Exploring Old Maps

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Preface

Many libraries own an extensive collection of historical maps. Beside their value as historical objects, these maps are an important source of information for researchers in various scientific disciplines. This ranges from the actual history of cartography and general history to the geographic and social sciences. With the progressing digitisation of libraries and archives, these maps become more easily available to a larger public. A basic level of digitisation consists of scanned bitmap images, tagged with some basic bibliographic information such as title, author and year of production. In order to make the maps more accessible, further metadata describing the contained information is desirable. This would enable more user-friendly interfaces, relevant queries of a database, and automatic analyses.

The International Workshop on Exploring Old Maps provides a forum for the communication of results that may be useful to the community. Researchers and practitioners of many areas working on unlocking the content of old maps have contributed to this year's program — humanities scholars, developers, computer and information scientists as well as librarians, archivists and curators.

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Program

08:30 **Registration**
UL, Campus Belval, Maison du Savoir, Room 3.220 (third floor).

09:00 **Welcome**

09:10 **Invited Talk 1 — Wolfgang Crom**, Staatsbibliothek Berlin:
Digitisaton of maps – Only a Colourful Picture or a Value Added Service?

10:00 Break

10:15 **Invited Talk 2 — Catherine Jones**, CVCE:
Geohumanities on the Web: Exploring Rules for Engagement

11:05 Break

11:20 **Invited Talk 3 — Petr Pridal**, Klokan Technologies:
Old Maps Online: from paper to vectors

12:10 Lunch

13:30 **Contributed Presentations**

Old Maps for Land Use Change Monitoring
Hendrik Herold, Robert Hecht, Gotthard Meinel

Rostock Giant Atlas: An Important Scientific Source
Annette Hey

Towards a Pipeline for Metadata Extraction from Historical Maps
Benedikt Budig

Landscape Change Induced by Separation and Reunification
Marco Neubert, Robin Gutting, Oh Seok Kim

Knowledge Organisation with Maps as Nodes
Hans Bauer

Open Historical Data Map
Thomas Schwotzer

Vectorization of Historical Maps
Thomas Hirsch, Florian Westphal, Kai Saeger, Thomas Schwotzer

Georeferencing, Annotation, and Analysis Tools for Old Maps: An Overview
Winfried Höhn

16:30 EOM 2017: When & Where?
Group Discussions: What's next for old maps?
Reports
Wrap-Up

17:20 **End of the Workshop**

18:00 Joint Dinner

Keynote Speakers

Wolfgang Crom

Head of Map Department, Staatsbibliothek Berlin - Preußischer Kulturbesitz

Title: Digitisaton of Maps – Only a Colourful Picture or a Value Added Service?

Abstract: For the digitisation of old maps and old land survey sheets, the map department of the Staatsbibliothek cooperates with partners in order to create a new presentation of the scanned map sheets. The elaborated georeferencing allows an electronic seamless map presentation with an easy navigation. So the old sheets will allow new perspectives on old landscapes.

About the author: Wolfgang Crom studied geography, pedology, botany, and ethnology at the University of Bonn. He worked as a Bibliotheksreferendar in Tübingen and in Köln as well as a Fachreferent at the Württemberischen Landesbibliohtek in Stuttgart. Since 2000, he leads the Map Department of the Staatsbibliothek zu Berlin.

Dr. Catherine Jones

Digital Humanities Lab Coordinator, CVCE - Centre Virtuel de la Connaissance sur l'Europe

Title: Geohumanities on the Web: Exploring Rules for Engagement

Abstract: There has been a steady growth in the number of humanities projects that use web mapping technologies as a mechanism for data curation, presentation, visualisation, analysis and collection. As with anything new, it is necessary to reflect on the question, "What is the end goal?" This paper reflects on the assortment of elements required to develop geohumanities on the web and how they can be evaluated to define best practices and rules for engagement. The paper will draw from experience gained during the development of www.bombsight.org and also present results from a recent evaluation of a diverse range of web-based geohumanities projects.

About the author: Kate joined the CVCE in June 2014 as the Digital Humanities Lab Coordinator where she is working on the development of digital tools for exploiting historical resources. Prior to joining CVCE, she was a senior lecturer in Human Geography at the University of Portsmouth, UK, where she was Project Director and Principal Investigator for the JISC-funded Bomb Sight Project, developing an interactive web mapping and augmented reality mobile app to explore the WW2 bomb Cencus in London. She is interested in the development of useful and usable products which join disparate datasets together to form meaningful narratives for public engagement. She studied for an MSc in Geographical Information Systems at University College London in 2002 and went on to complete a Knowledge Transfer Partnership, PhD and Post Doc at the same university, with a focus on interdisciplinary research and mapping science.

Dr. Petr Pridal

CEO, Software Architect, Klokan Technologies

Title: Old Maps Online: From Paper to Vectors

Abstract: OldMapsOnline.org is a search engine for old maps. It indexes over 400.000 high-resolution maps from over two dozens of institutions from all over the globe and is free to use and open for contribution. It is one of the most visited websites in this area (over 120.000 visitors per month), comes with a mobile application, linked data outputs, GeoSEO optimisation and unique search technology. The content is powered by crowdsourcing pilots usually made with the Georeferencer technology which can be applied by the institutions to enrich the scanned maps with precise geographic location and turn the

images into map services and overlays, and interlink, derive new content or conduct research with the old maps in online environments.
This talk showcases technically exciting parts of the related projects, demonstrates some of the new features that are under active development and explain the vision of the project for future.

