HistStadt4D – A four dimensional access to history

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Structured Abstract

Purpose – We propose a multidisciplinary approach based on an extensive data base which provides digitalized photographic material from the end of the 19th century up to recent times. Thus a large amount of photographic evidence will be exploited, structured and enriched by additional sources to serve as a foundation for an application relying on 3D visualizations. The application addresses scholars as well as the general public and will provide different kinds of information and tools for research and knowledge transfer.

Design/methodology/approach – The method applied will be diachronic: the virtual model may show one point in urban history depicting a certain state of past Dresden and also its development through the various eras. In addition the method works in a dualistic mode: on the one hand the physical development of the urban area will be explored and presented in detail, on the other hand the analysis of the pictures will give profound insights in the specific perception of the urban space.

Originality/value – This methodology aims to make large repositories more accessible and proactive in information-seeking. Using a 3D application as an access for media repositories, research tools and functionalities which can improve the scientific handling of the data will be considered. How should the data and information be processed to meet the researcher's needs? Which information can be retrieved from the visual media? What needs to be considered to ensure scientific standards and motivation while working with the image repositories? Users of the virtual archives can benefit extensively form effective searching functions and tools which work not only content- and theme-based but also location-based.

Practical implications – The outcomes of the research will be presented in a 4D browser and available in an Augmented Reality presentation. The design will comply with the requirements of the field of application, whether aiming at a scientific, educative or touristic purpose. The paper itself considers three different approaches to the topic highlighting the multidisciplinary strategy and opportunities of the project. The first one considers research questions from art history. The second one reflects on concepts from information science, photogrammetry and computer vision for visualizations and the third one introduces an interaction concept for an AR application for the Zwinger in Dresden.

Keywords – Visual knowledge, image repositories, 3D reconstructions, mobile AR, interaction concept

Paper type – Academic Research Paper

1 Project Introduction

Dealing with multi modal accesses to photographic data bases to support historical research and communication the project HistStadt4D is financed by the BMBF supporting young scientists. The project is set to start in August 2016 with a planned duration of four years.

The interdisciplinary project aims to create a spatial visualization of Dresden's old city quarters, not in a conventional three-dimensional way, but with the fourth dimension included in the model. Therefore, it investigates and develops approaches in order to deal with image repositories of the city of Dresden. Historic photography, plan material, additional historic information and sources of the picture library of the Saxon State and University Library in Dresden (SLUB) provide valuable information on the appearance and architecture of the city and their development over time. Usually, access to information repositories relevant for a general public as well as scientific research is challenging and an intuitive interaction and navigation concept can at most be found for applications made for touristic and educational purposes.

The visualization of images and information within a historic 3D city model taking into account their location and time will allow gathering, systematizing, structuring, merging and annotating architectural and cultural history knowledge and provides a direct access to complex data. In consequence, the application tries to ease the research on urban history and cultural studies.

Involved Institutions

The HistStadt4D projected is carried out by a junior research group (Münster and Niebling, 2016) with participants belonging to the TU Dresden (Media Center, Photogrammetry) and the University of Würzburg (Human-Computer-Interaction, Art History). Other associated partners are the SLUB Dresden who provides the image data base through their picture library (Fotothek), the HTW Dresden (Dresden University of Applied Science) and Staatliche Schlösser, Burgen und Gärten Sachsen GmbH (State Palaces, Castles and Gardens of Saxony).

The Deutsche Fotothek (picture library) provides an extensive data base also including items from 80 partnering institutions which serves as the project's foundation for research concerning Dresden as well as knowledge that needs to be made accessible

for everyone interested. About 1.7 million photographs, paintings, graphics as well as a collection of maps and architectural drawings are available.

2 Increase of art history knowledge through 4D visualization

In modern art history the use of digital images steadily grows more important. Visual media is consulted in order to analyze buildings, to draw stylistic comparisons, to document changes in the building structure or – in general – to answer open questions on the history of a certain building, quarter or city. Finally, in case of a complete loss of physical traces historic pictures can form the basis for different kinds of reconstruction. Overall, for art history research images are a major source.

