Towards Preservation and Availability of Heterogeneous Cultural Heritage Research Data via a Virtual Museum

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Abstract: Responsible use of cultural heritage requires networking of different research approaches and documentation techniques from different disciplines, as well as, the appropriate preservation and multi-functional availability of research data. Furthermore, the provision of information and the transfer of knowledge to the public are also indispensable for social acceptance and responsible and conscious handling of cultural heritage. Especially, with extensive collaborative research, this can lead to major challenges due to different data formats and requirements for the analysis and provision of data. It is, therefore, useful to first identify requirements on an informed basis. For this purpose, we demonstrate the handling of data from a research network based on the ancient cultural heritage in Trier (Germany) through a virtual museum. This museum splits into three levels of metadata abstraction and is represented by three parts: an entrance through a web front-end, a 3D museum's lobby, and a 3D open-air museum.

Keywords: virtual reality, research data management, cultural heritage, virtual heritage, archaeology, data integration, human-computer interaction

1 Introduction

Research data management in cultural heritage often may benefit from Virtual Reality (VR) applications. A high share of data represents reconstructed archaeological sites, which is profitable when visualized in explorable 3D space [San06, ZCG05]. A second and not less important share is the presentation and involved experience of ancient life: of people, their behavior, rituals, etc. While this part of knowledge is often underrepresented in immersive cultural heritage (virtual heritage) applications [TR09], the reason for it is not that VR is not the appropriate medium but that it is very difficult and expensive to implement. However, the possibilities to create plausible experiences of ancient cultures in VR is unlimited. Thus, VR seems to be an overall valid medium for research data management in cultural heritage but it is not. There is a lot of data that is not properly visualizable in VR. Text is omnipresent data in archaeology and cultural heritage but it is hard to read in today's VR displays and even worse, difficult to browse and search. Furthermore, a lot of data is not attached to a specific place, but rather to a region or only to a point in time or tribe. These data

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are storable in a knowledge graph and for instance much better explorable in a desktop or web-based application. Then, web-based access to cultural heritage research data [MRB18, DCB+17] seems to be more open, as nearly anybody can access it even independently of the device. On the other side of accessibility, VR seems to have the opportunity to attract and thus include especially younger people to cultural heritage [DLL11].

With this project, we want to combine the advantages of both technologies. The entry point for this will be a web front-end, which tries to exactly position and define a multi-level transition between desktop (web-browser) and VR content to create a prototype for an accessible, dynamic, seamless and consistent platform for the management and exploration of research data management in cultural heritage, such as demanded by Champion [Cha16]. This prototype will visualize the content from a given research network that best matches a web-platform, in the web (see Section 3.1) and content that best matches VR, in VR respectively (see Section 3.3). Both are connected and linked data-wise by common data back-ends, technological-wise linked by *WebGL*, and metaphorically linked through a virtual museum's lobby, which visualizes data from both platforms to seamlessly recognize and carry the data from one medium to the other (see Section 3.2).

2 Related Work

Cultural heritage in VR (sometimes referred to as Virtual Heritage) is very common and constantly developing over about two decades now. There are virtual museums of Troy [KJ01] (2001), Koguryo [PCP06] (2006), Leicester [HBE+12] (2012), and Dudsbury Hillfort [JHCM18] (2018), to just name a few. However, rarely there is space intended to hold cultural heritage metadata outside of pure architectural sites.

On the other side, there are many approaches that catalog parts of cultural heritage on the web. As an example may serve the work of Dellepiane et al. [DCB+17] describing a process to transfer paper-based catalogs collecting pottery types into the web. Those approaches often already include web-accessible 3D renderings or 360° videos, such as Atalaya3D [MRB18], which combines the cultural heritage (including 3D scans of sculptures and buildings) of ten public Andalusian universities. Lercari et al. [LTSO11] successfully ran an experiment to reconstruct the Piazza di Porta Ravegnana (Bologna, Italy) user-driven in Second Life utilizing different web-services, such as *Google Maps*, *Panoramio*, *Google Docs*, and *Google Warehouse*.

However, to the best of our knowledge, there is currently no project that actively tries to combine the strengths of web-based content and VR in a data-centered, seamless cultural heritage experience, which is the goal of the initiative described in the following.

