Eisenbahndirektion Berlin established its new headquarter opposite the Schöneberg harbour, right between the two railway stations. Around 1900, two great cold storages with an ice factory were built for the Gesellschaft für Markt- und Kühlhallen, which was founded by Carl Linde. At the same time the eponymous Gleisdreieck was erected and served as central junction for the first elevated railway lines.

Fig. 2: Crossing of 5 different traffic levels at the Landwehr Canal right behind the Gleisdreieck. Photo: SDTB, Historical Archive, Sig. III.11 010222.

In the 1920s, Egon Erwin Kisch described the whole area as a "sea of tracks" [Kisc12]. The writer and journalist Joseph Roth even dedicated a special essay to the area with the title *Bekenntnis zum Gleisdreieck* (Commitment to the Gleisdreieck). For him it serves as an allegory for a thoroughly industrialized metropolis as he writes: "It's the center. All vital energies of the surrounding area have their origin and mouth here at the same time. […] This is the heart of a world that spins around its axis a thousand times faster than the change between day and night wants to

teach us." [Roth12] His essay ends with the words: "Shy and dusty, the future grasses will bloom between metal railroad ties. The landscape gets an iron mask." [Roth12; p. 290] But only about 20 years later, this prediction proved to be a fleeting one.
After the Second World War and the subsequent division of Germany, the two stations were cut off from the railroad network. Having lost its function, the area fell into disrepair, becoming a wild and weedy biotope in the process. The establishment of the German Museum of Technology in the 1980's marked a turning point in the development as well as in the perception of the area. With the creation of the Park at Gleisdreieck until 2014 the area finally changed its character from a restricted to a public recreation area for the surrounding neighborhood.

2 Industrial Archaeological Research

The aim of the research project was to examine and comprehend the development history of the area, particularly in the context of technical, economic and urban development interdependencies. This also included the identification of important institutions and facilities on the site over the past 180 years, as well as the mapping of any architectural or structural remains.
The main source for the research was an inventory of 50 volumes of building documents, which are preserved in the archive of the German Museum of Technology. These documents cover at least large parts of the 120-hectare area, particularly between the years (1841)/1869 and 1920. Further sources such as documents, plans and photos were found in the Berlin State Archives and in other institutions.
Due to the size of the area, the sheer number of individual structures, and the sources, which only documented certain parts of the area at certain times, – like in a three-dimensional mosaic – it was decided to use a geographic information system as a research tool. This made it possible to combine the sources and to manage the large amount of information.
The data basis was formed by scanned and georeferenced historical site plans. After digitization, the polygons and lines were provided with additional information, including their type, use, origin, time of existence, and

a reference to the source of each piece of information. In the first place, the dating of the historical plans and the designations they contained were used to date and classify the individual structures. In the next step, this database was supplemented and differentiated by the evaluation of additional sources such as building documents and historical photos. This procedure also made it possible to compare different sources with each other, sometimes to date them more precisely or to identify flaws in the historical maps. In this way, a database was created which reconstructs and visualizes the development of the area from 1838 to the present in annual steps.

3 Gleisdreieck Online – An Interactive WebGIS Application

Naturally, the next step was to make this vast amount of data available to the public in a meaningful way and to encourage discourse. Teaming up with industry partner bitGilde IT Solutions UG, we set out to transfer and visualize the research data on the web by creating a web-based geographic information system (GIS) for use by the general public.

Due to the spatial extent of the study area, which covers around 100 ha, the researchers at the German Museum of Technology used Quantum-GIS as a research tool, which stores the geodata in so called Shape files databases. In this, both the still existing and the past buildings and facilities on the site were recorded in their geographical position and spatial extent and enriched with further information and attributes (see section 2). Split into three separate databases for polygons (containing mainly buildings, technical equipment and land data), lines (containing former and current track and route guides), and points of interest (with additional metadata), we first had to transform and reduce the dataset to a web manageable form. For our use-case the open standard GeoJSON was the obvious choice, allowing for wide usage of the data and supporting many tools and platforms.

Our goal was to develop a web-based GIS app, which not only presents the geodata but also provides an overview of the development of the area and provides information on individual historic residents and objects through

interactive queries on the part of the user. Therefore, the WebGIS application allows for dynamic queries for specific criteria. Results are displayed in real-time, as over 7.000 WebGIS features are rendered dynamically and projected across multiple scale-accurate maps. The target audience includes scientists and interested lay people (hobby researchers), people interested in industrial culture and history, and visitors to the German Museum of Technology and the surrounding Park at the Gleisdreieck.
We implemented the app in a responsive design (using CSS3 and HTML5) to be usable both at home on a laptop or desktop computer and on-site on mobile devices. It also had to work on all current browser platforms. We wanted to use only open source software to ensure broad reusability and free use of the final app.
To satisfy the target audience criteria, the app had to have a simple and intuitive interactive user control and hide the complexity of the underlying data queries. Lastly, to ensure sustainable administration and accessibility beyond the project's lifetime, we build the app as individually connected modules to facilitate adding new features later on and keeping individual parts maintainable.

3.1 Building Process – Platform and Tools Used

When looking at the above requirements, it became clear that we needed a widely-used open and free infrastructure to host the planned system. For this we choose Wordpress[1] as the content management platform because of its large user base, good standing in the open source community, continued development, and modular plugin and theming architecture. Wordpress supports custom taxonomies and post types, both of which are necessary to implement media-enriched points of interests (from the research data) as well as guided tours to be curated by the German Museum of Technology.
The system was therefore implemented as a modular plugin and responsive theme using Wordpress as a backend. The easy to use backend for administrators had the further advantage of a short learning curve and ease of updatability for the curators at German Museum of Technology. As a "living" research project, new information and research results are regularly being added and updated long after the initial import. Additi-

1 See https://wordpress.org.

onal Wordpress provided basic functionality for user feedback, which we utilized and build upon for the citizen science aspect of the project.
Our import toolchain uses the open source software MapShaper[2] to convert the research Shape files to GeoJSON and strip unnecessary data. After that, the data is imported into Wordpress tables. The import is available via the backend and is capable of handling incremental updates of research data. For this we use the original Shape database IDs to correlate records.
The WebGIS client itself was implemented using JavaScript with the help of JQuery and Bootstrap frameworks. In addition we choose the Leaflet[3] framework as it supports GeoJSON and provides basic map displaying and layering capabilities as well as SVG (Scalable Vector Graphics) support, which we will use to graphically render the research data.
With these basic tools and frameworks we set out to recreate the complex GIS functionality and query capability in a browser client. Using Leaflet's map projection capabilities we first implemented user-switchable background maps. Users of the system can choose to see the area without any background map, with OpenStreetMap, or with historic areal photography provided by the Berliner Senatsverwaltung für Stadtentwicklung as a background layer. The research data and polygons are rendered using SVG and areas of interest are displayed using Leaflet markers. Both are dynamically loaded via requests to the backend plugin's JSON API as the user requests them and/or clicks on a marker.
Next, we tackled the problem of conveying time information of structures and tracks to the user. For this, we used an always-accessible timeline at the bottom of the map analog to timelines used in online movie players. Users can see the state of the Gleisdreieck area in any giving year by simply clicking on a point in the timeline or moving its year slider. Additionally a specific date can be entered. Any year or query change dynamically loads, displays and arranges about 7.000 polygons of research data. Using our JSON API, server-side compression as well as custom-made client side caching mechanism, this happens in near real-time providing a seamless experience for the user. The user can decide to highlight structures where research data is incomplete concerning time information (e.g. unsure dates of when a structure was built and/or torn down).

2 See https://mapshaper.org.
3 See https://leafletjs.com.

Areas of interest are also dynamically displayed depending on the date and zoom level of the map. We choose to filter the data using four scales: a large scale range (e.g. zoomed out view showing the entire area), a medium scale range (e.g. the user has zoomed in to a train operating factory), and a small scale range (e.g. zooming into details of a specific building complex). The fourth scale called "universal" encompasses all zoom levels and provides additional info on objects outside the narrow research area (e.g. the former headquarters of Siemens).

To support user queries to the research data, we employed a graphical system that lets users filter research data in multiple ways by structure/building usage, area usage, date, and structure function. The JSON API is used to filter the research data in the background using the relevant database fields and highlight structures visually. The complex nature of the queries is hidden to the user allowing for easy use of the system. Additionally, full text search of all database fields is supported using Solr. A click on the result transports the user to relevant area and year.

To enable on-site usage, we utilized the HTML5 geolocation API and capabilities of modern browsers. Lastly, we implemented guided tours, which combine curated information and media with a specific location, date and background map. This information is also encoded in the browsers URL allowing users to share specific areas and times of the Gleisdreieck area with others and bookmark them.

3.2 Pitfalls

After much optimization we were able to display over 7.000 GeoJSON features in near real-time on all current browser platforms except Mozilla Firefox. After performing further speed tests we discovered that Firefox`s implementation of SVG XML and DOM tree manipulation is significantly slower and lacking behind other common browser engines like Webkit (used in Google Chrome, Apple Safari, and others) or Microsoft Internet Explorer and Edge browsers. This issue has been well documented over the years and is still filed as an open bug/improvement on Mozilla's forums.

To mitigate this, we implemented browser checks in our app. If Firefox is detected, we disable display of tracks and other resource-consuming SVG structures, while the user is panning the map or manipulating the timeline.

With these tweaks we were able to bring Firefox almost up to speed with other browsers with little or no impact on the user's experience.
We also learned that there is no support for many of the visual styles (e.g. for train tracks) used by professional GIS software in Leaflet or other freely available JavaScript libraries. We therefore had to re-create patterns and styles for map features and legends using SVG patterns and CSS animations/styles.
Additionally the geolocation API and capabilities of all modern browsers are disabled over normal web connections for security reasons. Therefore, the whole Wordpress system and JSON API had to be hosted on an encrypted HTTPS connection. As this is good security practice we enabled HTTPS support site-wide.

3.3 Collecting User Feedback

To support the citizen science/crowd-sourcing aspect of the research project we tapped into the Wordpress comment functionality and transferred it to the Leaflet map. Users are able to click on a specific map point, year, and map data and provide feedback/additional information using a simple form. The results are stored as comments in the Wordpress backend and the users are notified of their submission. SPAM filtering of comments is performed. This allows the researches to incorporate historical information provided by hobby scientists and contemporary witnesses.

3.4 Delivering the App

In addition to the graphical representation of the objects and structures in the area around the Gleisdreieck, the objects are also linked via areas of interest (called "info points") with further information in the form of a short textual description, photos and links. It is also possible to tap into the history of the development of the area via a virtual guided tour.
The user can query the dataset, switch maps, perform full text searches, and optionally highlight uncertainties in the researched historical dates, all from a retractable sidebar (see Figure 3) which also conveys a dynamically changing map legend depending on the query. This allows for an easy access to the complex functionality. In addition, "locate me" and "provide feedback" buttons are always accessible to the user when panning and zooming the map or exploring different times. The user may also start or

interrupt a guided tour at any time. This option, along with an introductory note, is also displayed when the user first opens the site, providing a tutorial and introduction to the system.

Fig. 3: The Gleisdreick app with query/functions sidebar, points of interest and timeline.

Using GPS, users on mobile devices can project their location onto the historical Gleisdreieck data and view the virtually reconstructed area on the map for any given year.

4 Conclusions and Continued Development

The aim of the interactive online WebGIS application "Industrial heritage at the Gleisdreieck" is primarily to make the industrial heritage research results, compiled by Berlin Center for Industrial Heritage, available to the public. Due to the historical importance of the area, this project has the potential to gain national importance. We were able to implement a complex WebGIS and database query system that runs in current browsers and make this important research data available to the general public. The museum curators can continuously incorporate further research results.

New features including more user query capabilities are planned for this year and the system is further developed and continually maintained by industry partner bitGilde IT Solutions UG.

The system is available free of charge via:
https://www.gleisdreieck.industriekultur.berlin.

Literature

[Kisc12] Kisch, Egon Erwin: Die Untergrundbahn. In: Engeler, Jürgen [ed.]: Berlin literarisch, Berlin 2012, pp. 290–294. Quote: p. 292. Dated: 1923

[Roth12] Roth, Joseph: Bekenntnis zum Gleisdreieck. In: Engeler, Jürgen [ed.]: Berlin literarisch, Berlin 2012, pp. 286–290. Quote: p. 286ff. Dated: 1924.

MauAR – Berlin Wall in AR

Peter Kolski, Markus Abel
MauAR
info@MauAR.berlin

Abstract

With the further rise and development of AR technologies, impactful applications are getting more in the focus of the creators. We present an approach and realisation which we believe to give the user an excellent showcase of how AR can be used purposefully and with an optimal use of state of the art technologies. The objective is showing the Berlin Wall in its historical context and furthermore waking emotions of how it must have felt living in a divided city at that time.

Knowing about best usage of AR which covers providing additional information to the surrounding, game-like addition of fantasy elements as well as storytelling, we focus at the latter to fulfil our goals of emotional involvement. In the scope of the Berlin Wall, the base story is already set by the real history. This is intended with our visual and auditive storytelling which will be intensifying experiences on location. To achieve this we make use of several technologies and self tailored algorithms. First to be named is ARKit for AR tracking. The binding to a mobile platform which has a wide coverage of AR accessibility expands AR to a larger audience. Secondly the GPS supported positioning of the Berlin Wall in AR, to be independent of location bound markers. This increases the flexibility and spatial extend of where to use the MauAR experience. As our target audience is broad as possible and covers also users with few experience in newest technologies, we go for a rich guided and visually appealing user interface and user experience. To achieve this, the whole app is developed natively in Swift for iOS.

This also required the usage of native Scenekit integration for the AR rendering. Going beyond a plain exhibition of the Berlin Wall towards storytelling is achieved by usage of multi-media – namely audio, video, photos and animated 3D models. To sustain world class quality in these fields our team consist of experienced music creators, visual artists, a director, filmmakers, actors, 3D artists, UX/UI designers and high-end programmers. So the basis is expertise in each of the distinct media field – the new challenge is to combine each into a new approach of storytelling which fits the new medium of Augmented Reality on a mobile device.

During the timespan of development we received lots of appreciation by winning the price "Most Technical Application" in the Coding Da Vinci Hackathon in 2017. Media attention span from news papers (Berliner Zeitung, Zeit, FAZ etc.) to radio, youTube channels to TV. And also high interest by the world wide largest players in the field of augmented reality, with a one to one showcase of the app to Tim Cook, CEO of Apple. This shows a real demand of the current approach as it opens the opportunity to truly immerse into the desired topic. Especially taking into account that 2019 is the 30th anniversary in the wall being teared down.

We conclude this application to be of historic importance as well as current cultural and political relevance.

Arrested Space

Virtual Reality as Representation of Expressionism Concepts of the Visual World

Slawomir Nikiel
Faculty of Economics and Management
University of Zielona Góra
ul. Podgórna 50, 65-246 Zielona Góra, Poland
S.Nikiel@wez.uz.zgora.pl

Abstract

Proliferation of Virtual Reality continues at an amazing pace. The incorporation of VR technology into the palette of new digital media is appealing not only to game designers, but is also obvious to artists, documentarians, journalists, educators and scientists – the professions involved in creating or explaining the reality. Generally the synthetic or cinematic quality environment of the Virtual Reality is created in order to give the impression of "presence" in the three-dimensional sensory space, however the experiential phenomenon of immersion is very closely related to the stimuli of sight, hearing and touch. To create virtual experience in a highly captivating way, we should balance three crucial elements: cutting-edge technological solutions, psychological/sensual evaluation of the viewer (perception of presence) and the narratives. Moreover Virtual Reality is a medium of (three dimensional) space, contrasting with classic 'framed' image typical to cinema and games therefore it needs new visual language and tools. Some solutions seem to be ready available when we refer to the vivid epoque of the early 20th century. The article presents the problem of constructing the 'virtual space' defined as an emotional experience based on concepts of space typical to Expressionism artwork. The aim is to trigger a discussion on the impact of century old art ideas on Virtual Reality.

1 Concepts of Space

1.1 Space in Art – Expressionism

According to Gombrich, early 20th century artists took the revolt against the illusion of the linear perspective and realism of the peep-hole/ lens pictures. Cubism was one of the most radical attempts to redefine our perception of flat pictures. While using all elements of perspective shading, shadows and texture cubist artists did not place it in harmony but in attempt to evoke contradictory evidences of perceived space. [Gomb99]. Expressionists, on the other hand tried to present the surrounding world from a highly subjective perspective, distorting it radically for highly emotional effect in order to evoke strong moods or ideas [Bald08]. by modern experience they strived to have their works evoke all kinds of experiential sensations – not only those visible to the spectator's eye. The Expressionists brought to the viewer sensations of the hassle, paranoia, fear and even the smell of the metropolis.

The most remarkable examples include German Expressionism. The works of Ernst Ludwig Kirchner, Hermann Warm clearly illustrate the stylistic techniques and distorted visual qualities exploring themes of paranoia, fear and schizophrenia (Figure 1).