During the last years, gathering of large amounts of historic photography has become a main task for archives, libraries and museums (Hoppe and Schelbert, 2013), e.g. Deutsche Fotothek, Prometheus, Arachne, Foto Marburg, Biblioteca Hertziana and others. The digital photo data bases finally allow an examination of objects located spatially distant. Thus, the extent of this large data volume on the one hand offers big opportunities for academic research, but on the other hand creates an essential need to access and structure the information available through those sources (Kohle, 2013, p. 16). Only by means of this additional procedure the analysis and a further interpretation through scientific questions will lead to reasonable results.

The present inquiry standard is primarily concentrated on the embedded metadata, such as the author, the dating of an object or photography, a more or less exact localization, a description of the depicted matter and, of course, several keywords that classify the object in various aspects (Kohle, 2013, p. 23). Momentarily, the use of photographic data bases still requires a large amount of supplementary work, therefore methods to quicken and increase efficacy in research are desirable. Another valuable help would be an instrument to find cross connections that aren't necessarily traceable through a language based search but through the images themselves.

One possibility of deepening knowledge and opening up further scientific questions for single buildings or even wider spaces like cities can be reached through a computerized visualization. The number of projects in this field of interdisciplinary work increase each year, though major methodical and processual problems still remain open (Ioannides et al., 2013).

Usually, virtual 3D models are limited to a certain period of time, whose length depends on the temporal distance of the objects visualized. This method guarantees the scientific exactness by avoiding confounding the results with those of other time layers. Concurrently only a small part of the historic reality is illustrated, while even

more knowledge can be drawn from a synoptic view (Ioannides et al., 2013). We propose therefore to integrate a fourth dimension into such a model, namely the element of time. It allows widening the focus on the differences between the various time layers by employing a comparative analysis.

The method applied will be diachronic: This will lead to an additional increase of information which would not be possible if only three dimensions are taken into account, without considering other points in time. From an examination over a longer period of time and its visualization profound insights can be achieved that concern the urban tissue and its development throughout the years and decades, including turning points and breaks, but also continuity (Münster and Niebling, 2016). Besides large scale changes due to wars, earthquakes or simple city reorganizations, also smaller observations are relevant for art historians and building researchers, for example the changes of building details like the roofing, decorations or façade renovations. Another setting for art history research is the perception of the city and its stock of historic and modern building based on the analysis of photography. How did buildings determine the cityscape? Which buildings statistically tend to be photographed more than others? What does this tell about the interests, self-image and intellectual attitude of the photographer? Through the eyes of a contemporary it will be possible to evaluate which buildings dominated the idea of Dresden as an ancient city of culture and of vivid bourgeois participation in politics, arts and economy. It will be shown that a whole catalogue of further leading questions can be derived from the work with a 4D visualization that supports and pushes forward scientific tasks. In accordance with the computer based implementation additional information can be incorporated in the model: This concerns for example ground and elevation plans, written sources such as building invoices or descriptions and similar material which go beyond the mere photo which was included into the visualization. On the one hand this points exclusively to an academic target group of users, on the other hand one may also think of a pedagogical usage that introduces the history of a quarter to interested people in an adequate way.

2.1 The specific example Dresden

The project HistStadt 4D aims to develop answers to such questions and to test those basic thoughts by means of a specific example (Münster and Niebling, 2016). The city of Dresden is especially interesting as different time layers are extensively documented by historic images in the Deutsche Fotothek. As a basis we have a large amount of photos starting with the late 19th century with the black and white pictures of Ermenegildo Donadini, Hermann Krone, Walter Hahn and others. Furthermore, the booming époque of the early 20th century and the vibrant cultural development through those years that abruptly end with the time of the Third Reich and the almost

complete destruction of the city in February 1945 are recorded. Finally the years of the clearance of the ruins, the socialist rebuilding and the time after the fall of the Wall complete the picture of a rich historical and architectural development. Thus, a large amount of photographic evidence will be exploited, structured and enriched by additional sources to serve as foundation for the visualization.

2.2 Research questions raised by art history

Especially the methodical access demands an extensive research as some parts of the approach are not undisputed in expert groups (Kohle, 2013, p. 163). On the one part, this concerns the range and extent of visualizations: How should its design be chosen to emphasize that it does not portrait reality? Experience shows that a different design for distinct target groups can be useful as lay people often are enthusiastic about faithful and naturalistic reconstructions that also appeal on an emotional level and enables truly to experience the time layer in question. More educated and especially academic scholars on the contrary declare themselves in favor of a more simple and schematic model that explicitly shows its virtual character. Another problematic aspect results from weaknesses in the model itself. Gaps in the photographic documentation may lead to ambiguity which, of course, cannot be depicted in an optic model but only explained in a written form. How is it possible to deal with such problems and how can they be displayed in an appropriate way?