About the author: Petr Pridal received his Ph.D. in the field of cartography and geodesy and a master degree in computer science. He is a consultant, researcher, programmer and entrepreneur. Within last years he participated on several international research projects, and developed popular software (MapTiler, Georeferencer, MapRank, Gdal2Tiles, EPSG.io,..)

Knowledge Organisation with Maps as Nodes

First steps to integrate information content and information context of thematic maps in library services

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***Abstract*—Thematic maps are an ideal medium for storing and visualising data on social or economic relations as well as for visually represented arguments. Using different layers and signatures they are able to create a synopsis of geodata with temporal, statistical or factual data. In traditional map cataloguing this informational dimension of multimodality in many cases is not included. The library of the Institute for East and Southeast European Studies (IOS) is searching for ways how to extract the different information layers encoded in maps to get better access to complex spatiotemporal relationships.**

Keywords—map retrieval; thematic maps; metadata; georeferencing; linked data; authority files; GeoPortOst

I. Thematic Maps and History

Thematic maps are an integral part of humanities research. They assign data and information to concrete measurable spatial entities by visually linking temporal, geographic and factual issues. As media with highly concentrated information content, thematic maps synthesise quantitative and qualitative assertions [1]. So they often play not only an illustrating but also predicative role [2]. Especially within historical research maps printed in publications can become an argument in a discourse and function as rhetoric device.[1] They are able to overlay the metric space of geography with meaningful arguments and to mark specific semantics. By using text, signatures, colour and raster codes these maps develop complex representations of spatial concepts [3].

II. Purpose: Decoding the Information Content of Thematic Maps

For information specialists, the density of meaningful data encoded in maps is a challenge as well as for researchers looking for historic map documents concerning certain events or actions[2]. Extending the metadata for this type of maps to cover all encrypted information by subject indexing, is difficult because of a) the heterogeneity of data, b) the extent of the collection, or c) limited human resources – the IOS library is small. Automated image retrieval solutions for indexing the maps are insufficient so far particularly because of the heterogeneity of data. We propose to reuse existing bibliographic descriptions of thematic maps to overcome these problems. Digging the bibliographic metadata out of the OPAC data silos and making them available for new forms of aggregation may support linking them with external meta-information[3]. This triggered the IOS library to start the project GeoPortOst.

III. GeoPortOst

GeoPortOst aims to provide georeferenced information about maps printed in books. Since the foundation of the IOS predecessor institutions, the library indexes even the contents of books and journals, among them maps. Therefore, over time a catalogue of 27.000 so-called hidden maps has grown. Unfortunately, this catalogue was never accessible online. This lack was the germ of the idea to digitise the catalogue, and furthermore, to provide the public domain maps in a digital form. Therefore, first, the card catalogue was converted to make it searchable in a separate database of the library catalogue [4]. Then, 980 maps were digitised and prepared for georeferencing by crowd sourcing with the web application Georeferencer (Klokantech) [5].

IV. GeoPortOst-Data Aggregator

By georeferencing this collection of hidden thematic maps is turned into rendered maps with coordinates, but also metadata in formats appropriate to enriching our library catalogue and to be integrated in GIS [6]. These spatial

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[1] Particularly for East and Southeast European history this approach of Critical Cartography, following J. B. Harley, Deconstructing the Map, in Cartographica 26, 2, pp. 1-20, 1989, is highly significant. How spatial categories are constructed to define patterns of socio-historical developments and create stereotypical narratives of an area, discuss e.g. L. Wolff, Inventing Eastern Europe. The map of civilization on the mind of the enlightenment. Stanford, Calif.: Stanford Univ. Press, 1994 and in a much more polemic way M. Todorova, Imagining the Balkans, updated ed. Oxford: Oxford Univ. Press, 2009.

[2] Opening out and decoding map content nowadays is treated primarily in two ways: by annotating (e.g. in the projects MapHub, GlobalMapLab, or as crowdsourced editing of tithe maps in the Welsh Cynefin project) and by semantic enrichment (e.g. the projects LODUM, or GeoBlacklight).

[3] This corresponds to the expected new role of libraries, not only managing content containers, but linking and contextualising information objects "… as a basis for new potential knowledge." S. Gradmann, "From containers to content to context," in Journal of Documentation 70, 2, p. 255, 2014.

metadata can be used as identifiers, operating as nodes for linking information objects with spatial search interfaces [7] and with other resources from outside containing the same entities [8]. Because of the strong context-dependency of hidden maps, recording their spatial dimension is just the first step. GeoPortOst aggregates a mashup of geodata, translated into the GeoSPARQL vocabulary [9], and the index information of bibliographic metadata, extracted from the Bavarian LinkedOpenData-Service [10]. GeoPortOst compounds in a lightweight way distinct spatial data with GND authority files for publishing in RDF. These aggregations could offer links to other informational bases (e.g. to Wikipedia) for geographical enhancement.

