Exploring Historical Cities with the 4D Community Browser

Requirements of a Spatio-Temporal Research Tool

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Introduction

Cities are complex cultural developments, dependant on urban development plans, architecture, heritage sites, cultural, social and economic structures and much more. Therefore, research on the historical evolvement of cities is a multi-faceted task and needs a multidisciplinary view of experts.

The online research tool 4D Browser enables a spatio-temporal immersion into the architectural-historical development of a city with a digital 3D city model enriched with historical photographs and a timeline. The 4D Browser was developed in the junior research group HistStadt4D (UrbanHistory4D) at the University of Würzburg in cooperation with the Technical University of Dresden.[1] An interdisciplinary team of PhD students and postdocs developed the interactive online application between 2016 and 2021. This prototype, which includes the city of Dresden, is currently under further development.

The aim is to develop the existing 4D Browser into a 4D Community Browser. For this purpose, the application possibilities for the research community are being fundamentally expanded. This will be realised on the basis of the results of a user study as well as by linking the 4D Browser with other digital and interactive applications in the field of historical urban research and tourist development of cultural heritage sites. The resulting advanced online application aims on suggesting innovative ways to actively involve the research community in regard to shaping the tool, researching the historical development of cities and providing open access to cultural heritage for research and the public alike.

In the following, the objectives and implementation strategies are presented. In addition, it is outlined how other applications access and disseminate the data to different target groups. An outlook sketches the vision of future possible applications of the 4D Community Browser.

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[1] Website of the junior research group HistStadt4D: http://www.urbanhistory4d.org/wordpress/index.php/research-group-urban-history-4d/ (accessed: 08 July 2022); website of the 4D Browser: https://4dbrowser.urbanhistory4d.org (accessed: 08 July 2022).
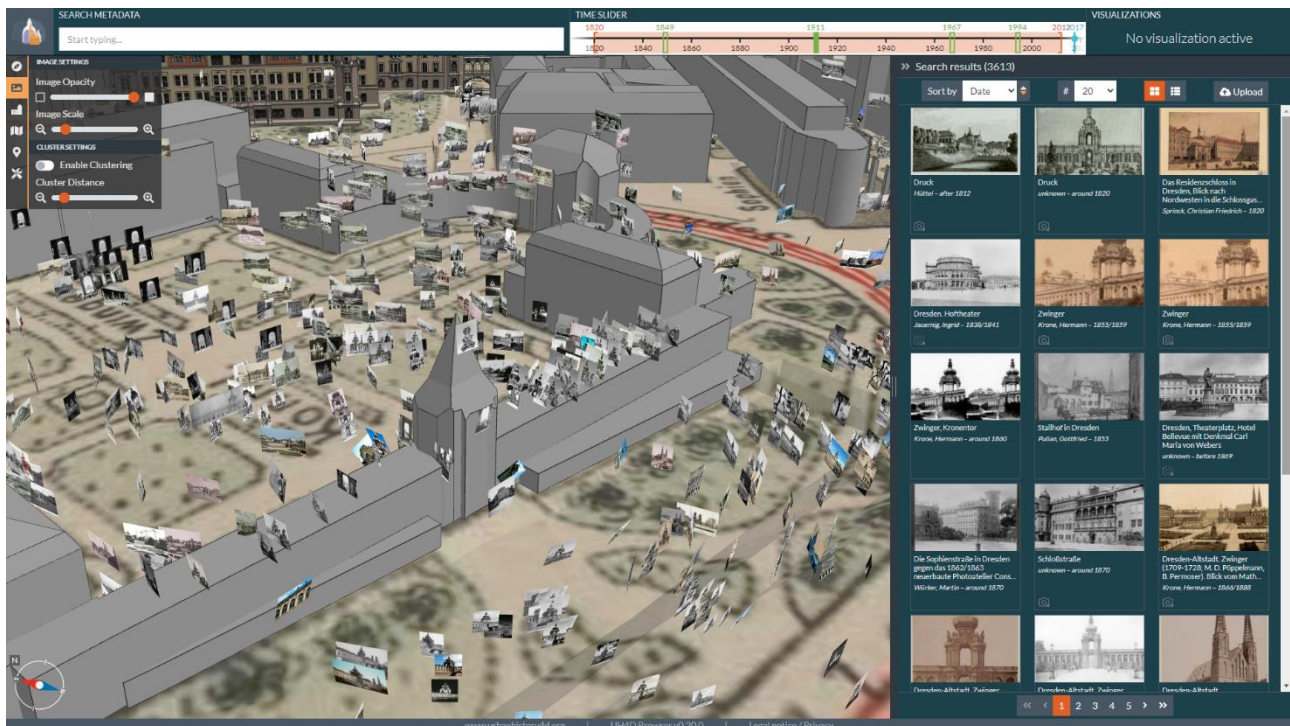
Fig. 1. Graphical user interface of the 4D Browser with 3D viewport and interactive timeline.