3 Potentials to support research using image repositories and visualizations

The vast increase in digitization of historic images, objects and information leads to more content available for investigation; more cross-analyses made possible; more knowledge collected, structured and shared (Schuller, 2009). Hence, the development pushes archives and researchers from humanities to become part of the open science movement. In recent years, the discussion on open science is growing and spreading. Scientists belonging to the fields of e.g., ecology, biology and medicine have already stated how open science increases dissemination, understanding of research results as well as transparency concerning quality and integrity of research (Groves and Godlee, 2012) which are also valuable for humanities.

With the massive amount of data available, the success of an archive and the actual benefit for users depend highly on usability of the application and suitability and efficiency of research tools. A lot of the existing tools of research programs and applications stem from computer science and do not necessarily meet the needs of humanities (Dudek, Blaise, De Luca, Bergerot and Renaudin, 2015). In order to improve research tools and applications, the desires of the stakeholders need to be identified, distinguished and processed for an implementation by computer scientists. Therefore, a distinct definition of the target group is essential.

3.1 Requirements of users

The use of archives and image repositories is usually open to anyone. Collaborating with the Fotothek for the project actually defines the target group generally as the users of their database. Sweetnam et al. nicely break down users of digital collections to be (1) professional researchers, (2) apprentice investigators, (3) informed users and (4) the general public (Sweetnam et al, 2012). The target group is obviously closely connected to its dedicated purpose, e.g., scientific research, pedagogical application, study of historical sites (Barreau, Gaugne, Bernard, Le Cloirec and Gouranton, 2014), etc. Within the HistStadt4D project a main focus lies on architectural and urban history of the research object Dresden documented through images.

Common requirements of the users may be an ease of understanding concerning the data and knowledge, the development and improvement of tools for accurate search/ research as well as an intuitive navigation and interface (Barreau, Gaugne, Bernard, Le Cloirec and Gouranton, 2014). Scientists will put high emphasis on adherence of scientific standards, a thorough documentation through the supply of metadata and the possibility for collaboration, cross disciplinary work and even crowd sourcing (Maina and Suleman, 2015). Whereas someone vaguely interested is more in need of a straightforward introduction to the data and topic (Maina and Suleman, 2015) as well as possibilities to select further material without getting frustrated by an overload of information.

3.2 Visualizations to facilitate research

Visualizations seem to be amongst the most promising presentation types that support additional information in the context of architectural and urban history research with image repository.

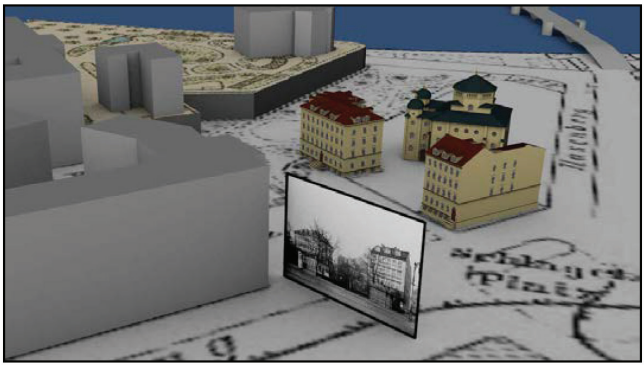

Figure 1: Display of a picture within a 3D city model

A very simple visual presentation is the display of a picture right at the position of the camera during its acquisition within a 3D model (see Figure 1). By including images taken over a certain timespan, this visualization can promote research on acquisition preferences of specific photographers or during certain years.

Virtual 3D reconstructions are digital three dimensional visualizations of an object. Different ways may lead to the creation of a virtual model. A digitization of the object's surface using a terrestrial laser scanner will give a very detailed and authentic point cloud of the object which can be turned into a virtual 3D model. This method can only be applied for existing objects. For the HistStadt4D project this technique may serve for comparison purposes to evaluate results of other reconstructions. Reconstructions produced for the HistStadt4D project will mostly be created automatically using SFM (Structure From Motion). SFM relies on processing several pictures of an object through corresponding features to derive the initial camera positon and eventually 3D coordinates (point cloud) of the object. A manual reconstruction can be done with the help of 3D computer graphics software using images and plans (Münster, 2013). Also, Lin et al. propose an algorithm for the creation of a depth map from a 2D image (Lin, Chang, Huang, Shen and Fan, 2012) which is relevant for 3D analysis when only single images are available.

