# Towards Discovering Meaningful Historical Relationships in Virtual Reality

Melanie Derksen*
TU Dortmund University

Tim Weissker†
RWTH Aachen University

Torsten Kuhlen‡
RWTH Aachen University

Mario Botsch §
TU Dortmund University

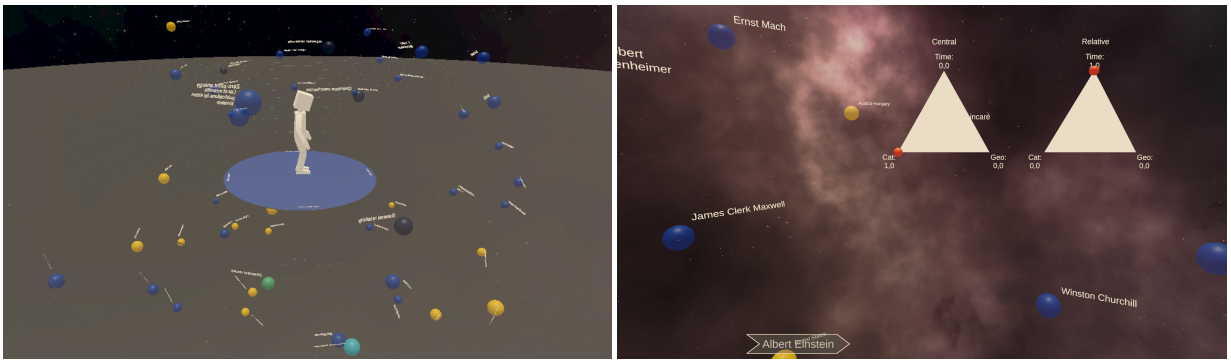


Figure 1: We present a tool for exploring historical data in virtual reality. Fragments are represented as colored and labeled spheres floating in space and their arrangement gives clues regarding the fragments' interrelationship (left). The user can modify based in which attributes the fragments should be arranged and explore the scene from an immersive egocentric viewpoint (right).

## Abstract

Traditional digital tools for exploring historical data mostly rely on conventional 2D visualizations, which often cannot reveal all relevant interrelationships between historical fragments. We are working on a novel interactive exploration tool for historical data in virtual reality, which arranges fragments in a 3D environment based on their *temporal*, *spatial* and *categorical* proximity to a reference fragment. In this poster, we report on an initial expert review of our approach, giving us valuable insights into the use cases and requirements that inform our further developments.

**Index Terms:** Human-centered computing—Visualization—Visualization techniques; Human-centered computing—Visualization—Visualization systems and tools

## 1 Introduction

Exploring historical relationships requires the analysis and comparison of different sources that are often difficult to interpret without specialized domain knowledge. To assist learners with this process, several digital tools have been proposed that provide curated interactive visualizations like maps, timelines, or graphs. While some tools like *Palladio*[1] are more tailored to the purpose of presenting finished research results, others like *HisVA* focus on an active learning process while interacting with the data, which is claimed to be more beneficial than traditional textbook-based learning [1]. However, historical exploration tools to date are all based on classic 2D visualizations, which are inherently optimized for demonstrating attribute relationships along only two spatial dimensions. Unfortunately, this is often not optimal to discover more complex interrelationships between historical fragments (e. g., contemporaries or events), which still requires considerable manual efforts. Wagner Filho et al. [3] stated that exploring 3D scatter plots with an HMD leads to a smaller effort in finding information and offers a much larger subjective perception of accuracy and engagement as opposed to desktop applications but may suffer from occlusions. Therefore, we decided to work on a novel interactive exploration tool for historical data in virtual reality. By adding a third spatial dimension the position of a historical fragment can be influenced by more than two attributes, which allows to make complex interrelationships more directly visible. To overcome occlusions, the user is put into the center, which in addition leads to a larger exploration space.

In this poster, we present our work in progress and report on the results of an initial expert review of our basic approach, which led to the following contributions:

- the introduction of a novel 3D visualization of historical data in virtual reality,
- the positive results of an initial expert review with domain experts informing our further developments.

Based on our results, we believe that our tool, once further developed, has the potential to serve as a viable supplement to conventional historical exploration methods.

## 2 Immersive Exploration of Historical Data in VR

Our prototype builds upon the historical databases *DBPedia*[2] and *WikiData*[3] to retrieve important historical fragments as well as connections between them. We embed fragments relevant to a specific reference fragment in a 3D virtual environment which can be experienced with an HMD.

### 2.1 Visual Appearance of Historical Fragments

In our visualization, the user is standing on a circular platform that is labeled with the name of the currently selected historical fragment. All other fragments that are related to it are represented by labeled floating spheres that surround the user (see Fig. 1). Selecting one of the fragments with a ray pointer attached to the user's controller makes it the new reference fragment and updates the visualization,

*e-mail: melanie.derksen@tu-dortmund.de
†e-mail: me@tim-weissker.de
‡e-mail: kuhlen@vr.rwth-aachen.de
§e-mail: mario.botsch@tu-dortmund.de

[1] http://hdlab.stanford.edu/palladio/

[2] https://www.dbpedia.org
[3] https://www.wikidata.org/wiki/Wikidata:Main_Page

which enables to explore the database by selecting the topics and concepts of interest. While a sphere's color indicates its fragment's category (e. g, agent, event, ...), its size is related to the number of sources available in the corresponding article on *DBPedia*.