Fig. 1: Nollendorfplatz (Kirchner 1912) and
The Cabinet of Dr. Caligari (Warn 1920)

1.2 Proxemics and VR

Space is the ontology for three dimensions, taxonomy and linguistics that organize it. The American researcher Edward T. Hall conducted research on how we behave in various socially and culturally defined spaces [HaPe96]. Proxemics defines the invisible personal space of a man whose reach is shaped by a culture specific to a given person. It determines not only distances, but also the boundaries that divide us from others (intimate, personal, social, public). For example, Jandt specifies the dimensions and method of interpersonal communication in these spaces [Jand07].

Space category	Distance	Description	Sound volume
Intimate	up to 45 cm	highly emotional experiences incorporating touch and body contact	whisper
Personal	from 45 cm to 1,2 m	distance of a handshake	silent
Social	from 1,2 m to 3,6 m	customer and seller relations, co-workers	loud
Public	more than 3,6 m	teacher/speaker in the classroom, concerts	very loud/ amplified

Table 1: Distances in interpersonal relations.

Similar concepts can be applied to Virtual Reality. According to Slater and Wilbur we can be immersed within the VR to the extent that displays are capable of delivering an extensive, surrounding and vivid illusion of reality to our senses [SlWi97]. The more we forget about the medium delivering stimuli, the more immersed in this environment we are. Then, we experience a high feeling of presence when we have a more vivid memory "as if we were there". The limitations of currently available virtual environments interfaces mean that VR primarily uses the public and, exceptionally, social space of contacts defined by Jandt. The question is whether we can explore other forms of space perception, e.g. the private emotional experience of space as defined by the Expressionism.

2 Implementations

2.1 Space in VR

Virtual Reality perfectly fits claims of the 20th century artists. The spectator is isolated and under full control of the medium. Rather simple manipulation of light and parallax allow to explore our fear of heights (https://www.crytek.com/news/cryteks-the-climb-coming-to-oculus-quest). Horror and nightmares of cursed dungeons (http://www.dreadhalls.com/) are the effect of suggestive narratives. Is it possible to explore other visual means, then? A good example of new means of expression offered by Virtual Reality in the field of telling stories is the "Sightline: the Chair" – computer generated experience created by the Czech programmer Tomas Mariancik. (https://store.steampowered.com/app/412360/SightLineVR/).

In the case of a room, each time the viewer looks at one of the walls, it is closer than when he was looking at it earlier. After some time, the walls around the participant are so close that they can see the structure of each brick. At this moment the viewer literally feels physically compressed, he almost feels it with all his body, although of course there is no tactile stimulus. The space is shrinked but the images are not distorted.

Another way is to explore 360 images and virtual collages, where techniques similar to rotoscoping offer manipulation of perceived space (Figures 2, 3 and 4).

Fig. 2: The 360° collage (inspired by 'The Agglomerato' by Giacomo Costa)

Fig. 3: Slanted buildings by the sea

Fig. 4: Potsdamer Platz

2.2 Discussion

Our vision combines two different images into one recognizable space. Leonardo da Vinci suggested the painter to use mirrors to keep up the accuracy of the image, however he was aware that no painting could look like mirrored image [Rich39]. The painter's role was to reflect the effect of image cameras introduced centuries later. The mirror provided a glimpse of projection on a plane, with static eye position it made possible to retrieve the effect of perspective. Building sizes recedes with the distance and parallel lines converge to infinity points (lying on the optical-observation axis). When compared with 'constancies' like "buildings are big"

and "humans are smaller than buildings" it was shocking to observe that on the image humans can be bigger than buildings and buildings themselves were just a small patches on a canvas. The main cause in difficulty of that experience lied in fact that perceived distant objects appear to us larger than their apparent (optically correct) size. This suggests that our visual experience is prone to illusion and sometimes rejects the 'objective' image. The same holds for the moving camera, 'image patches' of the buildings change their sizes but the view/perception of them remains stable. The same holds for perception of VR environments, 360° mono panoramas are nothing else but image spheres with canvas placed, thanks to lenses in VR headsets, in a distance of approx. 3.5 meters. How do we know than, that what we see is a distant building or a small model or even a painted patch on the image canvas? According to Gombrich we just guess, assigning meaning (size and distance) to the observed image. The 'constancies' help us with that process and any alteration of that process opens path to different alternative interpretation of what is seen. Apparent size is dependent on the arbitrary assignment of distance [Gomb82]. When the image is a collage of 'building patches' (see Fig. 2) we assess their distance based on local features, so the upper side of image represents 'closer' walls than those ahead of us. The result is a dense 'claustrophobic' effect typical to the Expressionist imagery. Similar effect can be obtained with 'slanted' buildings and walls. Figure 3 represents the composite scenery that induces the feeling of "falling to the sea" high-rise buildings. Three images with different orientation of cameras were composed into one that induces 'uncertain space'. Figure 4 combines different perspectives of cityscape, inducing similar effect of 'brain adaptation' to changed views, at first sight we see rotated image but after a few seconds we adapt to the scene and see it as normal till the moment we change the view angle and spot contradictory perspective. The effect is caused by the fact that our field of clear vision is very limited and looking up, looking down and looking sideways, different vistas come into view. Our brain combines all views into one "as much consistent as possible" world [Pire70]. Taking this into account we may start experimentation with different visual effects.

3 Concluding Remarks

No other medium than Virtual Reality can so vividly encapsulate you in the space where you cannot estimate the distance and the world around you is so close that you can almost touch it and cannot escape it without breaking the whole experience. Already existing modern techniques of visualisation, such as 360° and VR can be used to develop upon century old artistic concepts which, combined with the new technology, will result in new vivid experiences.

Literature

[Bald08] Baldick, C.: Concise Oxford Dictionary od Literary Terms, entry for Expressionism, Oxford University Press, 2008.

[Gomb82] Gombrich, E.H.: The image and the eye, further studies in the psychology of pictorial representation, Phaidon Press, London 1982

[Gomb99] Gombrich, E.H.: Art and Illusion, Phaidon Press Ltd, 1999.

[HaPe96] Hall, E.T., Pellow, D.: Setting boundaries: The anthropology of spatial and social organization, Greenwood International, 1996.

[Jand07] Jandt, F.J.: Intercultural communication, Sage Publications Inc. 2007

[Pire70] Pirenne M.: Optics, Painting and Photography, Cambridge 1970

[Rich39] Richter, J.P.: The literary works of Leonardo da Vinci, Oxford, 1939

[SlWi97] Slater, M., Wilbur, S.: A Framework for Immersive Virtual Environments (FIVE): Speculations on the Role of Presence in Virtual Environments, "Presence: Teleoperators and Virtual Environments" 1997, 6(6), pp. 603–616.

Managing Large Sets of Multidisciplinary Research Data Using 3D Models of Cultural Heritage Objects and Augmented Reality

Case Study of King's Chinese Cabinet in Wilanów

Piotr Siekański[1], Eryk Bunsch[2], Anna Guzowska[2], Robert Sitnik[1]

[1] Warsaw University of Technology
Faculty of Mechatronics
ul. św. Andrzeja Boboli 8 · 02-525 Warsaw, Poland
{p.siekanski, r.sitnik}@mchtr.pw.edu.pl

[2] Museum of King Jan III's Palace at Wilanów
ul. Stanislawa Kostki Potockiego 10/16 · 02-958 Warsaw, Poland
{ebunsch, aguzowska}@muzeum-wilanow.pl

Abstract

King's Chinese Cabinet in the Museum of King Jan III's Palace at Wilanów, Warsaw, Poland is an unique example of interior decorative art. Since the beginning of XXI century, multiple examination have been made in this interior resulting in dozens of different data samples. Orientation in spatial relations between these results is a challenge even for restorers permanently involved in the implementation of long-term conservation projects and constitutes a complete cognitive barrier for people interested in reinterpreting only a narrow range of collected data. In this paper we present an AR application that visualizes the places where each data sample was collected and shows these results to the user. This approach can significantly shorten the time required to localize each data sample comparing to the manual data search among the paper documentation stored in the binders.

1 Introduction

The conservation of cultural heritage objects requires a lot of detailed research. To obtain the desired result, it is often necessary to synthesize many different research methods. On the other hand combining multiple methods require proper alignment between the data samples collected using each of them and efficient data management. Orientation in spatial relations between the results of hundreds of samples is a challenge even for restorers permanently involved in the implementation of long-term conservation projects and constitutes a complete cognitive barrier for people interested in reinterpreting only a narrow range of collected data. Hence the idea was developed that we can combine: three-dimensional models of the objects, the algorithm to estimate camera pose and the database with results of research into an Augmented Reality application. This application allows the restorers to work with a complex data that comes from a wide range of methods in an intuitive way.

We developed an AR application to allow the user to correlate the position of each data sample in the interior and to view them on the screen as he/she is walking in this interior. Firstly, the image is acquired and then the camera pose is computed relative to the 3D model. Then we employ estimated camera pose to render the markers indicating the samples (Fig. 1). And if the user decides to click the marker, the data inside this sample is shown (Fig. 2). Markers can be visualized directly over camera frame or on the rendered model. This approach can significantly shorten the time required to find each data sample comparing to the manual data search among the paper documentation stored in the binders.

Fig. 1: Developed AR application: (a) sample frame acquired by the camera; (b) rendered model with exemplary hotspots indicating samples

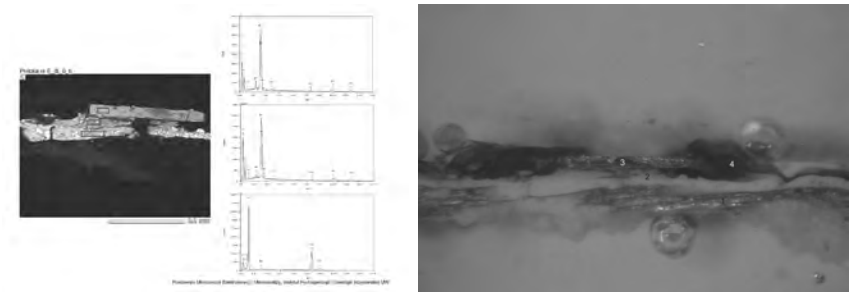


Fig. 2: Two examples of collected samples; (a) backscattered electron image of the sample; (b) microphotograph of the sample in reflected light

2 Related Work

The concept of using AR to visualize background information related to the particular object is not new. It has been widely used in medicine, e.g. in liver surgery [HWRR10] or in assembly industry [WBEG13, YuON08]. In the domain of Cultural Heritage this concept is also present. The works presented by Tillon et al. [TiMH11, TMLS10] reveal the huge potential in AR when used to aid the visitors discover the details of the paintings. Moreover, the ARrtifact application [VaSK12] developed by Vanoni et al. allow the users to visualize multimodal data on renascence fresco in Florence, Italy. The same concept is used by van Eck and Kolstee [EcKo12]. They allow the visitors to visualize the multimodal images of van Gogh's paintings. Another approach was presented by Ridel et al. [RiRL14], they proposed a projector-based AR to reveal the details of CH objects. We are not aware of any AR-based system designed to aid the restorers in navigation between hundreds of samples taken during complex conservation processes.

Regarding past works in King's Chinese Cabinet, this interior was scanned twice in 2009 [BuGS12] and 2015 [SBMZ16]. Based on this data the authors have developed the AR application [SiBS18] that visualizes the past state of the interior and camera tracking algorithm [SMBS18] as a base for this application and future research.

3 King's Chinese Cabinet

Object analyzed in this case study is a King's Chinese Cabinet in the Museum of King Jan III's Palace at Wilanów, Warsaw, Poland. This unique example of interior decorative art was made in XVIII century using a European lacquer technique. Polychromatic decoration painted on the wooden panels is attributed to the famous craftsman Martin Schnell and his workshop [KoKw05]. After leasing Wilanów to King Augustus II the Strong, artists from the court of Saxony were working on the new appearance of the royal apartments.

At the beginning of XXI century multiple examination of this interior have been made [ZGJL10]. To name a few, stratigraphic cross-sections of paint samples were analyzed with SEM-EDS technique. The results were combined with observations of pigments from particular painting layers in reflected and transmitted light, ultraviolet fluorescence microscopy and completed with additional microchemical tests. Identification of dyes was conducted by means of UV, VIS and FTIR absorption spectrometer and HPLC. For identification of binding media FTIR and GC/MS were used. Finally, it turned out that over the years the color of the cabinet decoration has changed significantly. Under green parts of wooden paneling that were certainly not original, blue- and pink-like colors were discovered. In the year 2009 a decision to remove secondary coatings had been made revealing the interior's original character.

In the same year three-dimensional documentation of the whole room decoration has been made (four walls and ceiling, about 90 m^2 with an accuracy of 100 points per mm^2) [BuGS12]. Then, in the years 2010–2012, complex conservation works were carried out. In 2015, the room with completely changed colors was re-scanned using structured light technique [SBMZ16] with the same accuracy as in the year 2009. Thanks to this approach, we have the precise 3D documentation of the interior before and after conservation. Thus we can collect all the results of research and place each of them in the place from which the sample was taken. It is vital because the examination of the Cabinet is still ongoing.

4 The Application

We developed an application to visualize the position of each data sample inside real interior. These samples can be placed on two different models of King's Chinese Cabinet – prior and after conservation and the model can be changed during runtime. To visualize the models we employ the free open-source WebGL-based point cloud renderer called Potree [Schü16] deployed as ElectronJS-based desktop application. The tracking component communicates with the renderer via a named-pipe. Due to the performance reasons camera-tracking algorithm developed previously [SMBS18] is written in C++ language. A data-flow diagram of the application is shown in Fig. 3.

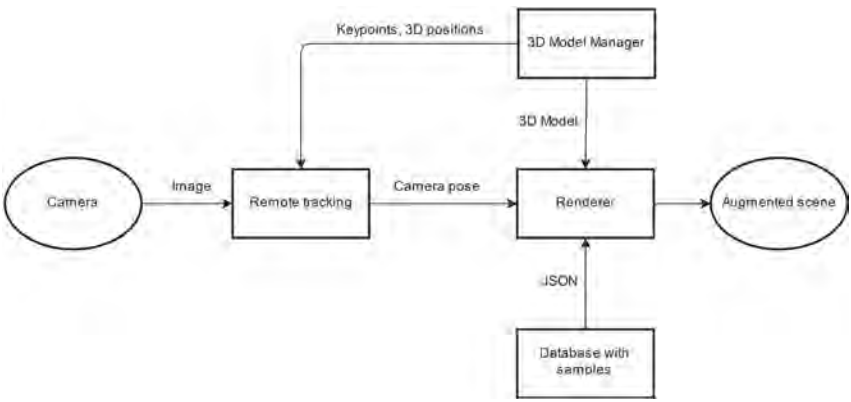


Fig. 3: A data-flow diagram of a developed application

4.1 Hardware

A Logitech B910 camera is attached to Lenovo Yoga convertible laptop via a 3D-printed mount. The laptop has Intel Core i5-5200U 2.2 GHz processor, Nvidia 840M graphics card, 1TB of SSD storage and 8 GB of RAM. This computer can handle both rendering of a massive point cloud (up to one billion of points) and tracking tasks. However, to ensure proper tracking performance we decided to separate these two tasks and run the tracking algorithm remotely on a dedicated desktop computer equipped with Intel Core i5-8400 2.80 GHz processor and Nvidia 1060 graphics card. With this setup we are able to achieve more that 40 fps what is

necessary to provide proper application responsiveness because the maximum framerate of the camera is equal to 30.

4.2 Tracking Algorithm

In an offline stage we first prepare the model of the King's Chinese Cabinet for tracking. We render 5 ortho images from the scanned model, one for each wall and one for the ceiling. Then from each rendered image we extract SIFT [Lowe04] descriptors on the GPU and save the corresponding 3D location of each keypoint. These correspondences between image points from ortho images and its 3D locations from the model allow us to determine the camera pose relative to the interior.

During exploration in the Cabinet, we analyze each frame taken by the Logitech B910 camera separately. We also extract SIFT keypoints from the frame using GPU and match their descriptors with those extracted from orthographic renders. We find two closest points in ortho images to each keypoint in the camera frame. Then we filter these matches using Lowe's ratio test [Lowe04]. We compare the ratio of the distances between first and second closest point in the descriptor space. If this ratio is lower than 0.8 (first match is much closer than the second one), we assume that the first match is the correct one. Otherwise, we threat this match as ambiguous and reject it. Because we know the corresponding 3D location of each keypoint in ortho images, we estimate camera pose using ePnP algorithm [LeMF08] based on correspondences between 3D model points and image points in current camera frame. As we estimate the camera pose from each frame separately the resulting camera trajectory is shaky and this results in unpleasant user experience. Therefore we apply a Gaussian filtration [SiBS18] method to eliminate jitter in camera trajectory. Filtered camera pose is then transferred to the renderer and the augmentation from the current camera view is rendered.