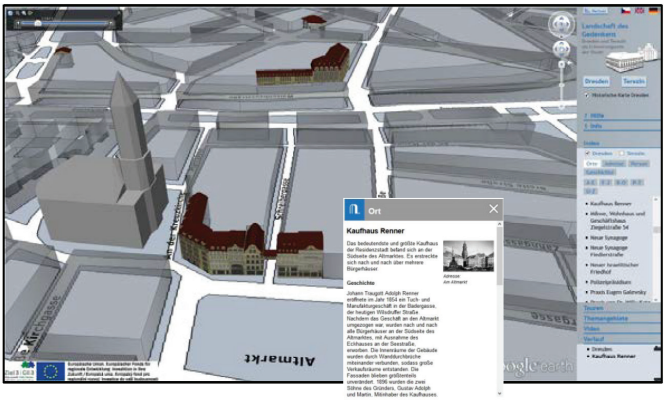

Figure 2: Screenshot of the GEPAM application (www.gepam.eu)

A 3D reconstruction is easily enhanced with further information on the appearance of an object through a texture. A virtual 3D landscape allows showing the location and duration of a visualization and its actual surroundings and can even provide further

detail information through text and media (see Figure 2). Moreover, visualizations support the depiction and validation of hypotheses and may communicate connections and coherences (López-Romero, 2014). Additional key words can be used as hyperlinks and put emphasis on further connections (Maina and Suleman, 2015). Image processing through e.g. feature tracking for historic pictures of buildings helps to detect changes within the cityscape or certain buildings.

3.3 Challenges for an implementation

The afore-mentioned methods for 3D reconstruction come from photogrammetry and computer vision. Their application fields are very different and dictate the importance of certain aspects like geometric quality and automatic processing. The photogrammetry community puts more emphasis on accuracy and reliability concerning image orientation and camera calibration whereas, the computer vision community focuses more on algorithms that promise a high degree of automation (Remondino, Del Pizzo, Kersten and Troisi, 2012). HistStadt4D is set up to consider different approaches coming from different disciplines which help to contribute to a technique for using historic pictures as a data base for the creation of a 3D research application. This is a great example of how cross- and interdisciplinarity can promote new solutions and encourage to seek innovative ways.

López-Romero points out that only few projects have considered the potential of historic images for 3D reconstruction. As pointed out before, pictures are sources which allow an authentic documentation of losses. He lists several issues (e.g., missing camera parameters, image quality, inadequate coverage of the object) encountered during the experiment of a 3D reconstruction using historic images (López-Romero, 2014). To ensure further use of the application interoperability of the data, open access, maintaining standards and a thorough documentation of the metadata must be taken into account.

A difficulty often pointed out by scholars is the authority that 3D reconstructions convey. A design approach that introduces possibilities to display different levels of reliability and vagueness within a model may remedy these concerns.

3.4 Research approach

In order to identify and investigate potentials that image repositories hold for a support of research an empirical inquiry and systematization of requirements need to be carried out. A concept for the data survey is essential and includes interviews and investigations concerning user needs, user behavior and user interaction. This will help to identify and assess possibilities of the application. Scholars from the humanities do not have an extensive knowledge of technical limitations and possibilities. Constant

dialog and exchange is necessary to ensure transparency and satisfaction on the user's side. An extensive literature review will support the identification of useful tools and functionalities. Research on open science, cross-disciplinary collaboration and knowledge transfer may bring further impulses. The proposed options will be turned into use cases to ensure a satisfactory transfer of the ideas and suggestions into software tools. All developed tools will be evaluated with the help of usability testing.

4 Interaction concept for a mobile AR application

The main goal is the development of visualizations and information access for a location and object-based knowledge presentation using Augmented Reality (AR). The application will present historical as well as actual information on the Dresdner Zwinger. So that the users can rely on their private mobile phone to get all necessary information. The interaction concept forms the bridge between the user and the developer. In this way the user requirements will be considered and translated for the technical implementation.