3 Ancient Cultural Heritage Trier (AKuT)

In this proof of concept we aim at the plausible integration of heterogeneous research metadata in cultural heritage. The project tries to do pilot testing in this field, to uncover

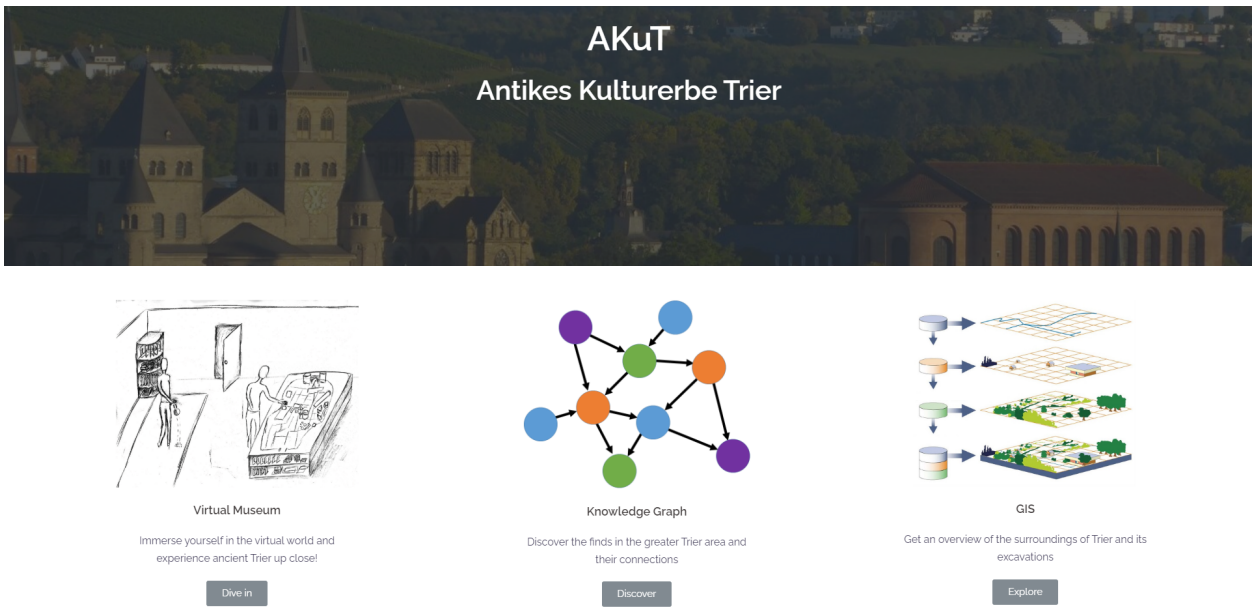

Figure 1: Screenshot of AKuT's current website (`https://akut.uni-trier.de/`) serving as an entry point, showing from left to right links to the 3D museum's lobby, the interactive knowledge graph visualization, and the web GIS visualization.

challenges, and possibilities that are meant to be discussed in a final, interdisciplinary workshop around the topic. The result of this discussion should initiate a research alliance, which further tackles the raised challenges to commonly benefit from its possibilities. The city of Trier serves as an example for the prototype with its rich history including several sites belonging to the UNESCO world heritage. The city was founded in the last decades of the 1st century BC as Augusta Treverorum and is recognized as the oldest city in Germany. In the late 3rd and 4th century AD, Trier became one of the capitals of the roman empire and an imperial residence.

3.1 The Entrance & Archive

The central access point, and still under development, is a website created with *wordpress*. Next to general project information, it provides three parts (see Figure 1). First, a web GIS (geographic information system) visualization holding excavation information in an interactive map of a larger area around Trier in form of excavation protocols, reports, and photographs. Second, an interactively browseable network visualization of a knowledge graph. Like a catalog, this knowledge graph holds all available media, thus including data that is also available through the web GIS but extended by data that is not precisely locatable (here documentation data about the imperial residence Konz, about 7km in the southwest of Trier). While the visualization of the knowledge graph is done with the *vis.js*-library, the back-end is implemented with *node.js express*. The database holding all the information for the knowledge graph is implemented with *Apache Jena Fuseki*. Unlike a catalog, a knowledge graph is organized in relations (linked-data), which meets the requirements of the hetero-