4.3 Visualization of the Samples

Each data sample is stored in a JSON file and has following properties: its 3D position relative to the model of the Cabinet, the type of a sample, the name of the sample and the path to the attached file. The samples are loaded from the database and the spheres representing the positions of the samples are displayed with the names of the samples attached to them.

The color of each sphere indicates its type (e.g., microphotograph, report, SEM-EDS). When the user taps the sphere on the touchscreen the attached file is opened in a separate window.

5 Conclusions and Future Works

We developed an AR application to aid the conservators navigate between dozens of data samples collected during many years of examination in King's Chinese Cabinet in Wilanów, Warsaw, Poland. Proposed application may significantly shorten the time needed to localize the sample compared to manual search in paper documentation stored in binders. Application may also be beneficial when introducing new person to the conservatory team of the Museum or to lower the cognitive barrier for people interested in reinterpreting only a narrow range of collected data.
We plan to further develop our application. Firstly, we plan to improve the tracking algorithm with IMU support to allow smoother and more stable tracking. Secondly, we plan to extend our solution to head-mounted displays that allow the conservators to have better immersion.

Literature

[BuGS12] Bunsch, Eryk; Guzowska, Anna; Sitnik, Robert: 3D scanning documentation of two different objects – The King's Chinese Cabinet in Wilanow Palace Museum and a Roman gravestone from archeological excavations in Moesia Inferior as a part of multidisciplinary research. In: Proceedings of the 2012 18th International Conference on Virtual Systems and Multimedia, VSMM 2012: Virtual Systems in the Information Society, 2012; ISBN 9781467325653, pp. 633–636

[EcKo12] van Eck, Wim; Kolstee, Yolande: The augmented painting: Playful interaction with multi-spectral images. In: 2012 IEEE International Symposium on Mixed and Augmented Reality – Arts, Media, and Humanities (ISMAR-AMH): IEEE, 2012; ISBN 978-1-4673-4665-8, pp. 65–69

[HWRR10] Hansen, Christian; Wieferich, Jan; Ritter, Felix; Rieder, Christian; Peitgen, Heinz-Otto: Illustrative visualization of 3D planning models for augmented reality in liver surgery. In:

International Journal of Computer Assisted Radiology and Surgery Bd. 5, Springer-Verlag (2010), Nr. 2, pp. 133–141

[KoKw05] Kopplin, Monika; Kwiatkowska, Anna: Chinois: Dresdener Lackkunst in Schloss Wilanów; [ein Forschungsbeitrag des Museums für Lackkunst Münster und des Muzeum Pałac w Wilanowie zum Deutsch-Polnischen Jahr 2005/2006: Museum für Lackkunst, 2005

[LeMF08] Lepetit, Vincent; Moreno-Noguer, Francesc; Fua, Pascal: EPnP: An Accurate O(n) Solution to the PnP Problem. In: International Journal of Computer Vision Bd. 81 (2008), Nr. 2, S. 155

[Lowe04] Lowe, David G: Distinctive image features from scale-invariant keypoints. In: International Journal of Computer Vision Bd. 60 (2004), Nr. 2, pp. 91–110; ISBN 1568811012

[RiRL14] Ridel, Brett; Reuter, Patrick; Laviole, Jérémy: The Revealing Flashlight: Interactive spatial augmented reality for detail exploration of cultural heritage artifacts. In: Journal on Computing and Cultural Heritage Bd. 7 (2014), Nr. 2, pp. 1–18; ISBN 1556-4673

[SBMZ16] Sitnik, Robert; Bunsch, Eryk; Maczkowski, Grzegorz; Załuski, Wojciech; Lech, Krzysztof; Michoński, Jakub; Krzesłowski, Jakub; Foryś, Piotr: Towards automated, high resolution 3D scanning of large surfaces for cultural heritage documentation. In: Electronic Imaging Bd. 2016 (2016), Nr. 21, pp. 1–7

[Schü16] Schütz, Markus: Potree: Rendering Large Point Clouds in Web Browsers, 2016

[SiBS18] Siekański, Piotr; Bunsch, Eryk; Sitnik, Robert: Seeing the past: An augmented reality application for visualization the previous state of cultural heritage locations. In: Electronic Imaging Bd. 2018 (2018), Nr. 3, pp. 4521–4524

[SMBS18] Siekański, Piotr; Michoński, Jakub; Bunsch, Eryk; Sitnik, Robert: CATCHA: Real-Time Camera Tracking Method for Augmented Reality Applications in Cultural Heritage Interiors. In: ISPRS International Journal of Geo-Information Bd. 7, Multidisciplinary Digital Publishing Institute (2018), Nr. 12, p. 479

[TiMH11] Tillon, Anne Bationo; Marchal, Isabelle; Houlier, Pascal: Mobile augmented reality in the museum: Can a lace-like technology take you closer to works of art? In: 2011 IEEE International Symposium on Mixed and Augmented Reality - Arts, Media, and Humanities : IEEE, 2011; ISBN 978-1-4673-0059-9, pp. 41–47

[TMLS10] Tillon, Anne Bationo; Marchand, Eric; Laneurit, Jean; Servant, Fabien; Marchal, Isabelle; Houlier, Pascal: A day at

the museum: An augmented fine-art exhibit. In: 2010 IEEE International Symposium on Mixed and Augmented Reality – Arts, Media, and Humanities: IEEE, 2010; ISBN 978-1-4244-9339-5, pp. 69–70

[VaSK12] Vanoni, David; Seracini, Maurizio; Kuester, Falko: ARtifact: Tablet-Based Augmented Reality for Interactive Analysis of Cultural Artifacts. In: 2012 IEEE International Symposium on Multimedia : IEEE, 2012; ISBN 978-1-4673-4370-1, pp. 44–49

[WBEG13] Webel, Sabine; Bockholt, Uli; Engelke, Timo; Gavish, Nirit; Olbrich, Manuel; Preusche, Carsten: An augmented reality training platform for assembly and maintenance skills. In: Robotics and Autonomous Systems Bd. 61, North-Holland (2013), Nr. 4, pp. 398–403

[YuON08] Yuan, M. L.; Ong, S. K.; Nee, A. Y. C.: Augmented reality for assembly guidance using a virtual interactive tool. In: International Journal of Production Research Bd. 46, Taylor & Francis Group (2008), Nr. 7, pp. 1745–1767

[ZGJL10] Zadrozna, I; Guzowska, Anna; Jezewska, E; Leśkiewicz-Laudy, Agnieszka: Conservation of Chinese Room in the Wilanów Palace of Warsaw as a result of multidisciplinary research. In: Multidisciplinary Conservation: A Holistic View for Historic Interiors (ICOM-CC, 23.–26.03.2010) (2010)

Development of AR Applications with Different Technologies

A Case Study and Comparison

Denise Bischof, Julien Letellier, Jürgen Sieck
INKA Research Group
Hochschule für Technik und Wirtschaft Berlin
12459 Berlin, Germany
denise.bischof@student.htw-berlin.de,
{julien.letellier, j.sieck}@htw-berlin.de

Abstract

This paper discusses the implementation of Augmented Reality (AR) applications with different technologies for native and web platforms. We will discuss the production of a real analogue book that serves as the marker or starting point of the experience and the demands that need to be considered for the attached AR application, as well as the development using different technologies. We will demonstrate the different functions and features of each technology as well as their advantages and disadvantages. We created three implementations of the same application for a recipe book, one with a classical approach using a native iOS/Android application developed with Unity and Vuforia, another using Unity and Apple's ARKit and an experimental web application using the WebXR API and a web browser. A usability study was conducted to test the hedonic and pragmatic quality of our web application prototype and the accessibility for creators with or without programming experience. This paper concludes with a perspective of the possible growth of AR technologies and future development approaches using web platforms.

1 Introduction

Nowadays, AR technology is mainly used within the entertainment industry, but the applicability for other fields, such as public safety, healthcare, tourism, industry, marketing and culture shows the gradual market growth and need for this technology [ABBF01]. In the last few years, the cultural and creative industries have seen an increase in AR applications for educational and entertaining purposes. Research projects such as APOLLO and AURORA try to bring technical know-how and computer scientists together with domain-specific knowledge and cultural scientists. Together they develop innovative AR applications to impart knowledge to a wide audience [KWCS05]. Numerous AR applications within the project APOLLO show the benefits of AR to reach new audiences and to create novel experiences, e.g. an augmented brochure with which the user can experience images, videos and 3D models from the Konzerthaus Berlin [LRSS18] and a virtual string quartet that shows the composition of individual voices (such as violin, viola and violoncello) in a low-threshold manner and is also appealing to a younger audience. The research project AURORA is successfully training people form the creative industries to develop their own AR experiences, i.e. through workshops and individual mentoring sessions [INKA19].

The above-mentioned programs show the need for professionals from the fields of computer science, cultural sciences and the creative industries to work together more closely. Since the rise of AR with technological advancements in computer vision and mobile applications, the necessary development tools have also advanced. Multi-purpose 3D engines, such as Unity and Unreal Engine, let developers create immersive 3D worlds and rich interactive content. Libraries, such as Vuforia, ARKit and ARCore, provide algorithms and platforms to show AR content to end-users. However, these tools are fairly technical and mostly require trained C#/C++ programmers to operate, especially in order to create interactive experiences [GMOF13]. However, specialized software and authoring tools have also started to appear on the market (see Section 2: State of the Art). While these allow non-technical users to create AR experiences without any programming involved, they are also very limited in terms of interactivity. This research examines the development process for an

interactive AR application with different tools and technologies. It tries to identify the strengths and weaknesses of each approach, especially in terms of interactivity, and the accessibility for non-technical professionals to develop AR experiences.

2 State of the Art

As mentioned before, there already exists a wide variety of platforms for creating AR applications [SeLB08]. These can be broadly subdivided into two different types, AR authoring tools for programmers and for non-programmers.
Tools for programmers mainly consist of code libraries such as the open source AR.js [Etie19], which is based on ARToolkit [Kato07] and provides vision-based tracking of black and white square markers.

Fig. 1: ARToolkit example markers

These tools usually require some planning, programming and testing efforts in order to produce polished AR applications, as well as other third-party software to create the AR content.
On the other hand, we have AR authoring tools that are specifically developed for non-programmers, such as designers or artists [Papa11]. These tools allow users to make basic AR applications, which associate virtual content with visually trackable markers. One example of such an authoring tool would be Artivive[1], which is a web-based drag and drop creational tool, where artists can easily put a digital layer with videos or 3D animations on top of a visual marker.

1 https://artivive.com/

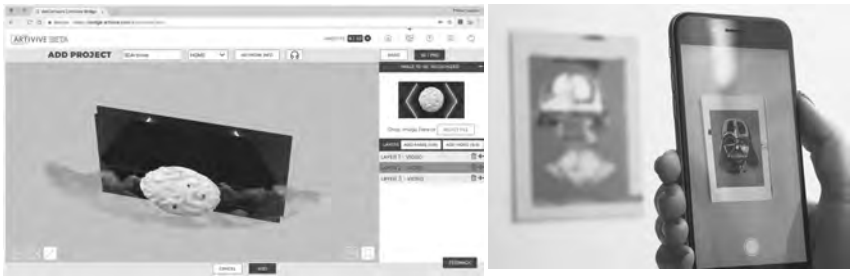


Fig. 2: Artivive interface components and working augmentation

Many online services provide a simple drag-and-drop interface, through which an AR product can easily be created without any prior programming knowledge [BiCL15]. This usually utilises the simplest form of AR, where pictures or videos can be displayed over a specified image marker, but no interactivity is offered for the end user. Only few of these tools offer script input and therefor give little room for developers to create an authentic AR experience. The lack of optimisation and the restriction of the application development mostly leads to disenchanting AR experiences, which offer sparse user engagement. Authoring tools with scripting capabilities such as Amazon Sumarian tend to be overwhelming and offer far too many options and customisations to be intuitively usable. Non-developers might struggle to use such tools because of their complexity and high learning curve.

Fig. 3: Amazon Sumerian interface components

3 General Approach

In order to compare different technological approaches to develop AR experiences, we decided to focus on manageable use cases with a predefined set of features to be implemented. These use cases focus on augmenting recipe books with additional virtual content, such as images, videos and 3D models. The recipe books depict Namibian delicacies and provide insights into the Namibian culture. The accompanying augmentations should either provide more information on the recipes themselves or help understand the rituals and customs surrounding the traditional Namibian cuisine. In order to show Namibian customs in an appropriate manner, we decided to use movies to capture the uniqueness of the culture. We decided that 2D imagery would not do the striking landscapes of the Namibian outback justice, so we decided to create a 3D landscape, which can be explored via the augmentation. In order to test the interactive possibilities of the development approaches, we decided to integrate some basic selection-based elements, e.g. selecting ingredients from a list to show the associated recipes containing those ingredients.
These use cases should yield the most common features that are needed in an easy-to-use and easily accessible authoring tool. Another goal was to make collaborative development an important part of the authoring tool, as well as fast design processes, where quick iterations and rapid prototyping are the main focus. One of the major advantages of this approach is that designers and programmers can use this tool to create new and authentic AR experiences together through sharing their ideas simultaneously. One way to achieve these goals is if the AR application can directly be tested through a web viewer, which should allow for a faster iteration process and lead to an overall better time management [LNBK04].

4 Development of Use Cases

4.1 Unity and Vuforia

The most commonly used library to create AR experiences is Vuforia, which mainly uses image targets on which it displays the virtual content.

Our first use case, an AR application for the recipe book "Delicacies from a Namibian Farm Kitchen – Corona Guest Farm", was developed with Vuforia and Unity [BiFS18]. It contains digital pages, which are displayed over the real-world markers on the book pages, containing videos, pictures, animations and further instructions for the different recipes.
Vuforia uses image recognition to use a visual marker within the real world on which it displays multimedia content, such as pictures, videos, 2D animations, sounds or 3D objects. It creates a predefined plane on which the content is placed and reacts to the gyroscope and camera angles to create an illusion of depth (see Figure 4).

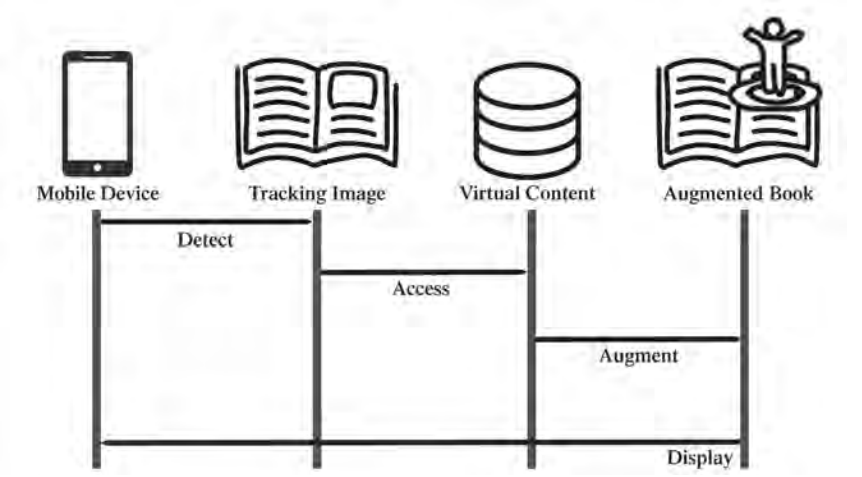


Fig. 4: Sequence diagram of an augmentation

4.2 Unity and ARKit

Whereas Vuforia mainly uses predefined markers to place virtual content, more recent libraries like Google's ARCore and Apple's ARKit provide a feature point cloud of the user's surroundings using a technology called Visual Inertial Odometry (VIO) [ScEC14], by combining features extracted through the device's camera with the data from the gyroscope and accelerometer. Both libraries can be implemented in an application using the Unity engine, which contains useful tools for fast editing and iterating the project, as well as a real-time preview to speed up the development cycle [LiBa17].

We decided to create a new instalment of our book series called "Lunch and Picnic on a Namibian Farm – Corona Guest Farm" and used Apple's ARKit to create a more advanced AR experience. ARKit allows to place content regardless of a fixed position within the detected 3D space and detects the user's movement as well as the device's orientation and thus the placement of the object.

4.3 Comparison

Comparing the applications created with Vuforia and ARKit we encountered different distinctions that influenced the development process, as well as the user experience. The development with Unity and Vuforia was significantly faster than with ARKit. Vuforia also heavily impacts the speed of the application, which is relative to the number of markers and content within the project and can lead to long loading times, which can impair the user experience. Since ARKit provides a representation of the entire surroundings, interactive content is much easier to produce compared to the Vuforia library. While the Vuforia application is easier to apply for users, its motion tracking can be rather unstable and disparity within orientation might occur. The Vuforia application is dependent on its image targets and doesn't offer as much interactivity to engage the user compared to the other application. ARKit has a much better motion tracking, yet the usage of image targets is still unstable and under heavy development by Apple. However, the interactive content is a much more satisfying experience, since the users are not limited in their movement within the detected 3D space. It is easier for the user to start the Vuforia application through the use of image recognition, but since the augmentation is dependent on the marker, the interactivity with the content is limited. Bigger content, such as the 3D model of the Namibian landscape that we created, cannot be placed on top of the marker, since the user would have to move away from it and once marker tracking is lost, the content will disappear as well. This can be circumvented through using device specific positional tracking, but at the current deployment stage of Vuforia, this feature is still under development. We think that currently Vuforia is the best library for image based augmentation, whereas ARKit and ARCore are apt for Motion Tracking and Ground Plane Detection. We noticed through our work with the AURORA: AR School for Artists that most artist and designers struggle

using Unity. Thus, we decided to try to create an easily understandable and quickly accessible authoring tool to create simple augmentations.