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Towards a Pipeline for Metadata Extraction from Historical Maps

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***Index Terms*—Historical Maps, Metadata Extraction, Digitisation Workflow, Efficient Algorithms, Crowdsourcing**

I. Introduction and Related Work

Historical maps are a valuable cultural heritage and an important source of information for researchers of various disciplines. However, metadata describing their (geographic) contents are scarce, because in practice such information mostly has to be extracted by hand: A complex process that takes prohibitive amounts of time and manual effort.

Since the problem is of increasing interest to libraries, some systems simplifying the extraction process have been developed (e.g. [1]–[3]). Providing convenient graphical interfaces, they still rely heavily on users to manually annotate the input maps. A system by Höhn et al. [4], [5] addresses the detection of places in historical maps, providing suggestions of possible place names based on a modern map (but still leaving a significant amount of work to the user).

There is not much research available on fully automatically analysing historical maps. Existing approaches are usually limited to certain types of features, for instance to forest cover [6] or building footprints [7]. The effectiveness of these approaches is in part due to the homogeneity of the relatively recent maps they are designed for (from the 19^{th} century onwards). Focusing on such maps as well, Chiang et al. [8] published an extensive survey covering a variety of image-based techniques. However, the pipeline we propose is aimed at supporting a larger variety of historical maps (which are potentially also much older).

II. A Pipeline for Metadata Extraction

In this paper, we propose a processing pipeline for metadata extraction from historical maps. We divide this pipeline into several individual subtasks in order to get goals more modest than "understand this map". In addition, this separation of concerns allows for rigorous problem statements and, thereby, reproducible experiments and comparability. This approach is also advocated by others [9], [10].

Segmentation: The first module in our pipeline addresses the segmentation of the various map elements. As an input, it takes the bitmap image of a scanned historical map; as an output, it gives the locations and shapes of the individual map elements. Considering that our input maps are hand-drawn and of varying conservation status, it is unlikely that this task can be solved fully automatically. Instead, we have developed a solution that supplements *template matching* with an efficient user interaction; see Budig et al. [11] for details. Screenshots of our implementation of this approach are shown in Figures 1 and 2.

Matching Labels and Markers: Once the important map elements have been located, it is useful to understand how they are related to each other. A fundamental task in this step is to find an assignment between text labels and the map elements they describe. Due to the often dense placement of text labels, this is by no means trivial (for an example, see Figure 3). An algorithmic approach we have developed to deal with this problem is discussed in [12].

Understanding Text: Recognising the handwritten characters that form the labels in historical maps is decidedly nontrivial. One complication is the variety of handwriting styles; another the limited space on many maps, which resulted in densely-placed characters. Additionally, non-textual map elements such as rivers and hills might intersect with the labels; see Figure 4 for examples. Preliminary experiments suggest that template-based matching for individual characters (which we might get as a by-product of the segmentation step) might yield useful information. This approach has also recently been advocated by Caluori and Simon [13]. For best results, we may have to integrate this step with the next: georeferencing.

Georeferencing: Based on the preceding steps, we propose to combine the extracted information to create a georeferenced index of places contained in historical maps. We can make use of gazetteers, modern geographic datasets as well as user feedback in unclear situations. Using places that have already been georeferenced, a modern-day map will allow an algorithm to provide suggestions for the place names based on geographic interpolation and textual similarities, and the user can be pointed to a specific area of the map.

III. Future Work

In future work, we want to develop solutions for all modules in our pipeline and design crowdsourcing applications for suitable sub-tasks. Particularly, we are interested in combining algorithmics with efficient user interactions. Our ultimate goal with this system is to drastically reduce the amount of time needed to georeference historical maps.

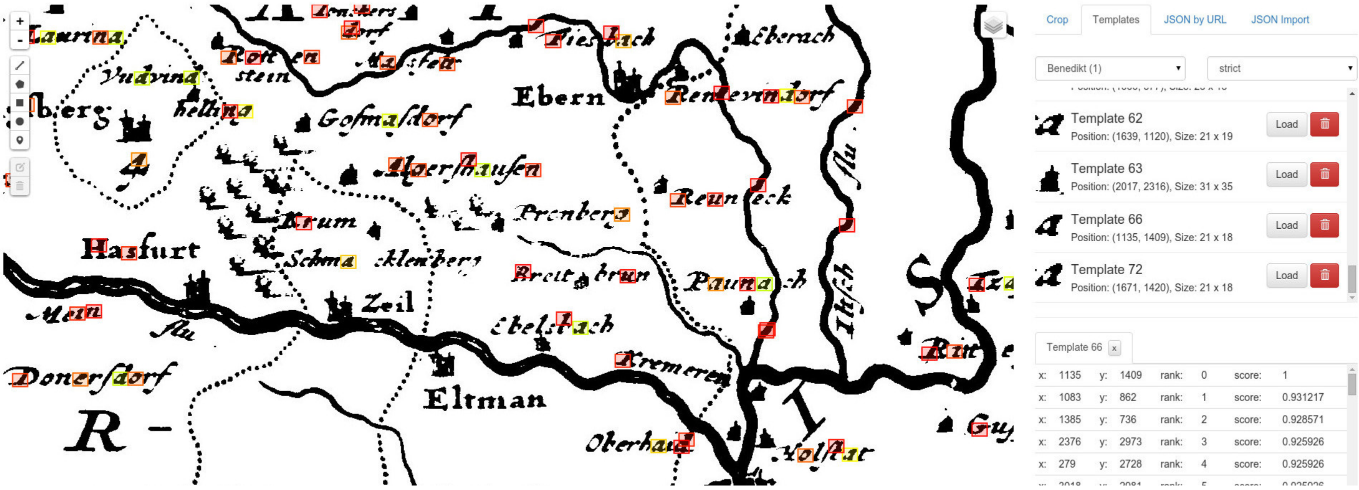

Fig. 1. Interface providing an overview of a historical map, a list of previously selected templates and the (unclassified) candidate matches for an “a” template.