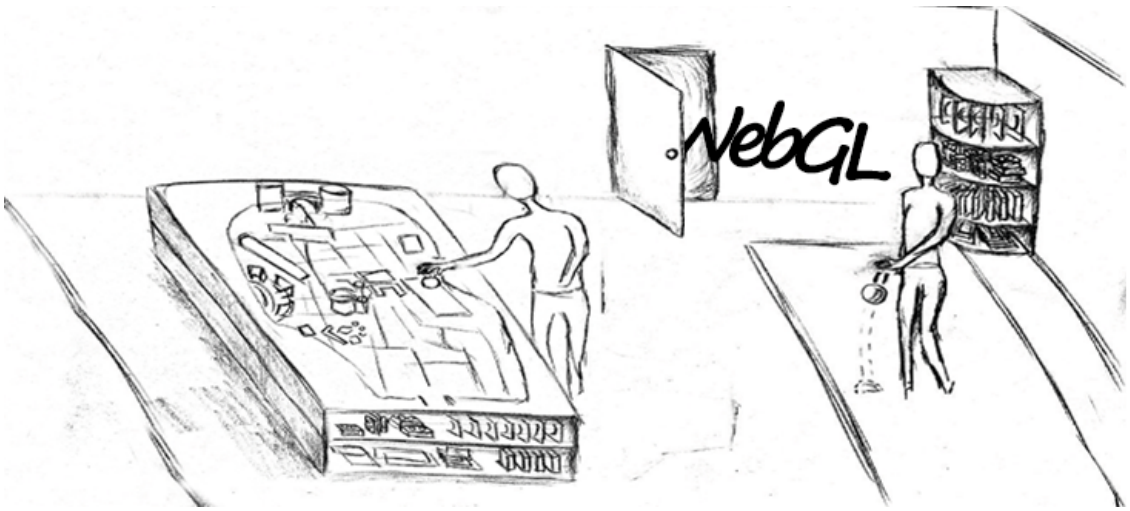

Figure 2: Concept of the museum's lobby, including a media shelf in the corner of the room, a web GIS visualization on the floor, and a miniaturized model of the reconstructed ancient city.

geneity of data types and formats well and naturally gives the possibility to explore the data through links and adds a further perspective. Third, there is a gateway to the 3D museum's lobby (see Section 3.2), which is accessible by staying with the screen or switching to a VR device. Both are possible by using *WebGL* to visualize the 3D environment developed in Unity via Mozilla's *WebXR Unity plugin*.

3.2 The Museum's Lobby & Immersive Archive

The so-called museum's lobby is a 3D modeled room (see Figure 2), which serves as a connector between web content (see Section 3.1) and the virtual reconstruction of the city of Trier as an open-air virtual museum (see Section 3.3). This connection is made on two different levels. First, the lobby provides an entrance to both media. There is a large TV screen on the room's wall showing the website and selecting it leads back to the website. Then, there is a table showing a miniaturized model of the reconstructed ancient city. Interacting with this table allows the visitor to directly teleport into the city. Second, the lobby also accesses the available data and media and displays it as books, CDs, and image folders on shelves and a large walkable map visualization of the web GIS visualization on the floor. This way, the data is also available and explorable in VR, obviously in a less efficient but more playful way. The most important point is that the data connects all parts of the museum. Thus, in our vision, it is possible that the users link (c.f. the concept of *linking and brushing*) and collect metadata in all parts of the museum in the way they want. For instance, they may take some texts and photographs with them into the open-air part of the museum, the 3D reconstructed Augusta Treverorum.