4.4 WebXR and ARKit

Finally, we propose a web-based authoring tool that works with the WebXR Device API[2], which is currently on a standardisation track, for future development of AR applications connecting with native libraries, such as ARKit. This facilitates the development of such applications by providing a high-level abstraction. With the use of this new technology, we created a web-based authoring tool, which can be used to easily create augmented applications, which then can be displayed through the use of a compatible web browser, such as Mozilla's WebXR Viewer [QRDL19]. This may provide a better user experience compared to the classical approach using Vuforia, as well as allowing for better accessibility of the application. Initial results show that the development process of the ARKit approach in conjunction with the WebXR API is still very unstable and more complicated regarding the described use case, i.e. augmenting printed books. However, the new interactive functions, as well as the increased utilisable space justify the more difficult development process.

5 Prototype: Simple Marker-based AR Authoring Tool

The research and development of the above-mentioned use cases yielded several new libraries and standards. One of these standards is the WebXR API, which allows web developers to make use of modern AR functionalities using a standardized programming interface. The API was designed to abstract methods and processes common in augmented and virtual reality development. Mozilla has been pioneering this effort and provides a reference browser for iOS. This experimental browser is only meant for prototyping but shows how the WebXR API can be used in web applications. Based on this API we built a simple authoring tool that lets users create marker-based AR applications. The prototype is called SMAAT and is available on GitHub as open source under a very permissive MIT license.

2 https://www.w3.org/TR/webxr/

The main goal of this prototype was to provide a simple user interface to upload marker images to be used as targets for placing the virtual content; to upload 3D files with meshes, materials, textures and animations; to do basic transformations of 3D root nodes in relation to the marker image and provide an interface for basic scripting, so that interactive functionality can be implemented. Figure 5 shows the tool with the basic features of adding markers and 3D objects. Finally, the prototype should integrate with Mozilla's WebXR Polyfill, which allows users to test AR scenes using Mozilla's WebXR Viewer on iOS. At the time of writing, this allows for testing the AR scene on iOS by navigating to the hosted SMAAT server application in Mozilla's test browser. In the future, this should work in all major browsers, once they support the WebXR API [NoBR10].

Fig. 5: SMAAT interface components

To verify these goals, the above-mentioned recipe book applications have also been successfully implemented using SMAAT. Furthermore, we conducted a simple usability study to verify if and how well the different user groups would be able to use the tool.

5.1 User Study

In order to estimate the usability and demand for our authoring tool we asked participants from different fields of work to test our prototype and give feedback. To test the superficial user experience, we used the single evaluation form from AttrakDiff to review the hedonic and pragmatic quality of our prototype [HaBK03]. This helps us understand how

users personally rate the usability and design of our interactive product and conduces us to affect the user experience positively. The results were presented in a confidence diagram as seen in Figure 06 and shows us the feedback our test users gave us.

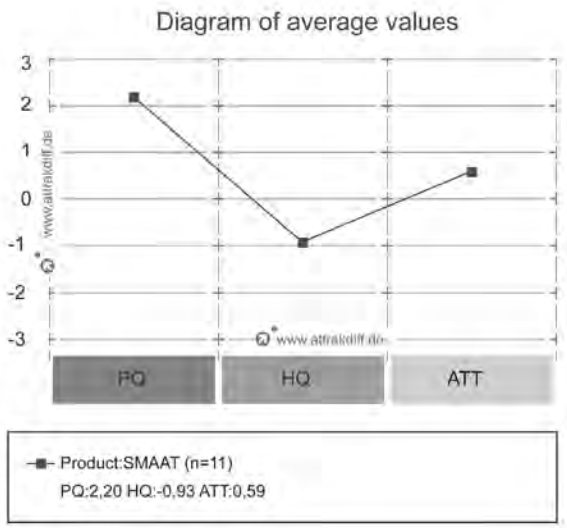


Fig. 6: The average values of the AttrakDiff™ dimensions for the evaluated product are plotted on the diagram.

The evaluation of the diagram shows, that while our prototype is very task oriented, the hedonic quality and thus the overall visual appeal of the tool might be lacking. This however seems not to be a problem, since the written feedback indicates, that through the simple interface, confusion or overload, which other authoring tools cause, are not present. The participants further suggest, that SMAAT would be very useful for rapid prototyping as well as for interactive AR applications, because of the expandability through the scripting input.

Furthermore, the direct output of the AR content through a web browser was very well received by the participants. The overall feedback was very positive and suggests, that the tool would be well received by developers and non-programmers alike. However, the prototype is still in a very early stage and requires further development and evaluation.

6 Conclusion

Through the research described in this paper, we assessed the currently most used libraries to create AR Applications and evaluated their different usages, as well as their strengths and weaknesses. This led us to develop an authoring tool for marker-based AR applications. Through its simple user interface and in contrast to feature-rich 3D engines, it allows creators of AR content to simply try marker-content combinations. The ease of access is possible due to new web APIs that browser vendors are gradually implementing. In the future, this approach will allow for more diverse AR authoring tools for various use cases. The prototype we developed gained an overall positive reception by test users and the feedback we received showed the demand of such an authoring tool. The next steps are to build more generalized tools that can be tested with more complex use cases and larger development teams, comprised of domain experts from the cultural and creative industries, designers and programmers. Another important aspect for these kinds of inter-disciplinary work is real-time collaboration. The web already provides many examples where real-time collaboration is used for content creation and software development and therefor seems predestined for these kinds of workflows. The ongoing effort, in standardisation and development of tools, lead to the conclusion that a large part of the future of AR will take place in the browser.

Acknowledgement

This paper describes the work undertaken in the context of the project APOLLO hosted by the INKA Research Group and the Konzerthaus Berlin that is generously funded by the European Regional Development Fund (ERDF). In addition, we would like to thank the management and team at Corona Guest Farm for their support in producing the recipe book and the associated applications.

Literature

[ABBF01] Azuma, R.; Baillot, Y.; Behringer, R.; Feiner, S.; Julier, S.; MacIntyre, B: Recent advances in augmented reality. 2001. NAVAL RESEARCH LAB WASHINGTON DC.

[Azum97] Azuma, R. T.: A Survey of Augmented Reality. In: *Presence Teleoperators and Virtual Environments*, 6(4), pp. 355–385, 1997.

[BiCL15] Billinghurst, M.; Clark, A.; Lee, G.: A Survey of Augmented Reality. 2015. In: Foundations and Trends® in Human–Computer Interaction. 8(2-3), pp. 73–272.

[LRSS18] Letellier, Julien; Reinhardt, Jens; Scholl, Peter; Sieck, Jürgen; Thiele-Maas, Michael: Providing Additional Content to Print Media Using Augmented Reality. In: International Journal of Computing, pp. 180–189, 2018, ISSN 2312-5381

[ScEC14] Schöps, T.; Engel, J.; Cremers, D: Semi-dense visual odometry for AR on a smartphone. In Mixed and Augmented Reality (ISMAR), 2014 IEEE International Symposium on (pp. 145–150). IEEE.

[BiFS18] Bischof, Denise; Fransman, Jacodia; Sieck, Jürgen: Interactive Recipe Book – Enhance your traditional Recipe Book. In: Proceedings of 2nd African Conference on Computer-human-interaction (africhi'2018)

[QRDL19] Qiao, X.; Ren, P.; Dustdar, S.; Liu, L.; Ma, H.; Chen, J.: Web AR: A Promising Future for Mobile Augmented Reality—State of the Art, Challenges, and Insights. In: *Proceedings of the IEEE*, vol. 107, no. 4, pp. 651–666, April 2019. doi: 10.1109/JPROC.2019.2895105

[Etie19] Etienne, J: AR.js – Efficient Augmented Reality for the Web. Retrieved March 19, 2019 from: https://github.com/jeromeetienne/AR.js

[Kato07] Kato, H: Inside ARToolKit. 2007. In *1st IEEE International Workshop on Augmented Reality Toolkit*.

[INKA19] INKA Research Group. AURORA: Augmented Reality – Organisation und Betrieb eines Anwendungs- und Trainingszentrums (2018–2021) Retrieved March 21, 2019 from: https://inka.htw-berlin.de/project/aurora/

[SeLB08] Seichter, H.; Looser, J.; Billinghurst, M: ComposAR: An intuitive tool for authoring AR applications. 2008. In *Proceedings of the 7th IEEE/ACM international symposium on mixed and augmented reality* (pp. 177–178). IEEE Computer Society.

[KWCS05] Knopfle, C.; Weidenhausen, J.; Chauvigne, L.; Stock, I: Template based authoring for AR based service scenarios. In: IEEE Proceedings. VR 2005. Virtual Reality, 2005. (pp. 237–240). IEEE.

[GMOF13] Gimeno, J.; Morillo, P.; Orduña, J. M.; Fernández, M.: A new AR authoring tool using depth maps for industrial procedures. 2013. Computers in Industry, 64(9), pp.1263–1271.

[Papa11] Papagiannis, H: The role of the artist in evolving AR as a new medium. In *2011 IEEE International Symposium on Mixed and Augmented Reality-Arts, Media, and Humanities* (pp. 61–65). IEEE.

[HaBK03] Hassenzahl, M.; Burmester, M.; Koller, F.: AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität. In: *Mensch & computer 2003* (pp. 187–196). Vieweg+ Teubner Verlag.

[NoBR10] Noll, J.; Beecham, S.; Richardson, I: Global software development and collaboration: barriers and solutions. 2010. *ACM inroads*, *1*(3), pp. 66–78.

[LiBa17] Linowes, J.; Babilinski, K: *Augmented Reality for Developers: Build Practical Augmented Reality Applications with Unity, ARCore, ARKit, and Vuforia*. 2017. Packt Publishing Ltd.

[LNBK04] Lee, G. A.; Nelles, C.; Billinghurst, M.; Kim, G. J: Immersive authoring of tangible augmented reality applications. 2004. In *Proceedings of the 3rd IEEE/ACM international Symposium on Mixed and Augmented Reality* (pp. 172–181). IEEE Computer Society.

sMapshot – A Historical GPS in the Crowd

Nicole Graf
Image Archive, ETH Library
ETH Zurich
Raemistrasse 101, CH-8002 Zurich
nicole.graf@library.ethz.ch

Abstract

Since January 2018, the crowdsourcers of the Image Archive of the ETH Library have also had the possibility of georeferencing images. The image archive uses the new collaborative and participative platform sMapshot, which is developed and operated by the University of Applied Sciences Western Switzerland HEIG-VD. In the first year, more than 172 people processed around 45,167 aerial photos. The playful tool is very well received by the participants and also has a certain "addiction potential".

1 Introduction

Since January 2016, anyone can provide feedback with further information on any image in the image database of the ETH Library's image archive, E-Pics BildarchivOnline (http://ba.e-pics.ethz.ch). By the end of February 2019, 1,1016 volunteers (90% men) had sent 54,000 notes on over 51,000 images, which could only be identified or improved in description, dating, etc. [Graf16, Graf17]. However, we only generate valid information in the form of texts. This means – and this is a fundamental problem in image research – that only textual information can be searched for. Usually this is metadata from the fields title, description or keyword. Image content can therefore only be captured very incompletely. It is hoped that this will be remedied in the medium and long term through decisive progress in the field of automated image recognition. An alternative possibility of metadata enrichment is the acquisition of geoinformation, the georeferencing of images.

2 Georeferencing Concepts

Virtually every documentary photograph in the ETH Library collection can be located geographically.

The simplest form of georeferencing is to locate a building. The exact geographical position of the object is referenced with the geographical point coordinates (length/width). Google Maps and similar applications can extract such data. In the ETH Library, the principle of point referencing is applied to the map-based platform ETHorama (http://ethorama.library.ethz.ch/de). An extension of georeferencing is the referencing of a surface. At least four corner points (edge coordinates) are referenced. This is used for aerial photographs taken vertically, the basis for map materials, and for map materials. In the ETH Library, two platforms are based on this principle: the cataloguing of printed maps in the library catalogue is reused in the Swiss Map Portal.CH (http://www.kartenportal.ch), and old maps are georeferenced using Georeferencer (http://georeferencer3.appspot.com). This principle does not work with aerial photographs flown at an angle,

these are no longer rectangular surfaces, but complex surfaces in space. In order to reference this polygon in space, we looked for a new solution.

3 sMapshot – Play Georeferencing

Since 2017, a new platform has been online that meets exactly these requirements, namely the georeferencing of landscape photographs in the broader sense: sMapshot (https://smapshot.heig-vd.ch/ethz). In fact, sMapshot is a participative and collaborative platform, developed in cooperation with the University of Applied Sciences Western Switzerland HEIG-VD from a doctoral thesis for semi-automatic georeferencing [PrIn18]. HEIG-VD has further expanded the platform in cooperation with the ETH Library and went online at the end of January 2018. The platform was presented to the participants of the ETH Library's crowdsourcing at the second meeting. This was followed in the summer by a report in the Neue Zürcher Zeitung [NeZZ18].

The central functionalities of sMapshot are the following:

- "Footprint" in the virtual 3D globe
- Recording of recording position, camera angle, recording height
- Calculation of the space covered by the image
- Metadata extraction of villages, mountains, rivers, field names, etc.

The very playful georeferencing is done in several steps: The participant selects a picture on the national map which he wants to georeference. The first step is to determine the approximate location of the image. In a second step, the participant indicates the viewing direction. Immediately, the image is provisionally placed in the virtual 3D globe, an application of Swisstopo. Now the actual georeferencing begins. The participant must indicate at least four points on the image and correspondingly in the virtual globe that correspond to each other. The image can then be roughly located. Then the participant is asked to define at least two further points so that the image can be completely geolocalized. Ideally, the points should be spread over the entire image to achieve the widest possible coverage. In this way, the image can be inserted more precisely into the virtual globe. Further functionalities are the improvement or correction of the metadata or the annotation directly in the image.

Fig. 1: sMapshot: georeferenced aerial photo of Staudamm Mattmark in the 3D globe, https://smapshot.heig-vd.ch/map/?imageId=106112 (Screenshot)

Participants can participate anonymously or register via Facebook, Google plus or a separate login. As soon as they are registered, they are ranked and can manage the status of the georeferenced images in mySMapshot.

All georeferenced images are managed in a dashboard specially programmed for the ETH Library. Each image is validated by employees of the image archive, i.e. the georeferencing proposal can be improved, rejected or accepted. As the participants will be georeferencing very accurately within a short time, the images can usually be validated in the first step. Because this is a very playful application, the "addiction potential" is very high.

The images are uploaded in packages in so-called campaigns. Since the end of January 2018, the image archive has launched a total of six campaigns with a total of 45,167 aerial photos. 172 people, most of them men, have participated so far. The Top 5 consists of the "normal" crowdsourcing gentlemen.

Rank	No. of images	Name
1	7’631	Sigi Heggli
2	6’432	Walter Zweifel
3	4’938	Hans Zumbühl
4	3’578	Anton Heer
5	3’116	Urs Witmer

Table 1: Ranking of the top 5 from 1.1.2018 to 14.03.2019.

After the end of a campaign, the new geodata is imported into the image database. Most of the data are geocoordinates: the location of the image and the so-called footprint, which are the coordinates of the area depicted, the polygon. sMapshot can also calculate the image height and evaluates the geodata according to visible place names. Here you can define in advance how exactly the so-called Swissnames should be evaluated. Are place names and landscape names sufficient or would you like to evaluate castles and palaces?
In addition to the wealth of new metadata for image research and the exact location of the images, these exact geographical coordinates can also be used for scientific research. In a smaller campaign, images of floods were georeferenced, which were now entered into the Mobiliar Lab für Naturrisiken (University of Berne) in the so-called Flood Memory (https://ueberschwemmungsgedaechtnis.hochwasserrisiko.ch/). Glacier shrinkage and natural hazards could be calculated, urban development analysed (e.g. the influence of infrastructure) or disappeared historical buildings virtually reconstructed. Swisstopo, the Swiss Federal Archives and the Swiss National Library are other participating institutions that are contributing their own holdings to sMapshot.

4 Outlook

Our crowd has very well received the new platform. At the start of a new campaign we receive around 200 georeferenced images every day. The campaigns are completed within a few weeks. Many original participants also take part in georeferencing. The contribution on the image database,

where the crowd can submit their comments, is still very high with an average of 1,250 e-mails per month. During the first year, a considerable amount of knowledge regarding the usage of the platform has been gathered. Improvements of the front-end interface and the implementation of a new architecture are planned for autumn 2019. Another desideratum is the integration of map materials worldwide.

