

Integration of Kompakkt into a Virtual Reality CAVE Environment: The CAVE-Kompakkt-Viewer

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Abstract

This poster presents the integration of the Kompakkt platform into the University of Cologne's CAVE (Cave Automatic Virtual Environment), forming the CAVE-Kompakkt Viewer as part of the broader "Virtual Campus" initiative. Kompakkt is a web-based tool developed for the exploration and annotation of 3D cultural heritage objects, supporting rich media content and FAIR data principles. The University's CAVE system provides the spatial framework for interactive visualization and collaborative research. The CAVE-Kompakkt Viewer serves as a bridge between web-based cultural heritage resources and immersive virtual reality experiences. It enables users to dynamically load, explore, and interact with 3D models in real time, offering an intuitive and high-fidelity environment for research and education. The system transforms the act of viewing into a spatial and embodied experience, enhancing understanding and engagement with digital heritage data.

1. Introduction

The "Virtual Campus" project at the University of Cologne explores the potential of virtual reality (VR) and augmented reality (AR) to enhance teaching, learning, and campus experiences. The project is predicated on the creation of a new campus map, which incorporates a three-dimensional representation of the university buildings, as well as a mobile indoor navigation system that is based in an augmented reality application. In the proposed poster, the emphasis is placed on the CAVE-Kompakkt-Viewer, which facilitates enhanced access to the CAVE of the University of Cologne and enables in-depth research by various institutes. In order to understand the purpose of the CAVE-Kompakkt-Viewer and how it functions, it is first necessary to explain the concepts of Kompakkt and the CAVE system [WCG*].

2. Kompakkt

Kompakkt is a web-based, open-source platform designed to facilitate the annotation, exploration, and scholarly dissemination of three-dimensional cultural heritage objects. Developed by the Department of Digital Humanities (IDH) in cooperation with the Theatre Historical Collection (TWS) at the Department for Media Studies and Theatre at the University of Cologne, Kompakkt emerged from a deeply interdisciplinary context that integrates insights from the digital humanities, performance studies, teaching with things, and cultural heritage documentation. At its core, Kompakkt enables spatially anchored multimedia annotations within a 3D interface, supporting textual, visual, auditory, and video-based content. These affordances are particularly suited for narrative-based aca-

ademic storytelling and contextualized digital curation. The viewer is equipped with comprehensive media format support, encompassing 3D models, images, audio files and videos[EST*19]. The development and maintenance of Kompakkt is organised through the Kompakkt Consortium, in which IDH at the University of Cologne and the Open Science Lab at the Leibniz Information Centre for Science and Technology at the University Library in Hannover (TIB) are the main players. The semantic annotation module in Kompakkt is planned for an extension into an integration between annotations and nodes in knowledge graphs. This partnership takes place within the broader institutional framework of the NFDI4Culture consortium, which promotes the sustainable and interoperable digitization of cultural assets[Eidng].

3. CAVE-Kompakkt-Viewer

The CAVE-Kompakkt Viewer is a unique integration of the Kompakkt database with the CAVE, representing a significant contribution to the broader "Virtual Campus" initiative. It dynamically loads selected 3D models during use within the CAVE environment, enabling real-time visualization and examination of the models as well as their annotations. With regards to the "Virtual Campus" Project, the system is primarily designed for use in academic teaching, where it facilitates the exploration of cultural heritage artifacts in a spatially and visually enriched manner. It supports interactive and collaborative learning scenarios, allowing students to engage more directly with digital objects and reconstructions as part of lectures, seminars, or workshops. The integration of the Kompakkt environment into the university's CAVE system is facilitated by the

advanced visualisation capabilities of Unreal Engine 5 (UE5). UE5, a game engine developed by Epic Games, offers high-fidelity rendering and interactive capabilities, making it an ideal foundation for immersive applications in virtual heritage and academic visualization. As UE 5 lacks native CAVE support, an external template and plugin developed by RWTH Aachen were employed to ensure compatibility [VGER24]. In order to deploy UE5 within a CAVE, it was necessary to make several configuration adjustments. Specifically, the Live Link connection to the ART tracking system had to be adapted in order to ensure precise user tracking. Furthermore, modifications to the nDisplay settings were necessary to ensure synchronised visual output across all projection surfaces. In addition to these adjustments, the CAVE-Kompakkt Viewer introduces unique challenges. Chief among these issues is the real-time loading of 3D objects while a simulation is already running, an operation not natively supported by UE5. In order to facilitate this functionality, additional plugins from the glTFRuntime suite were integrated. These plugins support the dynamic import of diverse 3D model formats, facilitating the seamless integration of Kompakkt content into UE5. [Rob24]. A custom interface within the Kompakkt platform facilitates the retrieval of metadata and entity structures associated with 3D models. Within UE5, a dedicated logic structure was developed to spawn these objects in real time into the CAVE environment, thereby enabling immersive and dynamic exploration of cultural heritage data (Figure 2).



Figure 1: View inside the CAVE system displaying a loaded 3D model from the Kompakkt platform

4. Current Project Status and Outlook

At its current developmental stage, the CAVE-Kompakkt Viewer supports the immersive visualization of selected 3D objects from the Kompakkt platform. A prototype user interface has been deployed for a subset of the database, enabling intuitive selection and dynamic loading of 3D content into the CAVE environment (Figure 2). Users can navigate freely around the virtual reconstructions, affording a high degree of spatial interaction and detailed inspection from multiple vantage points. Looking forward, the project’s objective is to achieve seamless access to the entire Kompakkt repository within the CAVE. Central to this vision is the integration of a web-based browsing interface, enabling in-situ navigation of the Kompakkt platform from within the immersive environment. This would allow users to interactively select and explore cultural heritage assets. Additionally, the incorporation of existing semantic

annotations into the CAVE experience is a core developmental goal, enhancing the interpretive depth of the 3D content through contextual metadata, enabling transitions between annotated 3D models and the visualisation of knowledge graphs, fulfilling the visions of integrating 3D models in a semantic web for cultural heritage [HSB*09].

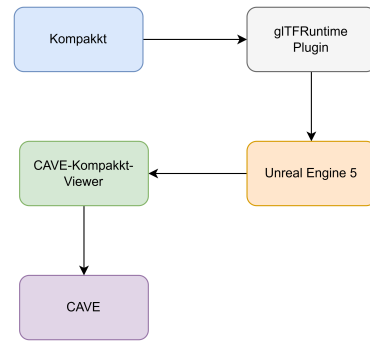


Figure 2: Workflow showing how Kompakkt 3D models are rendered in Unreal Engine 5 via the glTFRuntime plugin and visualized in the CAVE through the CAVE-Kompakkt Viewer.

5. Conclusion

The CAVE-Kompakkt Viewer constitutes a substantial advancement in the deployment of immersive technologies for research and digital heritage. By enabling the real-time integration of Kompakkt’s 3D models into the CAVE infrastructure, it facilitates direct, spatial interaction with digital heritage material. While still in development, the system offers a practical and technically grounded framework and it points to new opportunities for interacting with cultural data beyond conventional screen-based settings, while remaining closely aligned with existing academic practices.

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