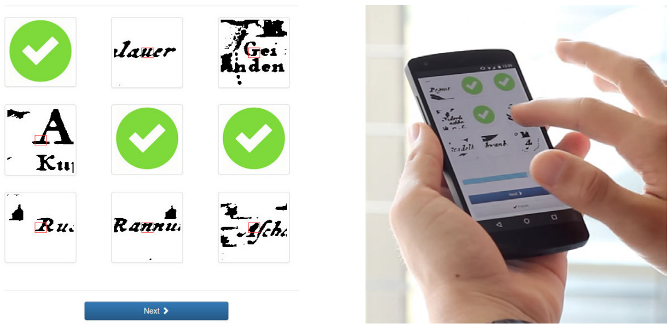

Fig. 2. Our classification interface implementing an active learning strategy to derive a threshold for the template matches. By clicking or touching any of the nine tiles, the tile turns around and shows a green check mark to indicate that the match was classified as positive. Note that this interface can be used conveniently on smartphones as well. You can see it in action in our video: `https://www.youtube.com/watch?v=msJNOn7JzBw`

Fig. 3. A possible matching of labels and markers, with each match colour-coded according to its sensitivity (left). The three red matches on top are indeed unclear: considering the two alternatives on the right, it is hard to tell the correct assignment without geographic or historical context.

Fig. 4. Section of a historical map from the early 18th century, containing information on settlements, woodlands, waterbodies and political territories.

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Old Maps for Land Use Change Monitoring

Analysing historical topographic maps for long-term land use change monitoring

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***Abstract*—Historical topographic maps are a valuable source of geospatial information for both landscape and urban research. In the same way as remote sensing imagery, topographic maps preserve snapshots of landscape and settlement patterns at certain points in time. Hence, old topographic maps are a rich and often also the only data resource for reconstructing and tracking land use changes over long periods of time. We present our approaches, findings and experiences in exploring old maps for land use change monitoring. We focus on some methodological aspects of the automated information extraction from old maps as well as some visualizations and applications of the retrieved historical geo-information.**

Keywords—Historical topographic maps; image analysis; land use change; long-term monitoring

I. Introduction

Historical topographic maps are a valuable and often only source of information for tracking land use changes over long periods of time. In the same way as other geospatial sources such as air- or spaceborne imagery, topographic maps preserve states of landscape and settlement patterns at a certain point in time. The geoinformation that is retrieved from these old maps can hence be used to "historize" existing land use and land cover databases [1, 2]. Fig. 1 shows a general outline of this concept.

Currently, large amounts of old maps are being made digitally available by libraries and national mapping agencies. To make the implicit information available for large scale spatial analyses and change detection, advanced image analysis and pattern recognition algorithms have to be applied to the scanned map documents. The information extraction process comprises three major steps: firstly, the scanning of the paper maps or – if available for the region of interest – the acquisition of digital images from a map repository [e.g., 3, 4], respectively; secondly, the georeferencing of the scanned maps (the reference is still only provided for the minority of digital available maps); and thirdly, the information or object extraction from the geo-referenced digital map images (Fig. 3).

In this paper, we focus on our experiences and some methodological aspects in using old topographic maps for land use change monitoring, in particular on the automated geo-referencing (II), the information extraction from the maps (III) as well as the visualization and usage of the retrieved historical geospatial information (IV).

II. Automated Georeferencing

When aiming for geospatial analyses within Geographic Information Systems (GIS), the maps need to be georeferenced. Considering operational, large-scale, and long-term monitoring applications, hundreds of topographic map sheets have to be manually prepared. To overcome the issues of the costly manual georeferencing, we developed – in contrast to crowdsourcing-based approaches such as used in [5] – a (semi-)automatic procedure for georeferencing a series of archival German 1:25K topographic maps [6]. As we aim at processing a multitude of maps with varying layouts, we used the least common features for referencing: the map margins and the map identifier. The real world coordinates of the map corners are inferred from the national map sheet line systems. Although the method assumes sufficient image quality and allows only affine corrections of distortions, the efforts for georeferencing could significantly be reduced [7].

III. Information Extraction

Despite the importance and increasing digital availability of old maps, the usage of these data for land use change research is still often limited to local studies. This is mainly due to the laborious manual digitization of the map content (e.g. the land use classes), which limits the temporal and spatial extent of studies [6]. Therefore, we work on the automated extraction algorithms for relevant land use features by means digital image processing and pattern recognition. We present our approaches for the automated extraction of building footprints [1, 2, 8] and built-up areas [9] for up to 60 year old maps. Finally, we show first results of our very recent research on the detection of settlement areas in more than 100 year old maps from [5].