Literature

[Graf16] Graf, Nicole: Sie wussten mehr! Vielen Dank! Offenes Crowdsourcing im Bildarchiv der ETH Library. In: EVA 2016 Berlin, Berlin: Gesellschaft z. Förderung angewandter Informatik, 2016, pp. 163–168.

[Graf17] Graf, Nicole: Lernen von der Crowd – Community Management und OnlineUmfrage. In: EVA 2017 Berlin, Berlin: Gesellschaft z. Förderung angewandter Informatik, 2017, pp. 172–176.

[PrIn18] Produit, Timothée; Ingensand, Jens: 3D georeferencing of historical photos by volunteers. In: Ali Mansourian et al., Geospatial technologies for all: selected papers of the 21st AGILE Conference on Geographic Information Science, Cham: Springer, 2018, pp. 113–126.

[NeZZ18] Die alten Swissair-Bilder erhalten ein zweites Leben. Neue Zürcher Zeitung, 13.8.2018.

An Intuitive Hand-Gesture Interface for Virtual Reality Applications Based on the Deep-Learning Approach

Mykyta Kovalenko[1], Paul Chojecki[2], Ingo Feldmann[3], David Przewozny[4]
Vision & Imaging Technologies
Fraunhofer Heinrich Hertz Institute HHI
10587 Berlin, Germany
{mykyta.kovalenko[1], paul.chojecki[2], ingo.feldmann[3], david.przewozny[4]}@hhi.fraunhofer.de

Abstract

In this paper we present a deep-learning based algorithm to be used for natural contact-free interaction with a virtual environment and virtual objects. We implement an approach that uses the RGBD device together with several pre-trained convolutional neural networks to detect important keypoints on the depth image, extract the hand finger skeleton joints, map the joints into the 3D space to allow immersive hand representation in the VR, and recognize several gestures to increase the accuracy of the interaction, as well as provide some interaction with the VR application itself. The approach is used in the VR application for medical rehabilitation where the user is encouraged to perform a series of simple tasks to test their memory and hand-eye coordination. We then perform several tests and performance evaluation of our approach.

1 Introduction

The recent years have seen an increase of Virtual Reality (VR) usage in neuropsychological clinical settings, e.g. for diagnostics and rehabilitation. This also leads to a growing demand for intuitive and natural ways of controlling and interacting with the virtual environment. Because current VR glasses allow high quality, realistic presentations of VR environments users also expect object interactions in VR to be natural or realistic.

Both Oculus Rift and HTC Vive, two of the most popular VR headsets, come with their own hand-held controllers that provide very accurate and convenient way of interacting with the virtual environment. However, in various applications some users might have problems with either getting used to such controllers or being able to reliably hold anything in their hands at all or for longer training durations. Therefore the use of game controllers is only an intermediate step on the way to natural, immersive and non-intrusive interaction.

Many researchers instead turn to using visual tracking devices such as Leap Motion, most often by mounting it to the VR headset itself (first-person inside-out perspective). This approach allows having an accurate 3D hand representation and immersive interaction physics [WWXM17]. However, besides typical hand tracking errors mostly due to occlusion, it also has a limited field of view and a limited operational distance, the latter of which can result in incorrect hand representation when the arm is fully extended away from the headset.

Another approach is using visual tracking from the third-person outside-in perspective, specifically the depth sensors like Intel Realsense and Microsoft Kinect, or as well as stereo-cameras. This allows easy mapping of the hand coordinates into the virtual environment, although Kinect does not have any built-in functionality for interaction, specifically, grip and release gestures.

Therefore, in this paper we propose a solution based on a deep learning approach to analyse the RGBD (RGB plus Depth) data from various visual sensors and recognize hand-postures associated with gripping and releasing of objects of different sizes and shapes, as well as provide an accurate hand-representation. The main application for our research is the Virtual Rehabilitation (VReha) project [Vreh19], which uses VR for physical or

cognitive rehabilitation of elderly people and people with reduced cognitive capabilities.

2 Related Work

The preferred devices for contact-free interaction in VR environments are currently the Microsoft Kinect and the Leap Motion (LM). Due to weight, size and sensing areas, the Kinect usually operates in an outside-in mode and is suitable for larger distances. The LM usually mounted on head mounted devices (HMD) provides an in-side-out mode for short distances and is currently the state of the art solution for touch-less VR interaction.
Examples of such research include the in-air gestures approach by Lages, Nabiyouni, Tibau, and Bowman [LNTB15], whose system uses a Leap Motion controller to implement a set of virtual musical instruments.
The main reason why we do not wish to use a Leap Motion with an egocentric perspective in our research is its very limited field of view along with a limited operating distance which restrict users in their hand movements. And since the main requirement for our approach in the scope of the VReha project is the ability to grab and move objects across one to three meters (see virtual tables in fig. 4a) without extensive body movements, it might lead to some tacking errors or incorrect hand representation when the hand leaves the field of view or extends away from the headset.
In another approach a Kinect device is used for real-time gesture recognition, where a finger emphasised multi-scale descriptor is proposed to represent the noisy and articulated hand shape segmented from the Kinect image [YaZY17].
Zhou et al in their research [ZJJZ13] have proposed a robust part-based hand gesture recognition approach using a Kinect sensor. They proposed a novel distance metric Finger Earth Mover Distance (FEMD), which provides accurate recognition, robust to orientrattion, scale and articulation changes.
A recently developed OpenPose framework [CHSW18] allows “semi-real-time” multi-person tracking of more than 100 keypoints (for body, hands and face) just from the 2D RGB data. The approach uses a complex deep

convolutional neural network along with a nonparametric representation, which they refer to as Part Affinity Fields, to learn to associate body parts with individuals in the image.
An open-source framework developed by Mazhar et al [MRNP18] uses the RGBD stream from the Kinect device along with the OpenPose framework to extract the 2D skeletal joint data, transform it into 3D space, extract the hand regions and then uses a custom made convolutional neural network to recognize a series of hand gestures. The developed gesture recognition approach is then used for real-time physical human-robot interaction.

3 The Proposed Approach

The approach proposed in our paper is based on deep learning inference, which with the development of easily available powerful GPUs has become very prominent in the recent years. Deep convolutional neural networks have shown very impressive results in various applications, including the tracking of different features and keypoints in humans.
Our approach attempts to take advantage of these recent developments to create a device-agnostic hand-gesture interaction system that would be able to use any RGBD sensor as input. In this particular paper we are using an Intel Realsense RGBD camera. The approach can therefore make use of the RGBD data from the third-person outside-in perspective along with the Deep learning approach in the following two scenarios:

- Scenario 1: the user has a Leap Motion device mounted on the VR-glasses for hand-tracking, hand-representation and interaction. We then supplement it with the analysis of the real-time third-person footage to cover up for the previously mentioned weaknesses of Leap Motion in the cases when the user's hands go outside of its operational space and to overall increase the accuracy and responsiveness of the interaction.
- Scenario 2: the user is only wearing the VR-glasses. The entirety of the hand-tracking, hand representation and gesture recognition is done via the analysis of the real-time third-person footage from the RGBD sensor.

To accommodate both these scenarios, we have developed the following RGBD data processing pipeline (fig. 1):

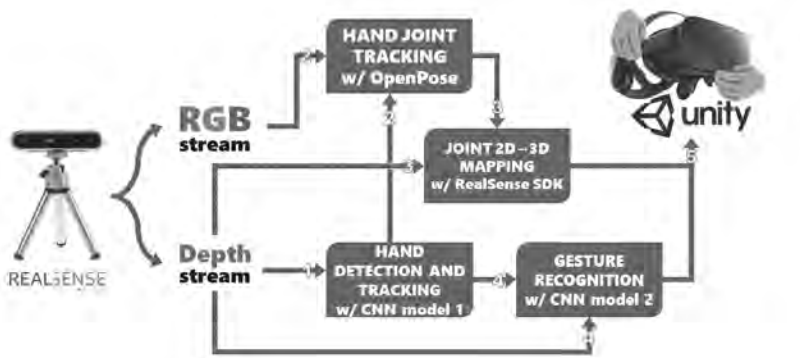


Fig. 1: Graphical representation of the system workflow

First we take the depth-stream from our RGBD sensor and, after some preliminary preprocessing (i.e. downscaling, normalisation and denoising), pass it through our *body keypoint detection model*. The output of the model is a set of coordinates for the user's hands and face locations.

We then use the hand locations, estimate the region-of-interest bounding boxes for both hands, based on their depth (i.e. the distance from the sensor) and crop both hand regions on the RGB stream. Both images are simultaneously fed to the OpenPose *hand keypoint detection model*.

The OpenPose model outputs a stack of 22 heatmaps: 21 hand skeleton joint and one for the background. After upscaling the heatmaps to the size of the input images and finding the maximum peaks in all of them, we get the 2D hand joint positions for both hands, relative to their respective bounding boxes.

Most of the available RGBD sensors, including the Intel Realsense, allow using the 2D point information to map it to the corresponding points on the depth image and then to convert this information into 3D points. As our next step we do that for the 2D hand skeleton joints.

At the same time, the hand locations and the bounding boxes are also used to crop the regions of interest on the depth image, which are fed to our *gesture recognition model,* which classifies a series of static gestures (*"Hand open", "Hand closed", "Thumbs-Up", "Both hands touching"* and *"Index finger raised"*). The model also outputs a linear floating-point

value in the range [0..1] to denote the intermediate states between *"Hand open"* and *"Hand closed"* to better and more accurately detect the action of grabbing and releasing the virtual objects.
The main VReha application is made in Unity, where users are prompted to complete a series of tasks related to picking up a series of various everyday objects and place them in positions which have been show to them before to train their memory and hand-to-eye coordination.
The output data of our approach is sent via HTTP protocol using the JSON format to the VReha VR application, where it is decoded, parsed and the used for hand-representation (by mapping the hand joint positions to 3D hand models) as well as for interaction with virtual objects (by using the hand-positions in 3D space and detecting the grabbing and releasing gestures).

3.1 Body Keypoint Detection Model

Even though sophisticated deep-learning based approaches for body keypoint tracking like OpenPose, as well as other easy solutions like Kinect already exist, we did not find most of them suitable for several reasons:

- Approaches like OpenPose require a lot of GPU processing power and memory. Considering that we also need to run a full VR application, as well as several other deep-learning models at the same time, preferably on one PC, smooth and immersive interaction in real-time quickly becomes very difficult, unless more than one GPU is used.
- The Kinect V2 device, though still very much usable, is discontinued by Microsoft. It has a very small depth-image resolution (also with the new Azure Kinect), and the tracking accuracy can in some cases leave much to be desired.
- Leap Motion cannot be used for full body tracking due to very limited range and its specific focus on hand-tracking.
- Since we also want to use the OpenPose hand joint detector, adding a full body tracker will reduce the processing speed and make real-time interaction difficult.

Due to all these reasons, we have decided to make our own light-weight body keypoint tracking solution, with two key differences: using depth

image as input and only tracking the most important keypoints (face and two hands) instead of 19, that are tracked by OpenPose.
We have decided to base our model on the existing VGG-structure [SiZi14], but with a reduced number of convolution kernels, fewer layers, different input image size, as well as a batch normalization layer for faster training convergence and a dropout-layer after every block to avoid overfitting during training (fig. 2).

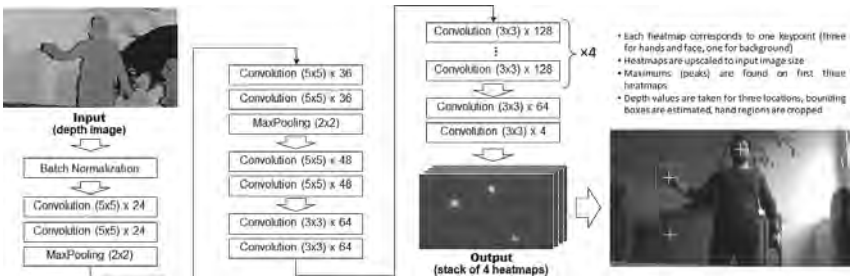


Fig. 2: The pipeline for the body keypoint detection model

The model outputs a stack of four heatmaps: one for each hand, one for face and one for the background. We then upscale the heatmaps to the original image size and find the local maximus peaks on the first three heatmaps to get the keypoint positions.
We trained the model for 750 epochs using close to 8 thousand training samples, with an additional data augmentation (with random shifts, rotations and horizontal flips) and achieved 89% accuracy and 0.0018 loss (using the mean squared error metric). We used the Keras framework [Chol15] with Tensorflow as backend for training.
Since we do not need high precision for keypoint localization and the performance tests have shown that the model requires 13.4 ms on average for the processing of one 384x216 depth frame, these results are more than satisfactory for our purposes of roughly estimating bounding boxes around the user's hands.

3.2 Hand Keypoint Detection Model

The hand regions cropped from the RGB image are fed into the OpenPose keypoint detector [CHSW18]. The original OpenPose implementation is

made using the Caffe deep learning framework. So to make sure that our entire pipeline stays within the same framework (Tensorflow) we decided to convert the original model into the pure Tensor graph as well.
We scale the hand images to the height of 184 pixels (the model was originally trained on 368x368 images, but we found that half the size is enough for our purposes) and feed them into the model. The model outputs a stack of 22 heatmaps: 21 for hand joints and one for the background. Same as with the body keypoints, we upscale the heatmaps to the size of the original images and find the peaks to get the joint locations (fig. 4b).
We then use the available Intel RealSense API to convert these 2D joint positions into 3D coordinates. The joint positions are then compared to the positions detected on the previous step and are corrected when using the Kalman smoothing filter [NgDo17].
The performance test for this stage shows a high accuracy, with a latency of on average 37 ms, making this stage the main bottleneck of the whole approach. To combat this we implemented multithreaded processing of frames with a processing queue of size 4, also processing only every odd frame. These optimizations allowed us to minimize the lag and achieve real-time performance.

3.3 Gesture Recognition Model

For this second model we also decided to use the VGG-16 structure as base, with several modifications:

- Input size is changed to 64x64 with one channel (depth image)
- Due to the smaller size of the input we had to get rid of one Convolution-Pooling block in the structure, as well as decrease the sizes of the dense layers
- After the flattening stage our network separates into two branches, with one branch having a categorical output with a softmax activation (for static gesture classification), and the other branch having an output with a linear activation to give the intermediate states between *"Hand open"* and *"Hand close"* in range [0..1].

As a result, we ended up with the following convolution neural network structure (fig. 3).

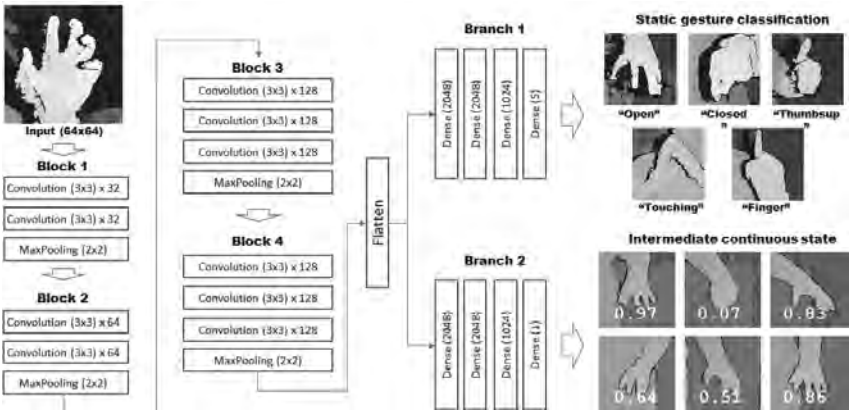


Fig. 3: The structure of the branched network for gesture recognition

For the static hand gestures we have recorded on average three thousand samples per gesture for each of the ten different people of different ages, genders and ethnicities. For the continuous output we recorded a dataset with every user gripping and releasing virtual objects from different perspectives with different hand orientations, and then quantized the sequences into separate frames with the corresponding interpolated "openness" stages in the range from 0 to 1.

The continuous output of the second branch is then smoothed out with a Kalman filter to make sure the gripping and releasing of objects is smooth and there are no accidental drops to annoy or frustrate the users.

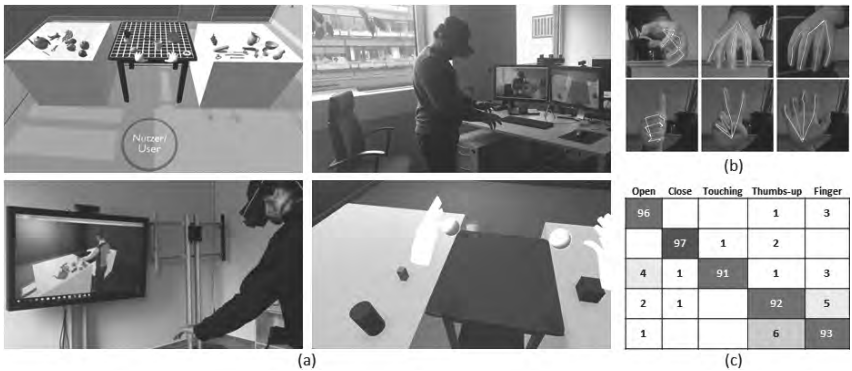
After 400 epochs of training we have achieved a 96.7% and 94.5% accuracy for the static and continuous outputs respectively, with the losses of 0.0023 and 0.0012 respectively (using the mean squared error metric). The performance test for the model shows that it requires on average 4.2 ms for the processing of one frame.