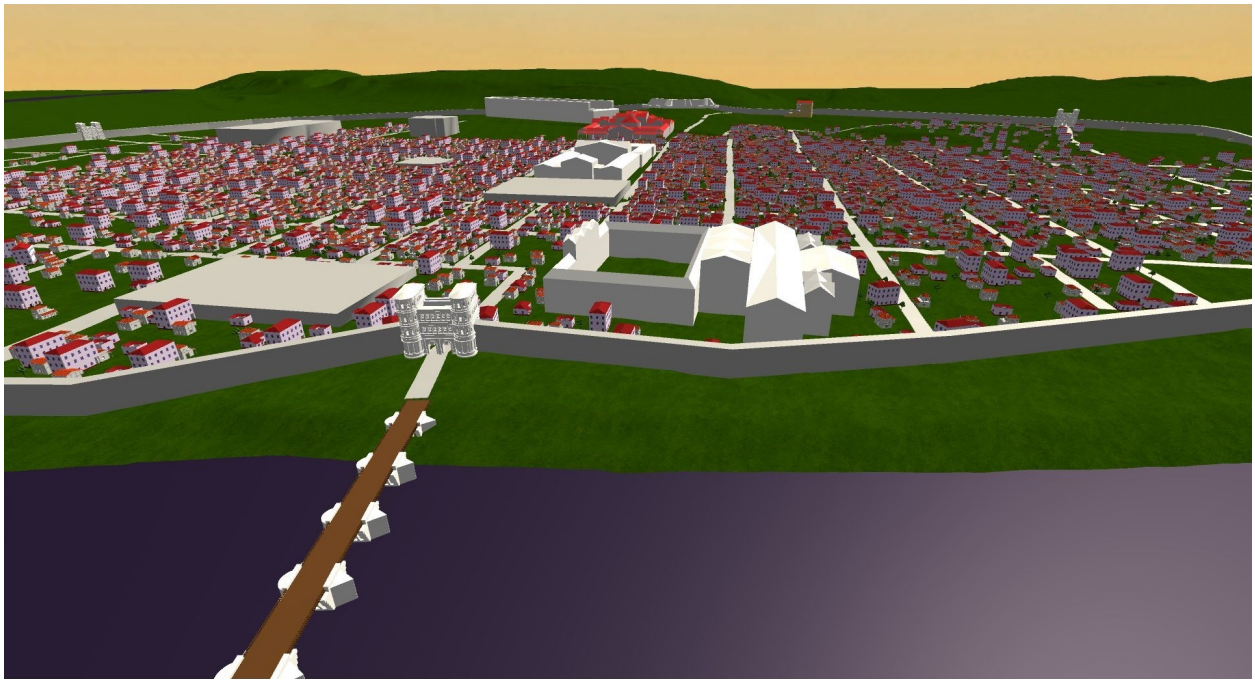

Figure 3: Screenshot of the open-air museum, currently a rough reconstruction of the ancient city Augusta Treverorum (Trier 400 AD). In the foreground one of the gates, the Porta Inclyta, as well as, the until today partially preserved and still used bridge across the river Mosel.

3.3 The Open Air Museum

Last but not least, a 3D reconstruction of Augusta Treverorum (Trier 400 a.d.) is provided (see Figure 3). This part of the museum is in constant development and one reason is that it actually does not only represent Trier 400 AD but aims to cover the whole history of the city founded in the 3rd century by the Romans. Currently, we are working on a demonstrator for this, concentrating on the different phases of the imperial palace and its immediate surroundings. In the finished proof of concept, we will provide the manipulation not only of the location but also of time. Today, the user already can virtually travel the whole city [ZLW20], containing different grades of reconstruction. The whole model of the city is dynamically recreated by our software with every launch, then always including the latest additions and changes. If the users want to go back to the lobby, they can simply lookup. There, they find a transparent ball in the middle of which the lobby is visualized. If they reach for it and throw it to the ground, they are teleported into the lobby. The reconstruction is just in its beginnings. There are not only missing buildings and details but also a convincing ancient life around the visitor.

4 Conclusion & Future Work

We have proposed our concept and first implementations of piloting towards the integration of heterogeneous research data in cultural heritage with the example of the ancient city

of Trier and its surroundings. We have created a virtual museum in three interconnected parts representing different layers of abstraction, each allowing for a different viewpoint and each integrating the subset of metadata that matches the given technology and metaphor. We are very excited to see which issues, challenges, and chances rise during the further progress of the project and in which ways the platform is used by researchers, scholars, and interested. We are looking forward to discussing these points in a broader audience and thus, make decisions and designs for broad use in the future. Next to finishing the proof of concept there is a lot of room to improve and extend. We want to go deeper into the 4D visualization of uncertainty that exists when visualizing time phases of archaeological sites. Then, the back-end, which was just scratched here and is integrating all the metadata and allowing for a dynamic and time-dependent city creation, is been further developed. Finally, there is a lot of room for better integration of one specific and crucial part of cultural heritage, namely the people and their life.

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