Aims for an Advanced Research Tool

The 4D Browser (Fig. 1) is already an innovative and unique research tool with its existing features (Dewitz et al., 2019). With the city of Dresden as use case, about 2,300 historical photos are spatialised within a digital 3D city model on the spot on which the photographer potentially stood. In comparison with common repositories of historical photographs the images can be searched spatiotemporally, i.e., users do not need to rely on the image's metadata only. The integrated timeline enables to select time spans and points in time to filter not only the photos but also 3D models. Thus, buildings which were destroyed, altered or added later are displayed when the respective time frame is selected. The 3D models do not only serve as visualisation and navigation vehicles: from the spatial relation between the images and the 3D models it can be determined which buildings are visible on which image. Hence, the 3D building models are an additional way of filtering photographs. First quantitative analysis tools have been implemented to support historians in their research.

The general aim of the 4D Community Browser is to actively involve the research community into the further conceptual development of the tool, of its application scenarios, and the generation of content. This user-centred approach reflects the needs of the target group to actively add and edit own content (Kröber, 2021): In 2020 an online user study in the Digital Humanities community about the usage and future conceptual development of the 4D Browser showed that the community sees high potential in the tool for research and higher education, especially when users can generate and manage their own content. This includes adding further 3D models (e.g., different architectural states of a building to show its development over time), photographs, historical maps, text documents, and metadata to enrich and depict the historical cultural complex of a city. This will enable the spatio-temporal research of urban development and interactive exploration answering complex research questions: How did the photographic view on a city change over time? From which perspective has a building been preferably photographed in a certain time span?

The user study also serves as a basis for improving the existing functions and to expand them with new features. This includes the implementation of user accounts such that users can contribute own material, organise their research results (i.e., image collections, analysis), and customise their search requests according to their research interests.

The conceptual developments are the basis for any future technical implementations. Hence, the first stage is to concisely analyse the user needs and design appropriate workflows. Any technical aspects also need to be reconsidered and prepared. Since the 4D Browser as a prototype is currently restricted to a limited number of scenes, e.g., the city of Dresden, it is mandatory to access any place independently. While the photographs in the 4D Browser have been spatialised manually so far, the goal is to automate this process as much as possible. Historical images are difficult material to work with, but progress has been made towards a semi-automatic spatialisation process (Maiwald and Maas, 2021) that needs to be integrated.

The Backbone of Third-party Applications

The 4D Browser is composed of a frontend component, i.e., the graphical user interface (Fig. 1), and a backend component consisting of a database, a data storage, and an API layer to handle all requests. The backend is targeted by other applications that reuse the 3D models, spatialised photographs, and accompanying data according to their use case scenario and potentially contribute new material. Within the scope of the HistStadt4D project, this has been demonstrated with an Augmented Reality (AR) application to browse the images in an innovative way (Dewitz et al., 2019, pp. 410–411).

The project Denkmalschutz4D (Friedrich Schiller University Jena) developed a mobile Virtual Reality (VR) application that is used in an education and cultural tourism scenario (Münster et al., 2021). Users can get an idea on how their surrounding buildings at their position may have looked in the past. In this case, the spatialised photographs are projected as textures onto the surfaces of the 3D models. The 3D scene is complemented with buildings generated from OpenStreetMap and building footprints from historical cadastre data. Points of interest are queried from Wikidata.

The project HistKI (Friedrich Schiller University Jena, Ludwig-Maximilians-Universität München, Julius-Maximilians-Universität of Würzburg, Bielefeld University) seeks to establish an AI-based approach towards modelling image sources and their multimodal contexts as a new technique for researchers in architectural history studies (Münster et al., 2022). Next to 3D models and photographs, linguistic sources are analysed to recognize entities and to contextualise them. The annotations need to be matched and linked across the different media such that architectural historians can be supported in discovering and evaluating relevant and relating sources.

Conclusion and Outlook

The further development of the 4D Browser to become a 4D Community Browser offers the possibility to undertake customised spatio-temporal research on cities and their cultural heritage. This helps to preserve the cultural heritage of cities (in the form of photographs, maps, and textual sources) in a digital format and to make it accessible not only for researchers, but also for the public.

To this end, the community is heavily involved to identify their specific needs and to rethink existing workflows to prepare any future technical implementation.

The outlined third-party applications demonstrate the potential use of the data. In future, such applications may contribute data by automated processes or by users. The integration of various application forms an ecosystem in the field of Digital Humanities that widens the perspectives and modes of access to the cultural heritage in different forms of media and their metadata for different target groups. This kind of a research framework offers a wide range of tools for analysis and innovative approaches to research the historic development of cities. Thus, it contributes to sustainability of data usage and data provision. In addition, the active involvement of the community into the conceptual development of the 4D Community Browser as well as the generation of content demonstrates a future concept of a research framework in the context of cultural heritage.

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Author Contributions

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Software: Bruschke, J.
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Writing – review & editing: Bruschke, J., Münster, S.

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