4 Use Cases and Test Results

Having trained the models and evaluated their performance on validation datasets, we then describe the main use case for our approach and outline the results of our performance evaluation via several synthetic tests and experimental comparisons with other approaches.

4.1 VReha Project

The main purpose of the VReha project is using VR for the cognitive and physical rehabilitation. This is achieved by prompting the user to perform several *virtual memory tasks* related to memorization of 2D positions of random objects on a virtual table. After a memorization phase objects are rearranged and users are asked to place the same objects in the previous positions on the table (fig. 4a). The second part of the application is a *virtual supermarket,* where users are supposed to navigate the virtual space and collect VR products which are on their shopping list using the best possible route. Both tasks are designed to evaluate and train spatial cognition, with respect to visuospatial memory and spatial navigation.



Open	Close	Touching	Thumbs-up	Finger
96			1	3
	97	1	2	
4	1	91	1	3
2	1		92	5
1			6	93

Fig. 4: (a) live testing in the VReha system, (b) examples of hand skeleton joint detection and (c) confusion matrix for gesture recognition

These tasks require precise, intuitive and natural ways of interaction that would allow users to accurately grab and release the objects. Since some people might find it uncomfortable or impossible to hold and operate hand-held controllers or concentrate on more complicated interaction metaphors, using an approach that would leave the user's hands free and rely only on visual hand tracking and gesture recognition seems to be the best option.

In a separate paper we will discuss the main problems and the solutions to virtual hand to virtual object interaction (such as what constitutes as "grab" or "release") in more detail [Vreh19].

4.2 Experimental Test Results

Here we will detail some preliminary observations and results of synthetic tests. A more detailed evaluation of the developed approach as well as the metrics used to determine the usability of the approach will be discussed in a separate paper and reported later.

4.2.1 Comparison with Oculus Rift Controllers

We have prepared a test case where several users need to perform a series of virtual memory tasks using the included Oculus Rift controllers, and then repeat exactly the same task (with the same set of objects) using our hand-tracking and gesture recognition approach. We then measure the average time it took each user to place each object in its proper place, as well as the average placement error, using the simple Euclidian distance between the target position and the actual position of the object on the table.

Preliminary experiments have shown than a user requires on average 2.27 s per object using the Oculus Rift controllers and 2.41 s per object using our approach. The average normalized placement error was estimated to be 6.83%.

4.2.2 Performance Evaluation

The experiments for this section were done on a PC with Intel Xeon with 24 cores, 64 GB of RAM and an Nvidia Titan X video-card, and a second PC with an Intel Core i7, 16 GB of RAM and an Nvidia GTX 980.

Our full pipeline with hand keypoint tracking, hand joint detection and gesture recognition was measured to run at an average speed of 24.3±5 fps on the first PC and 19.7±3 fps on the second one. For comparison, the original OpenPose implementation, with the MPI body keypoint model, single user and hand tracking enabled, only achieves on average 12.3 and 9.7 fps on both PCs respectively (without accounting for gesture recognition or communication with the VReha application), which is insufficient for seamless real-time interaction.

We also performed a series of synthetic tests for our gesture recognition approach using a new test dataset (not previously seen by our model

during training or validation), as well as using live-testing with volunteer users. The results of the testing were compiled into a confusion matrix, shown on fig. 4c. We can see here that most errors come from the fact that the fully open hand is sometimes confused with only one outstretched finger (for the *"Thumbs-Up"* or *"Index finger"* gestures), and the *"Thumbs-Up"* gesture is also occasionally confused with the fully closed hand in some cases, when the user is showing their hand to the sensor from a certain perspective (when the finger is not clearly seen).
While the *"Open"* and *"Close"* gestures are primarily used for the interaction with the objects (grabbing and releasing), the other gestures are used to communicate to the system that the user is ready to start or finish the test.

5 Conclusion

We have developed an approach to enable simple, immersive and contact-free interaction with virtual objects in a virtual environment. The goal of the approach is to eliminate any hand-held controllers or head-mounted sensors like Leap Motion, and only use a third-person perspective RGBD stream for hand tracking, hand representation and gesture recognition.
The deep learning approach was chosen for this task where we have trained several convolutional neural networks that take in both the RGB and the Depth data from the sensor, analyse it and extract the keypoints from the body (hand and face locations) as well as from the hands themselves (hand skeleton joints), while also recognizing several important gestures to enable easier communication with the virtual environment system.
We then evaluate the performance of our approach within a Virtual Rehabilitation (VReha) system, both to supplement the original approach that used a Leap Motion for hand tracking, and also to completely replace wearable input devices to only use non-intrusive third-person perspective video. Our approach allows test subject in the system to easily grab, move and release virtual objects in the virtual environment without using any hand-held controllers. Detection and tracking of hand-skeleton joints

allows us to provide the user with a virtual representation of their hands to further increase the immersion of the experience.
We then also performed several synthetic tests to evaluate the performance of our approach.

6 Acknowledgement

The work reported here has been supported by the Federal Ministry of Education and Research (BMBF) of the Federal Republic of Germany (project VReha, grant no. 13GW0206A).

Literature

[Chol15] Chollet, F. et al: Keras Deep Learning Framework. In GitHub, (2015), https://github.com/fchollet/keras, (last visited: 2019-02-27).

[CHSW18] Cao, Z.; Hidalgo, G.; Simon, T.; Wei, S.; Sheikh, Y.: OpenPose: Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields. In arXiv journal on Computer Vision and Pattern Recognition, 2018.

[LNTB15] Lages, W.; Nabiyouni, M.; Tibau, J.; Bowman, D. A.: Interval player: Designing virtual musical instrument using in-air gestures. In: 3D User Interfaces (3DUI). 2015.

[MRNP18] Mazhar, O.; Ramdani, S.; Navarro, B.; Passama, R.; Cherubini, A.: A Framework for Real-Time Physical Human-Robot Interaction using Hand Gestures. In IEEE Workshop on Advanced Robotics and its Social Impacts (ARSO), 2018, pp. 46–47.

[NgDo17] Nguyen, N. H.; Dogançay, K.: Improved Pseudolinear Kalman Filter Algorithms for Bearings-Only Target Tracking. In: IEEE Transactions on Signal Processing, no. 99. IEEE, 2017, p. 1.

[SiZi14] Simonyan, K.; Zisserman A.: Very Deep Convolutional Networks for Large-Scale Image Recognition. 2014, arXiv:1409.1556.

[Vreh19] VReha project, https://www.vreha-project.com, (last visited: 2019-02-04)

[WWXM17] Wang, Z.; Wang, P.; Xing, L.; Mei, L.; Zhao, J.; Zhang, T.: Leap Motion-based virtual reality training for improving motor functional recovery of upper limbs and neural reorganization

in subacute stroke patients. In Neural Regeneration Research. Vol, 12., Iss. 11., 2017, pp. 1823–1831.

[YaZY17] Yang, J.; Zhu, C.; Yuan, J.: Real time hand gesture recognition via finger-emphasized multi-scale description. In: 2017 IEEE International Conference on Multimedia and Expo (ICME). Hong Kong, 2017, pp. 631–636.

[ZJJZ13] Zhou, R.; Junsong, Y.; Jingjing, M.; Zhengyou, Z.: Robust Part-Based Hand Gesture Recognition Using Kinect Sensor. In IEEE Transactions on Multimedia, Vol. 15, 2013, pp. 1110–1120.

Virtual Object Shaping the City: Imaginary Undergrounds in Russia

Daria Radchenko
Laboratory of Theoretical Folkloristics
Russian Academy of National Economy and Public Administration Centre for Urban Folklore and Anthropology Research
Moscow School of Social and Economic Science
Moscow, Russia
darradchenko@gmail.com

Abstract

Underground transportation is a feature of the metropolitan cities. Many smaller cities, however, also have their own – virtual – undergrounds which only exist as schemes and descriptions on the web pages and social media (in Russia alone there are over 50 such subways). The virtual tubes become intertwined in the complex network of narratives which describe and explain the city: they are used to make sense of and structure the otherwise dystopian cities with significant lack of transportation connectedness. The paper is focused on semiotic mechanisms of this transformation of a virtual object into a mechanism for augmentation of urban space. As Marc Auge (1996) noted, the city exists due to the sphere of imaginary – and this is definitely the case of virtual undergrounds.

1 Introduction

Over 60 Russian cities can boast having underground transportation – a feature which defines them as metropolitan areas. However, in more than 80 % of them these undergrounds exist only as a virtual construct – a web page, a video narrative, a map – but not as a physical object. These cities are very different in size and number of inhabitants. In some of them tube was planned and even has been started to be buit (like in Omsk), others are so small that underground transportation has never been needed (like Korenovsk). However, the texts about virtual undergrounds are built to similar models, fulfil similar functions and produce similar reaction of internet users and local administration.

The research is based on the qualitative analysis of a number of sources: web pages and social network groups dedicated to virtual undergrounds, general interest local social network groups, local offline and online press of over fifty cities in Russia and the CIS.

2 Four Cases of Virtual Undergrounds

One of the typical cases of such virtual undergrounds is to be found in Bryansk (a city with over 400 000 inhabitants located to the southwest of Moscow, close to Ukrainian border). Here the narratives about underground are closely intertwined with discussions about the development of public transport. In 1989 a journalist in the local newspaper suggested that the city needed high speed transportation system. Following this, in 1990 a local historian Oleg Vyazmitin suggested a map of the would-be Bryansk tube, which ties together the key locations. After two years he published it in the local newspaper as an April Fool joke. Yet the idea has not been developed until 2006 when photos from the alleged "opening of a tube station" appeared on the net. In 2007, Bryansk tube was mentioned in a sci-fi novel by V. Golovachev, and later – in a book of local urban legends (Shushkanov 2012). Then a few more metro maps and even a mobile application appeared on the scene alon with public discussions of a project to build aerial tram in the city.

In Omsk (one of the biggest Siberian cities) the construction of the underground was actually started in 1992, but due to financial shortages the project was developing slowly and finally closed in 2005. It left some traces, however: a number of tunnels, a bridge and an underground passage which was designed as an entrance to the tube and even marked with letter "M" ("Metro"). In 2008 a group in social network "Vkontakte" was established under the name "Omsk Metro". It's messages imitated official communications of an underground's authorities: it published tube maps, news about the changes of cost of travel, job advertisements, photos of stations, etc. The problems of public transportation together with an idea of possibility of metro in the city and the public imagery of underground have triggered creation of multiple parodies and satires, including trips to Omsk Metro (actually to the passageway mentioned above), songs, artistic performances, etc. By 2015, when Omsk celebrated its 300 years jubilee, the Omsk Merto has become an unofficial symbol of the city. Finally, in 2019 the city major announced his final decision to quit with the project of the underground, but this only enlivened the artistic and folklore text production.

In Valday, a small historical city roughly halfway from Moscow to Saint Petersburgh, such imaginary underground has become a touristic object. In 2003 a local resident created a web site "Valday Metro", designed as an unofficial guide to the city. Every "station" here was associated with a point of attraction or an important urban object. It became so popular that in 2014 actual metro signs appeared in the city, and souvenir shops started to sell tokens and tube maps.

The last case to discuss here was the most resonant. This is the virtual underground in Barnaul (Altai region) that was created as a map and a web site by a local geographer Danila Churilov as a joke for his friends. The web site and a group in social media attracted the attention of journalists; Barnaul metro became popular within the city and a model for similar developments in other regions. The thoroughness of the parody has, however, almost ruined it when a tourist misinterpreted it as a web site of real tube, spend some time trying to find a station close to her hotel

and, enraged, wrote an official plea to the President asking to prohibit the fake.

3 The Construction of Virtual Undergrounds

These cases show that the virtual undergrounds, though based on local situations and narratives, share many common features which allows to investigate a general model behind them.

First and foremost it is their groundedness in the social and mental geography of the cities where they are "located". The tube maps tie together the key objects of the city, underlining their crucial importance. The typology of such objects is, however, limited. If we look at the map of the virtual Kursk underground, we'll find "stations" named after streets ("Moskovskaya", "Pushkinskaya"), transportation hubs ("Airport", "Bus station", "Train station"), vernacular regions ("Puchkovka"), health and education institutions. This set is typical for most of the maps, with rare additions of the objects of historical heritage. Discussing a tube map in Klintsy (a town of 62 000 inhabitants in Bryansk region) the users of social media suggest either "important" or "everyday" locations as ideas for new "stations", stressing the importance of the places which they inhabit or their routes:

Where is the 5th quarter?????? (male, 20/11/2008)

We the romantic people lack a station at the city park. (male, 15/01/2009)

I don't see my Evlanovka on the map!!!!!! (female, 21/03/2009)

And, vice versa, inclusion of a toponym or an object in the virtual underground scheme raises the status of this object as a key node of the urban mobility network. In an article about the public opening of a new business centre "NITI" a Ryazan newspaper "Novaya Gazeta" mentioned that a local Duma deputy has included the new object into a scheme of the non-existing underground:

Alexander Sherin has suggested that when the underground in Ryazan will appear, one of the first stations will be called "NITI".

"Constructing" their virtual undergrounds, the local enthusiasts try to find material denotates for the stations and tunnels. The role of the subway kiosk may be played by a small shop, an entrance to the shopping centre, underground passage, especially if they bear a logo or a name "Metro" (for example, a Voronezh restaurant called "Tube station Pub"). Such objects are photograghed, photoshopped to remind the actual subway infrastructure and downloaded on the "official" web pages and social networks. They also become the settings for excursions to subway – those which are performed in the physical space of the city and those which are downloaded on Youtube. The "trip to Barnaul Metro" video features, for instance, an underground passage, an escalator in a shopping mall and a turngate in a university as the elements of the virtual underground.

Being involved in such techniques, such objects acquire new status of the city's augmented reality. Here, we'll use the term rather metaphorically than technically. The gadget which enlivens such objects and bringst he AR into active existence is a person who knows the rules of the game and who can correlate the physical objects of the city with virtual objects of imaginary underground – either for herself or for the participants of a trip. The game, finally, becomes a method of "producing the space" when the city becomes involved in play and its objects convey an alternative story of virtual mobility.

Virtual subways are also rooted in the local narratives about hidden or abandoned underground tunnels and passages. This is a typical plot of urban legends, and in many cases the situations of a road caving in are associated precisely with a belief in secret empty spaces beneath the city level:

In seventies a bus once accidentally fell into a hole near the belfry tower. The guys examined the hole, they said it was all covered in oakwood, with an arch roof. Like a gallery. A part of the passageway led to the Kremlin, and part here, to the belfry (Jurievets, narrative by a local historian).

These holes in the ground, associated with secret passages, ironically confirm the virtual underground idea:

Some people ironically called the hole in the road a "drive to metro" (Sibnet.ru, 20/05/2016)

4 Vernacular Mimicks the Institutional

As we have already seen in the Barnaul case, the narratives about virtual undergrounds can cause conflicts. The source of anger of the visitors who failed to find subway in the city and the wrath of the city's inhabitants who find the jokes about virtual subway tactless in the tough transport situation both have a single source: the closeness of the virtual subway narrative to the texts of the real undergrounds. Here we'll understand the term "text" semiotically, which will allow us to see both the virtual and the "real" undergrounds as sign complex, which include material objects, management system, navigation, media presentations, maps, sounds and smells, historical and legendary narratives.

The veracity of the virtual metro as a text is achieved in two ways. The first is imitation of the institutional codes of real undergrounds, using the language frames exploited by such institutions to speak about themselves. For example, on the web site of the virtual Naberezhniye Chelny Metro there is a "historical" text that thoroughly follows the conventions of bureaucratic history writing:

In 1977 the construction of the first line of Naberezhnochelninsky Metropolitan was started. The construction is based on open cut trenching method. The first station has been the "Elektrotechnikov" which is now a crossing from Moscow to Tukaev Line. <…> In the unprecedentedly short period of time (from April 1977 to May 1986) four stations of the first construction phase were opened on Tukaev Line: Elektrotechnikov, Teatralnaya, Musa Jalil, Pedinstitut.

In 1931, the map of the London tube has first become autonomous of the city map: it was decided that it won't follow exactly the scale of the city and the flections of the actual tunnels in order to become more clear for understanding. The maps of virtual tubes, however, follow two different strategies of veracity. The first is marking the stations and connections on the physical map of the city (like the Belgorod case), and the second in creating autonomous maps following the most widely known schemes of existing undergounds. For example, the Bryansk tube map features a circle line painted brown – as on the Moscow tube map. In the last case we again can observe an imitation of existing "language" of institutional undergrounds.