The main objective is to bring information about the building and its history closer to the public. The concept will base on a mobile AR application in order to immerse the user in the past and present detailed information on spatial objects. Finally, the main aspect is to motivate and to raise interest in learning in an intuitive way about the development and important events of historical buildings like the Dresdner Zwinger.

4.1 Augmented Reality

AR describes the enrichment of the real world with the addition of computer generated objects (Mehler-Bicher, Rieß and Steiger, 2011). The use of an approach with AR methods allows contextual data display combined with the reality and thus enriches the environment with further data of historical as well as current information. That means that additional information will be integrated in the visualization in the form of text, images or animations. The sensors of mobile device (e.g., camera, GPS, accelerometer, gyroscope, light sensor) which capture environment information play a significant role in the process. Among other details, they provide information on the camera angle, time or the exact geographical location. Linking the images with texts and geometry data and promoting interactions additional to the use of AR form the foundation of the work. (Guimarães, Figueiredo and Rodrigues, 2015; Azuma, 1997)

4.2 Use Case: Dresdner Zwinger

The Dresdner Zwinger is a building complex including a garden area. Figure 3 displays an aerial view of the Dresdner Zwinger. It is a beautiful outdoor area which was built in the 18th century for festivities of the high nobility. The architect Matthäus Daniel Pöppelmann and the sculptor Balthasar Permoser created courtly artwork.

Today, the Zwinger includes public art exhibitions inside the buildings and it offers an atmospheric ambience for different events in the closed garden area. In addition, the garden area showcases different water fountains that invite the visitors together with the different sculptures to stay.

Figure 3: Aerial view of the Dresdner Zwinger (picture from Fotothek)

The Application will provide points of interest (POI) to navigate through the important historical areas and give the users the possibility of a new perspective on the object. The navigation through historical information will only include places in the garden area but it will also present actual information about exhibitions inside the buildings, like name, opening hours or entrance fees.

4.3 The interaction concept

The interaction concept describes an application for knowledge transfer with AR methods and a guidance service with the private mobile phone. Klopfer and Squire describe the connection between physical objects and virtual information as a central point within AR (Klopfer and Squire, 2008). The user navigation will be enriched with concepts of storytelling and gamification, so that the user will be entertained by learning historical facts, immerses in the history and feels part of the story (Fevgas, Tsompanopoulou and Bozanis, 2011; Gouveia, Branco, Rodrigues and Correia, 2015; Guimaraes, Figueiredo and Rodrigues, 2015; Malomo, Banterle, Pingi, Gabelloney and Scopigno, 2015). The user begins at a defined starting point from which he is able to explore in a self-determined manner while investigating with the help of multimedia support. The attention will be guided to important POI through the

storytelling. The localization of the user is provided through the GPS signal of the device and depending on the position of the user, information on nearby POI will be displayed. Furthermore, the user will be able to navigate around considering his preferences. The information representation with AR supports the dissemination of knowledge concerning historical events of the Zwinger in Dresden. Historical images related to relevant events and changes are imbedded into reality which supports a personal experience of the data. Another point is to get detailed views of difficult to access object or possibly an alternative visualization.

The development of the interaction concept is carried out, on the one hand, through research on existing literature concerning AR, information visualization, user guidance for knowledge transfer, interaction and usability concepts for mobile devices as well as the analysis of the state of the art research on interactive AR applications in particular with a focus on interaction and navigation in 3D spaces and museum fields. On the other hand, a conception for a mobile AR application with an incentive in order to navigate to and interact with POIs connected to the Dresdner Zwinger is developed. Thus, a draft concerning the visualization of the AR interaction concept and the development of mock up prototypes will be a result.

5 Conclusions

The involvement of several disciplines within the HistStadt4D project proved to be essential to develop holistic solutions for advanced research as well as knowledge dissemination based on image repositories. Art history is one scientific field that may profit from the progress of the project, but scholars from other disciplines will be involved as well. The interdisciplinarity helps to identify requirements and opportunities and promotes a dialog on the relevant topics between the users and developers. The most promising concept for information processing and further research already identified are visualizations especially 3D reconstructions.

The potential of information retrieval from image repository for touristic purposes should not be neglected. A specific interaction concept will help to address that audience as well. Usability and user satisfaction will be considered for all kinds of application.

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