IV. Visualization and Application

Fig. 2 shows an example visualization of the achieved results. The land use change information for the high-resolution monitoring of urban growth is solely derived from a series of old topographic maps. This information can, for instance, be used to estimate the historical population distribution. The future operational application of the extraction procedures will foster and extend a nationwide web-based land use monitoring system [10, 11]. In conclusion, we discuss some potential application and synergies that may arise from the combination of the extracted geocoded historical information with old socio-economic data.

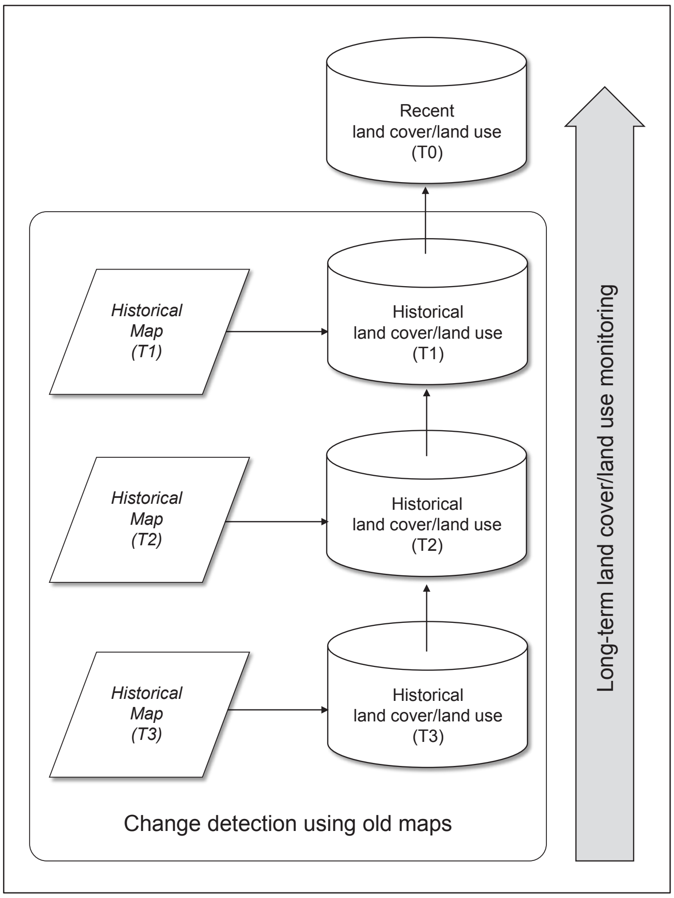

Fig. 1. Concept of map-based land use change monitoring, where T0, T1, T2, T3 refer to different points in time (modified after [2]).

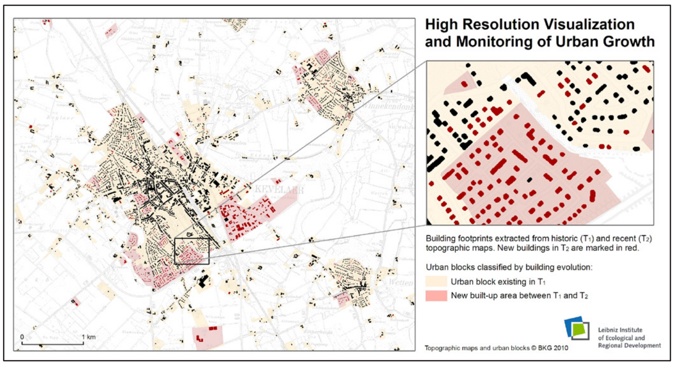

Fig. 2. Visualistation of map-based change detection, adapted from [5].

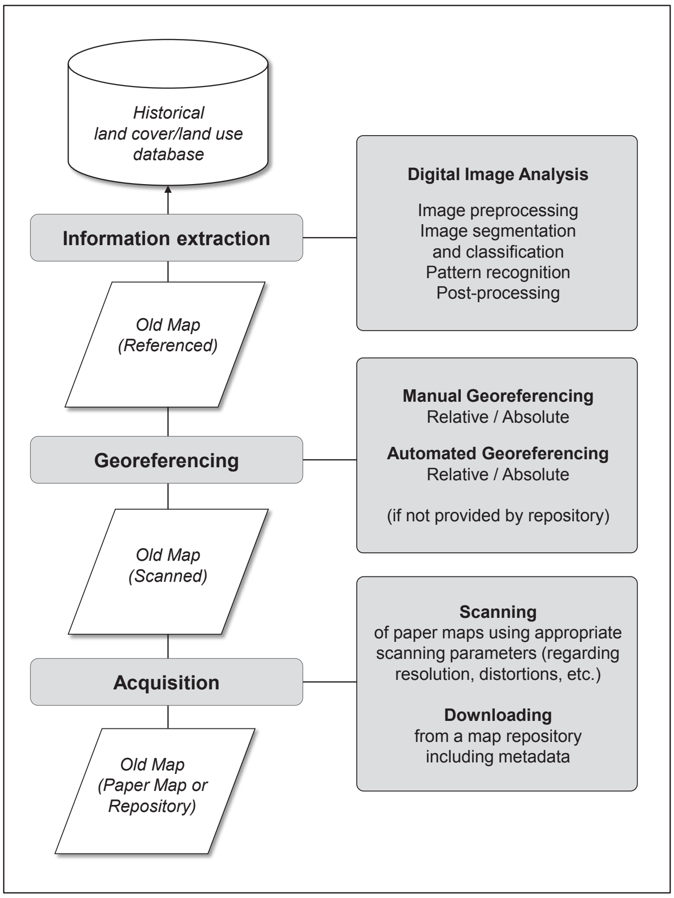

Fig. 3. Workflow for information extraction from old maps.