The second key strategy for raising veracity is adding dynamics to the virtual construct. This can be achieved either in very straightforward way of downloading videos and sounds of subway, providing animated visualization of the project, or in a more subtle way of „enlivening" the web site by rhythmically adding news to it. Finally, many social media users actively participate in creation of the virtual underground by submitting their own texts as "reviews" of experience of using it. As a journalist reflected on Barnaul Metro,

The web site is not empty – news have appeared there for a long time. What can it be, if not the reality? [Levk12]

5 Virtual Underground, Real Problems

The popularity of virtual undergrounds as an idea and a textual construct is grounded in the needs of the city's inhabitants. The key problem which it addresses is the status of a city. In the context where a subway is a marker of speed, progress and modern great metropolitan city, constructing virtual subway becomes a way to show that the city is an important urban centre. The loss of this urban status is one of the greatest anxieties of regional Russian cities.

"The idea of the metro was always there, and it wasn't probably just mine, – tells the creator of the web site Danil Churilov. – It is a dream of a provincial city dweller – getting closer to civilization, see the one's native city contemporary." [Komy11]

The problem is that Yaroslavl is a village – it's a big one, but still a village. And you don't need an underground in a village (male, Yaroslavl, 18/03/2017)

The problems which are associated with this loss of urban status and with the decline to the "village level" are usually transportation problems, the lack of social services, higher education, leisure possibilities and the decline of number of inhabitants. In other words, when the people call their city "a village" they mean that it has certain structural problems. A virtual subway simultaneously addresses these problems and brings them to the light, thus provoking conflicts. In many cases the discussions around a virtual underground map gradually transform into the public debates about the conditions for urban mobility, and then it is used as an argument in the negotiations with local administration concerning the routes of public transport.

The second type of problems which are brought to light by creation of virtual subways, is connected to the first one – it is unconnectedness of the city. It is very typical for the large settlements which have gradually absorbed smaller villages and towns around them to become city areas. Between these clusters of living quarters and industrial buildings there often are empty underdeveloped spaces, disconnecting parts of the city.

The underground makes the city more structured and connected. Even if only in virtual space, the network of urban objects and connections between them makes city more understandable, meaningful and predictable – in other words, more safe in the general sense. On the other hand, as John Urry states, the existence of routes (circulation networks) defines certain forms of mobility capital. The rising value of mobility leads to responsibility for circulation of people, objects, information. But in many of the examined cities which already share the value of circulation, it

requires speed which cannot be achieved because of the transportation problems. This leads to a need for high speed transport which organizes the city into a network of consistent, meaningful and predictable routes. Paradoxically, underground which is called non-lieux by Marc Auge, an intermediate connective tissue of the city without it's own sense, becomes the mechanism of making sense of the whole city, bringing in the connectedness, social capital, rhythm.

6 Conclusion: Augmented City and the Reality of the Virtual

Virtual underground is an element of an alternative and augmented city, but it lives its own life. This reality of the virtual is explicated in a number of texts produced by the adepts of imaginary subways through a notion of an "utopian" city.

Barnaul Metro is quite real, but it runs through a different dimension – the dimension of a dream (BezFormata.Ru. 20.02.2014)

Omsk is a fake city itself. It was created out of nothing, during the war it was saved by industry and in Perestroyka it turned into a fake again because no one needed it. That's why here appear legends and tell-tales that make the city live. So those who creates this <underground> web site are joking and yet they feel that they live in imaginary artificial reality and maintain it in this way. [NiAb14]

Thus, the virtual and imaginary is understood as "real" – a hidden yet true level of the urban existence. As Tom Boelstorff notes, the opposite to virtual is not real but physical [Boel16]. Our actions in the world of a computer game can have very real consequences (for example, money loss). From this point of view, the imaginary underground is both virtual (existing only in a digital environment) and physical (based on material denotates); unreal and real (because it structures the city, makes sense of urban objects and leads to real reactions – conflicts, negotiations, production of artifacts).

As we have seen, different types of objects and practices give birth to a new participatory augmented reality. The creation of virtual undergrounds becomes "weapon of the geek" [Cole13]: people who have certain professional knowledge – designers, architects, geographers, local historians – create an object in the virtual space and then use it as an argument in negotiations on the transportation policy of the city – and sometimes even as the model for the actual routes of public transport – subway or speed tram.

Literature

[Boel16] Boelstorff, Tom: For Whom the Ontology Turns: Theorizing the Digital Real. In: Current Anthropology 2016 57:4, 387-407

[Cole13] Coleman, Gabriella: Anonymous in Context. The Politics and Power behind the Mask. Internet governance papers. Paper no. 3. September 2013.

[Komy11] Komyakov, V.: Sleduyschaya stantsia – Malakhovskaya. Perekhod na Koltsevuyu Liniyu. (Next station Malakhovskaya. Change for Circle Line here). In: Vecherny Barnaul. 20 Jan. 2011. In Russian.

[Levk12] Levkin, A: Barnaulskoye metro, fakt zhizni (Barnaul underground, a fact of life. In: Polit.ru, 24 Feb. 2012. In Russian.

[NiAb14] Nikiforova, A., Abramova, Ju.: Bukva „M" – esche ne metro. Nesuschestvuyuschaya podzemka kak gorodskoy mif. (Letter „M" is not yet a „Metro". A Non-existing underground as an urban myth. In: Argumenty i Fakty, 21 Feb. 2014. In Russian.

[Shus12] Drugoi Bryansk (Other Bryansk)/ed. P.A. Shushkanov. Bryansk, 2012. In Russian.

Telling History in Stories

A Mobile, Multimedia Navigation System for Nuremberg's Medieval Dungeon

Jörg Engster
die InformationsGesellschaft mbH · xpedeo mediaguides
Bornstr. 12–13
D-28195 Bremen
engster@informationsgesellschaft.com

Abstract

For Nuremberg's medieval dungeons, an innovative mobile solution was created. The system takes on the following three tasks: To guide the visitors safely through small catacombs, to offer exciting information about the past at the appropriate locations and to open the exhibition to new groups of visitors by providing barrier free content. Therefore a bluetooth based indoor localization system was installed to automatically trigger the navigational instructions and the transfer of information. So the authenticity of the historic place has been preserved because no changes to the site were necessary for the installation of a classic signage.

1 The Task

1.1 The Nuremberg Dungeon – An Exhibition Under Ground

Twelve small dungeon holes and a torture chamber – cramped, inhospitable, cold: Nuremberg's medieval dungeon in the basement vaults of the Nuremberg town hall show a depressing image of medieval jurisdiction. Since the 14th century, this ghastly place was used to keep prisoners until their execution. A visit to the dungeons today provides an authentic insight into the inhumane conditions of medieval prisons.

1.2 Supporting Visitors by Multimedia Guides

Until now the dungeons could only be visited with the help of a personal guide. Due to the given acoustic and organizational circumstances visits could not be arranged for large numbers of visitors. It was even more difficult to arrange for foreign-language visitors to experience the place properly.

The idea therefore arose to develop a mobile information system to take on the following three tasks: To guide the visitors safely through the dark catacombs, to offer exciting information about the past at the appropriate locations and to open the prison to new groups of visitors by providing barrier free content.

The role of the museum's staff was to be limited to unlock the vaults for the people to enter and to gather the visitors together again on completion of their tour.

2 The Solution

2.1 Using Indoor Localization

It quickly became clear that largely unaccompanied tours would only be possible if a digital indoor localization was used. The multimedia guide to be developed was to take on the role of escorting visitors and providing them with the necessary navigational guidance at certain key points.

A bluetooth based indoor localization system was installed to automatically trigger the navigational instructions and the transfer of information. A so-called "fingerprint technology" was chosen to realize these needs. This means that the characteristic signal strength of the installed beacons serves as the basis to calculate the position. Each position has a unique "fingerprint" consisting of multiple MAC/RSSI pairs.

Thus, the audio/video content is not triggered solely by the receipt of a single bluetooth beacon, but localization is carried out by the evaluation of several beacons and the resulting characteristic signal strength patterns. In this way, rooms, passages and areas can be precisely distinguished. At the same time, this technology is also extremely reliable because the triggering of the information does not depend on just one single beacon.

There were some challenges to overcome with the installation and configuration of the localization system. For example, some exhibition areas should be entered and gone through several times during the tour. Simple room recognition would not be able to cope with this because different information needs to be given each time the visitor enters the room. For this reason, a logical component was implemented into the software to track the previous path of the tour and take this into account when selecting the correct audio/video-track.

The advantages of digital navigation are obvious: The authenticity of this historic place has been preserved because no changes to the site were necessary for the installation of a classic signage.

Fig. 1: Automatically triggered navigational instructions

2.2 The Devices

Standard smartphones have been used for the media guides in the Nuremberg dungeons. The devices have therefore been integrated into a tailor-made and robust housing. The housing completely covers the device except for the display. The only hardware interfaces are a headphone connection and a sturdy charging socket. This ensures optimum protection even in the narrow corridors of the dungeons for these high-quality technical devices.

2.3 The Content

As advanced as the technology may be, in the end it only serves the purpose of providing the best possible support for the provision of information and fill almost empty spaces with life.

While developing content for multimedia guides, it is generally recommended to focus on things that visitors can't see in the real exhibition. These can be additional graphics and illustrations, interviews with curators or thematically related objects exhibited in distant places.

For example, in some areas of the Nuremberg dungeon, medieval graphics are presented to illustrate what prison conditions would have been at that time. The historical representations were carefully animated by our team to revive them and to enhance their effect. This was ultimately rather a balancing act, because obviously one must also take care not to upset visitors when conveying on topics such as "torture".

Fig. 2: Multimedia guide with animated content

The tours are greatly dramatically enhanced by the audio clips developed especially for the multimedia guide. These have been produced using several different speakers so that many different protagonists can have their say:
A condemned robber tells of his spectacular, successful jailbreak. Prominent inmate Veit Stoß complains about the scars inflicted on him during torture. The prison guard's wife scolds at the burden of cleaning the cells.

2.4 Including a Wider Target Group

History is told in stories. And it is available in German, English, Italian and Spanish. In order to make this cultural heritage inclusive and accessible to even more people, the guided tours are also offered in easy language and in German sign language. This also ensures barrier-free access to the interesting and also entertaining content.

Fig. 3: Content in German sign language

Reinstating Relevance of Indigenous Proverbs in Contemporary Societies

Victor Adelakun Omolaoye
Namibia University of Science and Technology
Jackson Kaujeua Street 5, Windhoek
Adelakunvictoromolaoye1@gmail.com

Heike Winschiers-Theophilus
Namibia University of Science and Technology
Jackson Kaujeua Street 5, Windhoek
hwinschiers@nust.na

Abstract

Proverbs are short, generally known sentences of the folklore which contain truth, wisdom, morals and traditional views in a metaphorical, fixed and memorisable form. However they have been reduced to historical artifacts instead of active wisdom for daily application in problem solving. We hypothesise that using proverbs to support humans in solving problems would make them retain and use such proverb(s) which aided their decision making. Our focus is on Yoruba proverbs of which digital repositories exist yet no contextualisation is supported. We present our proposed solution giving relevance to proverbs in contemporary societies using semantic technology which leverages graph technologies, human language processing algorithms and machine learning principles.

1 Introduction

Arugbo s'oge ri, ekisa l'ogba ri, o d'ifa fun pe inu ikoko dudu l'eko funfun ti n jade
meaning elders were once young, and old clothes were once in vogue.

Proverbs are short, generally known sentences of the folklore which contain truth, wisdom, morals and traditional views in a metaphorical, fixed and memorisable form. They are used to treat socio-psychological problems [DaPN10]. Proverbs also guide actions and thoughts, help in giving advice and they express general truth [Ezek17]. They had great significance in indigenous societies, and were employed to unravel knotted deliberations in council and settle disputes at home [Adey14].
The significance of proverbs in today's society cannot be undermined. Thus, attempts have been made to compile proverbs and to archive them both digitally and in print. However we consider present dissemination efforts inadequate.
They present users with simple lists of proverbs, to be browsed through. They are hard-coded, static, non-incremental, time-consuming, frivolous and unfriendly [ZhGi17]. Thus, proverbs still lack the relevance they once had in indigenous societies in our contemporary societies. As a result, contemporary societies lose out on the wisdom and truth embedded in proverbs.

However, when adequate information like definition of terms, explanation of metaphoric meanings and context of applicability are provided, Yoruba proverbs can be used to deal with social problems [Ezek17]. Developing a computer software that embeds proverbs in relevant contexts would considerably increase their usefulness, applicability and application to social problem solving and decision making in present day society. Furthermore, users of such an application would indirectly learn those proverbs and intuitively employ them in solving basic daily social challenges.

In this paper we present the concept of a globally accessible application that represents Yoruba proverbs with supporting technologies which apply proverbs to domain context in order to throw light to such a context. Our

preliminary study reveals a minimum of initially identified metadata about proverbs needed to automatically generate ontological representations required to identify, explain, interpret and apply best fitting proverb(s) to a domain context from a pool of proverbs and to develop an application to collect such metadata. Furthermore an engine and microservices automatically generates ontological representations from the collected metadata about proverbs, identify, explain and apply best fitting proverb(s) to contexts by reasoning. A user front-end allows for the supply of contexts to guide the retrieval of appropriate proverbs. Users can express the usefulness of the proverbs relative to the given or described context or situation.

2 Background

Many proverbs have been documented and analysed in print. Adebayo's "Owe in Yoruba fun Ile eko giga" is a compendium of Yoruba proverbs for higher learning(reference). Others include "Owe l'esin oro" and "Yoruba proverbs: Their meaning and usage". Another comprehensive compilation of these proverbs is "Yoruba Proverbs" by Oyekan Owomoyela. It contains more than five thousand (5000) Yoruba proverbs in print. The proverbs are organised by themes and are translated into English. [Adey14], [Ezek17] and several other researchers have analysed some of these proverbs thereby preserving them indirectly.

Furthermore, there are early digital preservations of yoruba proverbs. Nigeria Institute of Social and Economic Research (NISER), Institute of African Studies (IFRA), Cocoa Research Institute of Nigeria (CRIN) and several others have contributed towards preserving Indigenous Knowledge (IK) including proverbs [Adeb17]. Adeyemo's study revealed that proverbs and other IK are stored in traditional file system on disks while some are stored in relational databases. University College London (UCL) with the aim to broaden language horizon of students developed ATLAS (A Taste of Language at School) where several languages can be learnt. Yoruba language was included and some proverbs were documented on the platform. Being a platform aimed at giving a taste of the language, it does not contain a considerable amount of proverbs.

However, they have their short comings because they were not designed to aid problem solving. One of such is 'The good person', an expert from the book "Yoruba Proverbs" by Dr. Oyekan Owomoyela at the University of Nebraska – Lincoln (University College London (UCL)). Proverbs are classified into several themes including humility, self-control, self-knowledge, self-respect, and self-restraint; perspicaciousness (good judgment, perceptiveness), reasonableness, sagacity, savoir-faire, wisdom, and worldly wisdom; caginess , caution, moderation, patience, and prudence; perseverance, industry, resilience, self-confidence, self-reliance, resourcefulness, daring, fortitude, and invulnerability; consistency; honesty, openness, plain speaking, reliability; consideration, kindness, and thoughtfulness. Each section or theme has proverbs grouped into alphabetic headings. Each proverb has direct or first meaning [Owom04].
Another robust storage is Matti Kuusi international database of proverb type. This was aimed at classifying proverbs into types. The resulting types are enormous for daily application, thus suitable for educational purpose. The project was started by Matti Kuusi, a Professor of Finnish and Comparative Folk Poetry Studies (today called folkloristics) at the University of Helsinki from 1959 to 1977 [Lauh01]. He compiled quite a number of cross cultural proverbs and created a card reference system for them. He aimed at revealing the relationship between proverbs from different cultures. The card index system being manual had a very great short coming, and managing such a huge data is difficult, until he got to know about paradox – a database management system. The project was furthered by Academia Scientiarum Fennica and his daughter. The outcome of the project is a system which classifies proverbs into "universal types" and reveals proverbs with equivalent meanings but from different cultures, [Lauh01].

Finally, we consider the work of Maayan Zhitomirsky-Geffet and Gila Prebor. They defined a multidimensional ontology with well-defined classes and relationships that separates explicit terminology classes from semantic meaning classes which was aimed at easing proverb retrieval [ZhGi17]. The application for which an ontology is created determines the definition given to objects of such ontology [NoMc01]. Therefore, the information about each proverb in the multidimensional ontology

defined by Maayan Zhitomirsky-Geffet and Gila Prebor are limited to those sufficient to ease retrieval but not to ease or aid solving socio-environmental challenges or social decision making by exposing the advisory content of proverbs to humans.