### 2.2 Arrangement of Fragments

The spheres' positioning depends on their fragments' *temporal*, *spatial* or *categorical* proximity as well as on a weighted combination of those attributes. Appropriate UI elements allow to modify the respective weights independently (see Fig. 1 (right)). The distance measure is used on the one hand to arrange the related fragments among themselves and on the other hand to point out the relation to the currently selected fragment at one glance. It serves as an input metric for the *UMAP* algorithm [2]. With the haversine as its output metric, *UMAP* finds a suitable arrangement of the related fragments on a spherical shell around the user. If the *spatial* attribute in the input metric has a high weight, fragments will aggregate into clusters if they share locations with a short distance. Moreover, it provides insight into the relation of surrounding fragments to the currently selected one. Consequently, fragments with a high proximity based on the three attributes are placed closer to the user.

## 3 Expert Review

To evaluate if our new data visualization is understandable, interpretable and thus helpful in exploring historical data, we conducted an expert review.

### 3.1 Procedure

Participants came to our lab, were informed about the purpose of the study and agreed to participate voluntarily. After a short guided tutorial of the system by the experimenter, they were given sufficient time to familiarize themselves with the system. Once they were satisfied, the experimenter asked four content-specific questions that participants should answer using the system, which related to analyses of category frequencies, peoples' lifespans and events that took place at a certain historical location. After all four questions were explored, a short semi-structured interview was conducted to learn more about the perceived usability and potential use cases of the application.

### 3.2 Results and Discussion

3 participants (1 female and 2 males) between 26 and 29 years of age attended the expert review. All of them have a Master's degree and are research assistants working in the field of history. They were hence able to provide valuable feedback and suggestions regarding our project, which is summarized in the following paragraphs.

Use Cases All experts agreed that the presented application is especially helpful at the beginning of a research process. It can be useful for collecting ideas, inspiration, forming and specifying research questions and providing an overview of a topic. In addition, undiscovered connections as well as gaps of knowledge can be identified. Furthermore, one expert explicitly highlighted the suitability of our tool for teaching historical relationships, while two underlined the ability to communicate research insights to laypeople in a comprehensible way.

Interpretability According to the experts, the new visualization can be interpreted well and allows to draw historically relevant conclusions, since the arrangement of the fragments can be modified based on one's own interest by adjusting the corresponding attributes weights that influence the distance calculation.

Suitability As stated by all the experts, the third dimension is very exciting, useful and helpful because more information can be encoded than in 2D representations. This shows non-obvious connections that otherwise would not be recognized immediately. It stands out from the classical exploration process based on texts due to the increased embodiment, walkability and engagement afforded by virtual reality systems. Furthermore, the abstract representation was described as very neat and pleasant by one expert.

However, since VR is new to the field of history, two of them also pointed out that the handling of the hardware as well as the initial effort in learning the interpretation of the visualization should not be underestimated. It was therefore suggested to offer a standardized tutorial, in which all features are explained clearly such that the tool can be learned without the help of a professional instructor.

Distance Measure Attributes One expert suggested to replace the *categorical* attribute on the central distance by a *semantic* distance that communicates content-related connections more clearly. Furthermore, one expert suggested an attribute like *source* for the relative distance to cluster data points that originate from the same institution or author. The *temporal* and *spatial* attributes were considered very helpful by all experts. Likewise, especially the ability to cluster the spheres relative to each other by their *category* was found to be helpful.

Further Comments Interacting with the application was considered to be complex initially and might be overwhelming, but the experts estimated that our system would be fast to learn during repeated usage. Experts also missed a feature that shows the relationship between two fragments in exact numbers. Besides, only little functionalities for interacting with the data beyond basic parameter adjustments and jumping between fragments are offered.

## 4 Conclusion and Future Work

We introduced a novel interactive exploration tool for historical data in virtual reality in which historical fragments are arranged based on their *temporal*, *spatial* and *categorical* proximity. The results of our expert review pointed out that the presented application is useful, e. g., for forming and specifying research questions, gaining an overview of a topic and finding undiscovered relations between historical fragments or knowledge gaps. Our visualization was found to be well interpretable and pleasant to look at. In addition, the 3D virtual space in general was perceived as engaging.

Future work will focus on the development of more advanced features like highlighting spheres, allowing to transform the whole constellation and providing detailed information on fragments as well as on how two specific fragments are related to each other.

As a result, formal usability studies involving diverse samples in terms of age, gender, and background will be carried out in the future. All in all, the expert review showed that the presented application is very promising and it is worth developing it further.


## Acknowledgments

This research was supported by the German Federal Ministry of Education and Research (BMBF) through the eTaRDiS project (ID: 01UG2122B). We are very grateful to all experts attending to our review. We also thank Prof. Dr. Erich Schubert, the whole eTaRDiS Team and especially Bettina Reglin and Markus Rothgänger for their efforts.


## References


[1] D. Han, G. Parsad, H. Kim, J. Shim, O. Kwon, K. A. Son, J. Lee, I. Cho, and S. Ko. HisVA: A Visual Analytics System for Studying History. *IEEE Transactions on Visualization and Computer Graphics*, 28(12):4344–4359, 2022. doi: 10.1109/TVCG.2021.3086414

[2] L. McInnes, J. Healy, and J. Melville. UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction, 2018. doi: 10.48550/ARXIV.1802.03426

[3] J. A. Wagner Filho, M. F. Rey, C. M. D. S. Freitas, and L. Nedel. Immersive Visualization of Abstract Information: An Evaluation on Dimensionally-Reduced Data Scatterplots. In *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pp. 483–490, March 2018. doi: 10.1109/VR.2018.8447558