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The Rostock Giant Atlas

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an Important Scientific Source

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In the mid-17th century three so-called "giant Atlases" were created at Johann Blaeu's map publishing house. The Rostock Giant Atlas is the youngest and smallest of those. Similar to its brothers, The Klencke Atlas (British Library London) and the Atlas of the Great Elector (Staatsbibliothek zu Berlin), the Rostock Giant Atlas contains printed wall maps which are often surrounded by multilingual texts. This kind of wall maps would be displayed in parlours and offices. Therefore these maps suffered from the exposure to light and dust, so that only a few survived the centuries outside the giant Atlases. The giant Atlases may be considered as a kind of time capsule for Dutch wall maps of the 17th century.

With a height of 1,67m and a page width of 1 m, the Rostock Giant Atlas is not suitable for regular usage. So the maps of the atlas are not accessible for anyone, neither scientists nor the public. Only seldom the Rostock Giant Atlas is on exhibition (see Fig. 1). With the texts full of information and the beautifully decorated maps (see Fig. 2), the giant Atlases provide an insight into a time long ago. They are not only interesting for map makers or geographers but also for historians and other cultural scientists. Though the Rostock Giant Atlas contains so much of interest only a few publications about it do exist (e.g., Schmidt and Hufeld [2]).

The presentation will give a short overview on recent work with one map of the Rostock Giant Atlas. In the Hispania map the depiction of settlements and the connection between the texts and the map names are explored. This research is done with scans of the atlas dating back to 2004. These scans only show map-halves and have a resolution of 200 dpi. The second part of the presentation will show a project idea concerning these scans respectively scans of maps in books/atlases in general.

To be able to evaluate old maps digitally, the scans of the maps should meet some quality requirements. Among these a sufficient resolution for map details and a preferably undistorted geometry are the most important ones. Like in all media with a book-like form the pages of the Rostock Giant Atlas are more or less curved. The only way to have plane pages is to separate the book/atlas into single sheets. As this is only possible in the course of restoration works a new method of scanning curved pages is needed. The pages of the Rostock Giant Atlas are curved not only towards the binding in the middle of the book but also along the middle of the pages perpendicular to the binding. This distortion is complex to describe mathematically. Therefore we want to use remote sensing methods, which are normally used when creating orthophotos from a series of aerial photographs. Some problems related with this workflow are an even illumination over the whole map and a sufficient depth of field to allow for a consistent resolution of details despite the curvature of the medium. Another problem with scanning these large maps is the need for a large scanner device. Our idea is to create some kind of framework spanning over the atlas to hold the camera. This framework shall be composed of smaller segments which can be connected to form bigger ones. So the framework will be flexible to adapt to different sizes of the scanned medium and it can be disassembled for easy storage. This project-idea is still at its very beginning, so no results can be presented yet.

With the help of modern information science, like the new way of scanning maps in books, the Rostock Giant Atlas shall be transcribed into a digital edition that allows access for scientific use as well as multimedia-presentations for the public. The scanning will only be a first step to create digital images that shall be organized in a virtual research environment. There are plans to georeference the maps and to connect them with other maps of the library's collection. In the long run we plan to compare all three of the giant Atlases and investigate the details of all contained maps. An interesting aspect is for example the evolution of each map contained in different atlases. There are some maps which seem to have been updated in between publishing the Klencke Atlas and publishing the Rostock Giant Atlas. Besides, with digitizing the maps it will be possible to include them into the extensive research done with maps of the Netherlands (e.g., Schilder [1]).

Keywords—giant Atlas, wall-maps, digital edition

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Fig.1: Presentation of the Rostock Giant Atlas during an exhibition in 2013

Fig.2: Detail of the VIII Germania map’s border decoration

Georeferencing, Annotation and Analysis Tools for Old Maps: An Overview

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I. Introduction

Early maps are valuable sources as they not only contain geographic information but are also a political and cultural mirror of their time. Nowadays becoming more and more available in a digital format, such digitized early maps are a way of getting evidence and detecting novelties in the field of historic research. Thus software systems are developed or classical GIS systems are used to support users in receiving answers to research questions, for example in following areas:

- Landscape dynamics [1], [2], [3]
- Flood mapping [1]
- Forest cover change [1], [4]
- Map accuracy [5], [1], [6], [7]
- Assessing geodetic knowledge [8], [9]
- Toponym changes [10], [11]
- Urban model reconstruction [12]

II. Software systems

As shown in the introduction there is a big variety of research areas that can profit from data contained in old maps. But these maps where not created with a standardized style and also have a different level of accuracy than modern maps. Following the big interest in the old maps and their unique problems there were many tools created to analyze them and this paper will give an overview over a diverse selection of these tools:

MapAnalyst is a desktop tool to analyze the accuracy of old maps. It can calculate statistics for the distortions in a map and visualize them (see Fig. 2). [6], [13]