3 Theoretical and Empirical Considerations

Our project seeks to give relevance to proverbs in contemporary societies in order to avail the wisdom, advice and truth embedded in proverbs to modern societies. We hypothesise that using proverbs to support humans in solving problems would make them retain and use such proverb(s) which aided their decision making. Whereas, several methods have been used to conserve and give relevance to proverbs in contemporary societies, we intend to explore alternative technologies and harness it's prowess in giving relevance to proverbs. Therefore, we conceptualise and propose a globally accessible application that represents Yoruba proverbs with supporting technologies which apply proverbs to domain context in order to throw light to such a context. A typical scenario could be a user entering a statement like 'I feel schooling is taking too long' to the system and in turn get a proverb like 'Rome was not built in a day'. Without much explanation, an advice has been passed to the user. We anticipate that such system can be adapted to represent other indigenous proverbs.

3.1 Proverb Representations

Our hypothesis that "a user of a computer application that aids solving social problems would use (remember, apply, suggest to others) proverbs the system suggested" raises two questions which must be answered sequentially. The first being can computers support (identify, explain and apply) humans in selecting relevant proverbs to a context? And secondly, if yes, will people use (remember, apply, suggest to others) computer suggested proverbs that aided their decision making? Answering the question 'can computer systems support humans in selecting relevant proverbs to a context' demands, we conceptualise a computer understandable representation of proverbs. After which an application that uses such representation can be implemented and tested. We can then conclude whether computer

can help or not. We therefore set to design a computer understandable representation of proverbs. Designing this representation raised a question on how humans determine a suitable proverb for a context out of a pool of proverbs in human memory. In order to answer how humans determine a suitable proverb for a context, we needed to know how the meanings of proverbs are derived. Finally, we can determine the technology and data structure best suited to represent proverbs. A sequence of questions therefore, needed to be answered to achieve our first aim. Each question and the method(s) used to answer them are discussed in the following sections.

3.2 How Humans Derive the Meaning of Proverbs

We reviewed literature on proverbs and metaphors in order to know how humans derive the meaning(s) of proverbs. A proverbial expression can be looked from at least four standpoints which are 'what is the proverb decoded to mean?', 'what do the words mean?', 'what does the speaker mean?' and 'how does the listener interpret the proverb?' [Gran11]. There are pros and cons to each approach. The first case ignores interpretation and context. Interpretation is bound to the meaning of words in some space (time and place) in the second case. However, when looking at the words and the meaning of the sentence in a new space, the meaning might appear absurd. In the third case the speaker gives the meaning to the proverb. This approach is problematic because the intention of the Speaker (or writer) is not really known. The fourth case deals with the listeners' perception [Gran11].

But proverbs are best applied to contexts [Akba12] [DaPN10]. This makes us eliminate the 'what is the proverb decoded to mean' approach to deriving the meaning of a proverb for this study. Also, unknown intention of a writer makes the 'what does the speaker mean' approach problematic, hence, we eliminate this standpoint for this study. We therefore adhere to 'what do the words mean?' and 'how does the listener interpret the proverb?' approaches in deriving the meaning of proverbs.

Our conclusion is that, the resulting data structure or representation of a proverb in our pool of proverbs should accommodate a representation of the meaning of the words making up a proverb and the meaning of the proverb so that the listener would have the same interpretation as the system.

3.3 Meaning of Proverbs and Their Metaphoric Nature

Having understood how the meanings of proverbs are derived, the metaphoric nature of proverbs poses another question on how metaphoric proverbs derive their meanings. Proverbs are metaphoric in nature and this property obscures meaning but increases range of application to contexts. The most important and the best known models of interpreting metaphors are Comparison Theory, Interaction Theory, Intention Theory, Literal Interpretation and the Possible World Semantics Theory [Gran11]. The metaphor in the Possible World Semantics Theory has been less used [Gran11]. Comparison theory bases interpretation on comparing. When thinking about proverbs, it means either looking at the words (compositional principle) or the whole sentence (contextual principle) [LaTu89].

Normally, according to the Interaction Theory, the literal interpretation is not possible. The interaction theory makes all proverbs fit into every context [Orto80]. The Intention Theory places interpretation on the intention of the speaker. The Literal Interpretation also called one-world metaphor bases interpretation on the words in a proverb and their meaning [Hintikka94]. This theory reduces proverbs to mere statements. The idea of the Possible World Semantic (PWS) Theory is that in order to understand the meaning of a term, we should understand the extension of the term both under the present circumstances and also its extension under other kinds of circumstances [LaTu89]. This theory permits both figurative and lexical meanings of proverbs [Gran11]. Based on 'how interpretation is derived', 'possibility of figurative interpretation', 'possibility of lexical interpretation' and 'range of fitting context' shown in table 1; we conclude the resulting proverb data structure to be derived in this study should allow machines interpret metaphoric meaning based on comparison theory and possible world semantics. For every metaphoric word or phrase, there are possible meanings attached to them.

S/N	Models of Interpreting metaphors	How interpretation is derived	Figurative Interpretation	Lexical / Literal Interpretation	Context Fit	Comment
1	Comparison theory	Comparing words or whole sentence with context	Possible	Possible	Related contexts	Excludes literal interpretation
2	Interaction theory	Relation between situation and utterance	Possible	Impossible	All contexts	Can possibly make proverbs irrelevant to context
3	Literal Interpretation	Direct meaning of words	Impossible	Possible	No context	Not applicable to context
4	Intention Theory	Intention of the speaker	Possible	Possible	Related contexts	human intention which can be biased
5	Possible World Semantics	Understanding the meaning of words in present circumstance and other possible circumstances	Possible	Possible	Related contexts	Meaning changes as emphasis changes

Table 1: Models of interpreting metaphors

3.4 Empirical Observations of Applying Proverbs

An adept user of proverbs has a collection of known proverbs from which s/he pulls proverbs to address a context. The question that needs address at this juncture is how humans determine suitable proverb(s) for a context. We did a rapid ethnographic investigation to unravel the intuitive process of identifying proverb(s) that addresses a context. We identified ten skilful Yoruba proverb users for interview. Due to distance barrier, the respondents were contacted online using the WhatsApp messaging platform. Respondents' access to internet, knowledge of English, adeptness in Yoruba proverb usage, readiness to participate in the research are some conditions considered in the choice of participants. The one on one

interview took the form of a regular chat. Ten adult respondents were interviewed. Five male and five female. The main question the respondents were asked is, what informs the proverbs you apply to contexts? The question is open ended and it allows the participant to talk without coercion. 'The art of applying proverb(s) to a context is intuitive' quoting one of the respondents. Their responses were mostly examples and scenarios of applying proverbs. Thus, they were told to describe while observations were made. Observation in this case is on the words participants used to express themselves. Those words further raised different questions until their points were clear to us. Two of the respondents were unable to express themselves basically due to lack of sufficient language skill.

3.4.1 Thematic Analysis of Observations

The observations made were coded (similar observations were merged into a code) and clustered (similar codes were classified) into the following themes as shown in Fig 1: Audience attributes, personal attributes, context attributes and proverb attributes.

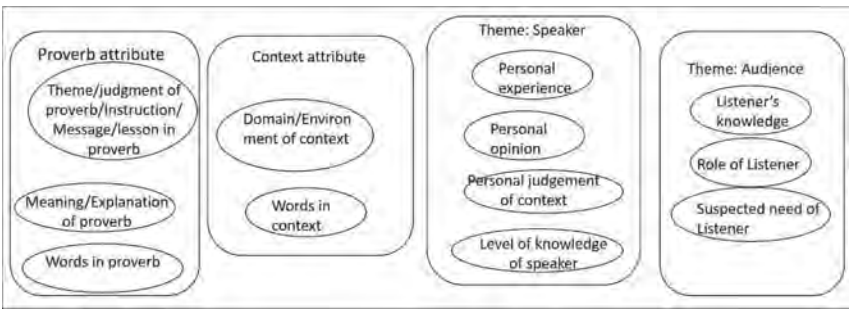


Fig. 1: Themes of coded observation

The thematic analysis revealed that attributes of a proverb namely constituing words, metaphoric meaning of words and direct meaning are not sufficient to determine its applicability to a context. Attributes of the context, speaker and audience must be considered. These attributes are intuitively used by Yoruba proverb users to questions the memory before a proverb is chosen and applied to a context. Some of these possible intu-

itive questions and corresponding possible computer queries in natural language are shown in Table 2.

Theme	Code	Possible Intuitive questions human ask	Corresponding possible natural language query
Proverb Attribute	Theme/judgment/ Instruction of proverb	What is the theme or instruction in the proverb?	What is the lesson the proverb teaches? (Q1)
	Words in a proverb	What are the words in the proverb? What is the meaning of the word(s)?	What words or group of words have meaning in the proverb? (Q2) What is the lexical meaning of those words? (Q3) What can a metaphoric word or group of words mean in a context? (Q4)
	Meaning/Explanation of the proverb	What is the meaning of the proverb?	What is the primary meaning of the proverb? (Q5)
Context Attribute	Domain/Environment of context	What is the domain/ environment of the context the proverb is to be applied to?	Which domain does a proverb primarily fits into? (Q6) What other domains can the proverb fit into? (Q7)
	Words in context	What are the words describing the context?	Which word or group of words are fundamental to the meaning of the context? (Q8)
Audience	Listener's knowledge	Does the listener understand the proverb?	Does the listener understand the proverb? (Q9)
	Role of listener	What is the role of the listener?	What is the role of the listener? (Q10)
	Suspected need of the listener	What is possibly the need of the listener?	What lesson can be passed across to the listener? (Q11)

Table 2: possible intuitive questions and corresponding possible computer queries in natural language.

A critical observation of the following pairs of questions (Q1,Q11), (Q2,Q8), (Q3,Q8), (Q4,Q8), (Q5,Q9), (Q6,Q10), (Q7,Q10) reveals that speakers intuitively question their repository of proverbs and the context described with similar questions. They then compare the results and apply the proverb which has common responses to the context. We observe that there is a need for a module which answers questions Q8, Q9, Q10 and Q11 from user supplied context. Having answered the questions that arose in the of course designing a data structure for proverbs, we consider the following to be some of what informs the application of proverb(s) to context(s):

- Lesson the proverb teaches
- Lexical meaning of a word or group of words that constitute the proverb
- Metaphoric meaning of words or group of words that constitute the proverb
- Primary meaning of the proverb (Translation and Interpretation)
- Primary domain the proverb can be used
- Other domains the proverb can be used
- The role of listener in a domain
- Domain of context

3.5 Resulting Data Structure of Proverb

Having understood how humans derive the meaning of a proverb and how humans determine the suitable proverb(s) for a context, we can define a proverb as an object with attributes namely content, lexical meaning of a word or group of words that constitute the proverb, metaphoric meaning of words in the proverb, translation, interpretation (relative proverb in destination language), primary domain the proverb can be used (e.g. family, work place, community, government etc.), other domains the proverb can be used, the role of the listener in a domain (victim or actor or observer) and lesson the proverb teaches. Thus, a proverb can be encoded in any suitable knowledge representation format like XML, JSON, Frame and RDF. For visualization purpose, we represent a Yoruba proverb as a graph and shown in Fig 2.

Fig. 2: A graph representation of a Yoruba proverb 'omode gbon, agba gbon lafi da ile-ife'

3.6 Proverb Definer

Whereas, there are computer applications versatile for defining data structure especially ontological representations, upon an exploration of these applications, we see the need to implement an application with the main purpose to define proverbs according to specification. This application will be used by proverb users to analysis (supply minimum information) proverbs and the application will generate a definition or ontology for such proverb.

4 Conclusion

Having designed a computer understandable representation of proverbs and a definer, of importance is the design of an application capable of using the defined proverbs. The resulting application would imitate a human proverb user as much as possible. As mentioned earlier, humans store proverbs in the memory and retrieve appropriate ones for contexts. Medical research reveals that human memory is a graph of linked neurons. Hence the artificial proverb user would have a graph database to store proverbs. And the structure of the proverbs would be as defined above. We

noted earlier the importance of a module to extract information needed to answer some questions from the human supplied context which will server as filters for the query against the database.

4.1 Components of an Artificial Proverb User

The basic components of an artificial proverb user include a graph database or any semantic enabling data storage system, human context analysing application and the proverb retrieval application. Fig 3 shows a block diagram of such application.

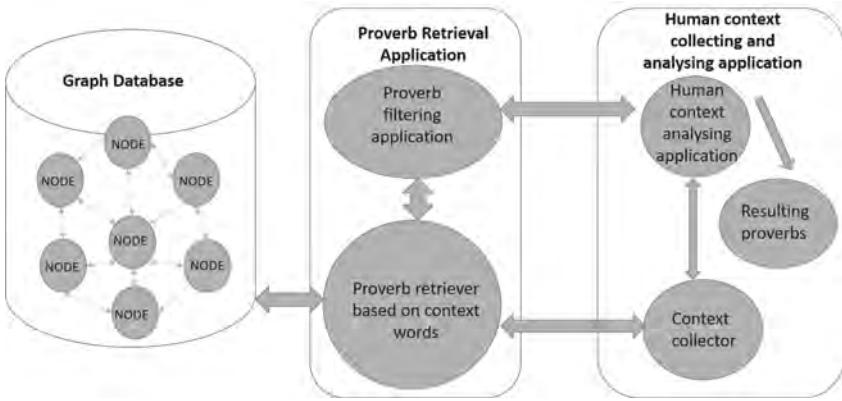


Fig. 3: Block diagram of artificial proverb user

The graph database holds a pool of proverbs and relationships between their attributes. The attributes are mentioned in earlier section. Leveraging graph technologies would ease retrieval. It should be noted that implementation would require some other data and relationships for efficiency. Such data will be determined by developers. Furthermore, the human context analysing application should extract the possible lesson a user needs, domain of context the user described, words in the described context and role of the user in the context. Finally, the retrieval application should retrieve proverbs based on the words in the described context and filter them based on the result of the human context analysing application.

4.2 Implementation Process and Further Works

Implementation of the prototype system should accommodate a learning process especially for the the human context analysing application. A

way is to intially request users to fill in a form containing user expected lesson, context domain and role of the user in the context along with the context described. Over time, the application should learn how to deduce those parameter without user filling forms. The competence of its learning should be tested before the form filling is deprecated. Competence testing can be implemented by suggesting its answers to the user and requesting the user to endorse or modify its suggestion.

4.3 Summary

We have described the process we took in designing a computer understandable representation of proverbs which would avail that computers support humans in selecting relevant proverbs to context.We further designed a proverb analyser, prototype artificial proverb user and described an implementation process of the prototype. We plan to implement and test the prototypes we have designed in our subsequent works and thereby answer the question 'can computers support humans in selecting a relevant proverb to a context?'

Literature

[Adeb17] Adebayo, J. O. (2017). Documentation and Dissemination of Indigenous Knowledge By Library Personnel in Selected Research Institutes in Nigeria. Library Philosophy and Practice (e-Journal).

[Adey14] Adeyemi Ademowo, N. B. (2014). Proverbs,values and the Development Question in contemporary Africa: a case study of yoruba proverbs. Antropologija, 2, pp. 149–163.

[Akba12] Akbarian, I. (2012). What Makes a proverb? the case of NYC's Dictionary of Proverbs and Cliches. https://doi.org/10.1177/1942602X08324904

[DaPN10] Dabaghi, A., Pishbin, E., & Niknasab, L. (2010). Proverbs from the Viewpoint of Translation. Journal of Language Teaching and Research. https://doi.org/10.4304/jltr.1.6., pp. 807–814

[Ezek17] Ezekiel Tunde, T. K. (2017). An analysis of the proverbs the Yorubans live by.pdf. Education Resource Information Centre, pp. 1–14.

[Gran11] Granbom-Herranen, L. (2011). How Do Proverbs Get Their Meanings? the Model of Interpretation based on a metaphor theory, (10).

[LaTu89] Lakoff, G., Turner, M. (1989). More than cool reason. A Field Guide to Poetic Metaphor.

[Lauh01] Lauhakangas, O. (2001). The Matti Kuusi International Type System of Proverbs. https://doi.org/10.1353/ort.2013.0016

[NoMc01] Noy, N. F., & McGuinness, D. L. (2001). Ontology Development 101: A Guide to Creating Your First Ontology. Knowledge Systems Laboratory Stanford University, 25. https://protege.stanford.edu/publications/ontology_development/ontology101-noy-mcguinness.html

[Orto80] Ortony, A. (1980). Understanding Metaphors. Natural History. https://doi.org/10.1145/2505515.2507827

[Owom04] Owomoyela, Oyekan. (2004). Yoruba Proverbs: The Good Person. Retrieved December 12, 2018, from http://yoruba.unl.edu/yoruba.php-text=8&view=0&uni=0&l=0.htm

[ZhGi17] Zhitomirsky-Geffet, Maayan & Gila Prebor, O. B. (2017). Improving Proverb Search and Retrieval with a Generic Multidimensional Ontology. Journal of the Association for Information Science and Technology, 68(1), pp. 141–153. https://doi.org/10.1002/asi