Georeferencer is a commercial tool to georeference old maps, for defining the area containing the mapping data and display them as overlay on a modern map. The accuracy analysis features of MapAnalyst are also available in the Georeferencer interface using the control points defined in the georeferncing process. [14]

LEMO is an annotation framework and was developed with the main goals of annotating multimedia documents, allow end-users to contribute annotations and to be open and interoperable. [15]

YUMA Universal Media Annotator was developed for Europeana as annotation framework for multimedia objects on the Web. It also includes the semantic annotation of images, including maps. [16]

Annotorious has its roots in YUMA and is also a tool for semantic annotations, which can be extended by plugins. [17]

Maphub is also based on YUMA and allows georeferncing and free text annotations for regions, for which then tags from Wikipedia are suggested. [18], [19]

Histograph wants to simplify geographic search. To reach this, Histograph allows to collect and link place names and uses these to georeference and standardize place names in time (see Fig. 3). [11]

LODUM Historic map georeferencer. LODUM is the Linked Open Data initiative of the University of Mnster, the portal aims at sharing scientific data organized in space, time and semantics. A subproject, the Historic map georeferencer, is concerned with annotating historic maps (see Fig. 1). [20]

Recogito is a tool that makes it easy to identify, record and export the places referred to in historical texts, maps and tables as Linked Open Data (see Fig. 4). [21], [22]

GIS and Historical GIS. A Historical GIS is as Geographic Information System that also tracks changes over time. Two major projects in this area are the Great Britain Historical Geographical Information System [23] and the China Historical GIS [24].

III. Conclusion

For many research topics there are already support tools available but these tools where often developed for a special project and are unmaintained since its end. This costs much time for recreating similar tools after one was abandoned.

A solution could be a framework that implements a common core and can be extended with special tools for different areas. If the framework gains enough momentum the burden of maintaining it could be distributed over many shoulders and it can outlive single projects.

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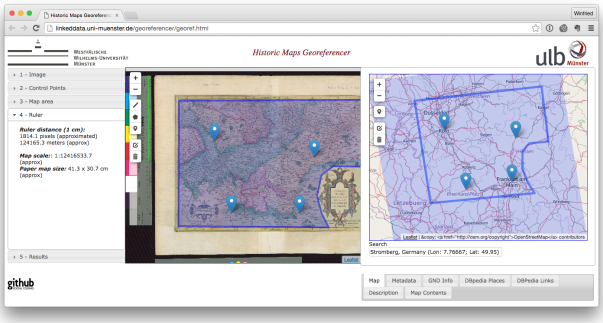

Fig. 1. Interface of the Historic Maps Georeferencer with annotations. Source http://linkeddata.uni-muenster.de/georeferencer/georef.html

Fig. 4. Recogito Image Annotation Editor. Source http://pelagios.org/recogito/static/documentation/index.html

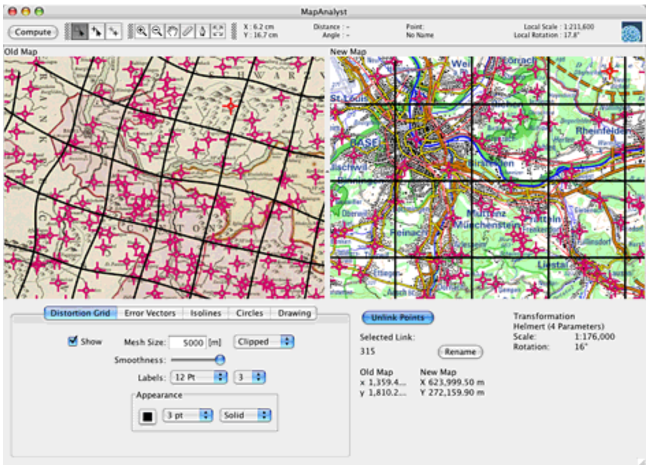

Fig. 2. Screenshot of the MapAnalyst interface. Source http://mapanalyst.org/screenshot/screenshot.html

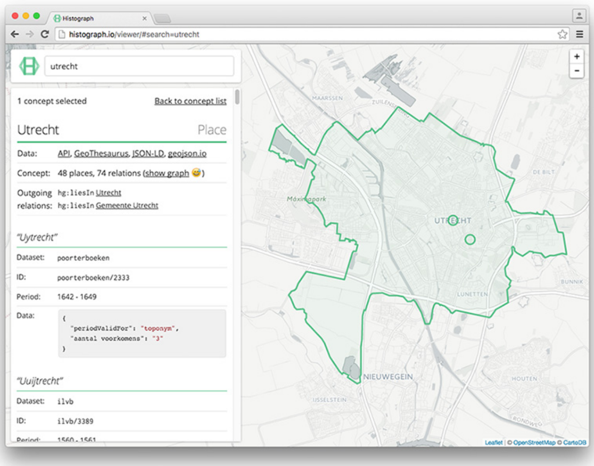

Fig. 3. Histograph screenshot for "utrecht". Source [11]

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Landscape Change Induced by Separation and Reunification

A Case Study at the Former Inner-German Border with Regard to Korea

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***Abstract*—Border regions are often biodiversity retreats, especially if they are largely undisturbed. The former Inner-German border is a good example – today following the idea of turning the so-called Iron Curtain into a Green Belt as migration corridor. Thus, this study is analysing the effects of separation and reunification on landscape change. For this reason, historical topographic maps for a case study area are analysed using a Geographic Information System (GIS). Corresponding research is underway for the Korean Demilitarized Zone (DMZ) to learn about potential future processes.**

Keywords—topographic maps, historic maps, GIS, landscape change, temporary borderlands

I. Introduction

In the aftermath of the Second World War, Germany was partitioned into two states, namely the German Democratic Republic (GDR/East Germany), which was under Soviet control, and the Federal Republic of Germany (FRG/West Germany), controlled by the Allied Forces (UK, France, USA). This separation lasted from 1945 to 1990. During this time, the East German government continued to fortify the 1,378 km Inner-German border. This was part of the so-called “Iron Curtain” dividing the Soviet bloc from Western Europe, running over 12,500 km from Scandinavia to the Mediterranean. The long-lasting separation, the massive border fortification as well as the different political systems had a strong impact on land use. The same is true for the processes after reunification, i.e. reestablishment of road, train, energy and communication infrastructure connections, reuse of properties in the border zone. These effects and land use changes are quantified by spatial analyses of historical topographic maps from before separation until today using GIS methods.

II. Study Area

The investigation area chosen for detailed analysis is the Eichsfeld region in central Germany with Göttingen as the nearest well-known city. The area covers the former border area between East Germany (now Thuringia [Thüringen]) and West Germany (now Lower Saxony [Niedersachsen] and Hesse [Hessen]). Six sheets of topographic maps provide an outline of the study area (35 by 22 km, 770 km ; Fig. 1).

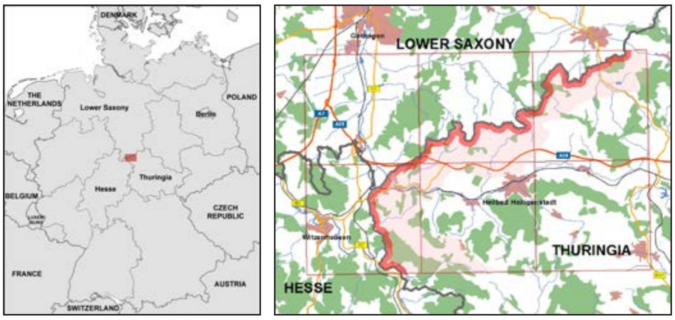

Fig. 1. Location of the study area within Germany (VG 25 © GeoBasis-DE/BKG 2015) and detailed map of the study area (VG25, DLM250 © GeoBasis-DE/BKG 2016) including the location of the used map sheets, the former fortified 500 m wide protective strip along the Inner-German border (red) and the 5 km wide restricted zone (light red).

The region is largely rural with some wooded hills and a large number of smaller towns. The fertile, loess-covered lowland encourages intensive agriculture. The elevation is between approx. 200 and 543 m (Goburg). The newly built highway A38 passes through a small mountain (the Heidkopf, elevation: 354 m), which required the construction of a tunnel (Heidkopftunnel) – also to preserve the continuity of the Green Belt.

III. Data and Methods

Table 1 indicates the timeframes of historic maps at scale 1:25,000 available for the six selected topographic map sheets forming the investigation area. A selection of these maps is shown subsequently to indicate land use development in one segment of the study site (Figs. 2, 3). In addition to the historic maps, recent digital topographic data is available for the years 2000 and 2014 from the German-wide Authoritative Topographic-Cartographic Information System, Digital Landscape Model (ATKIS-DLM, Fig. 4).

The recent ATKIS data give the opportunity to be used as digital base dataset. Thus, not the complete land use of the whole map has to be digitised manually but only the differences of the current dataset to the content of the historical maps while overlying. This method is called backward editing [1] and was applied in several similar studies [2, 3, 4].

TABLE I. EXISTING HISTORICAL MAPS USED FOR

Topographic map sheet[a]	Year				
	1937/38	*~1945*	*~1950*	*~1970*	*~1990*
4525 Friedland (LS)	1937	1945	1956	1971	1991
4526 Gleichen (LS)	1937	1945	1956	1969	1993
4527 Berlinge-rode (T)	1937	1945	1956		1993
4625 Witzen-hausen (H)	1937	1945	1956	1969	1993
4626 Heilbad Heiligenstadt (T)	1937		1956		1988
4627 Leinefelde (T)	1937		1956		1988

a. LS…Lower Saxony; T…Thuringia; H…Hesse.

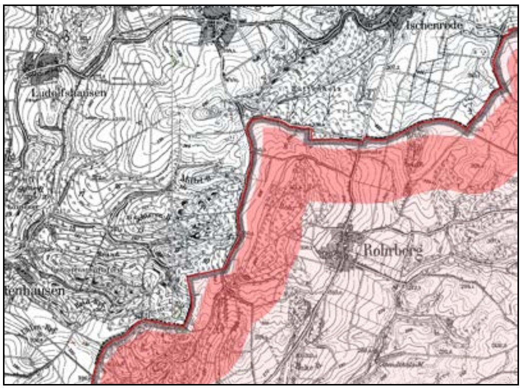

Fig. 2. Status 1969: Topographic map 1:25,000. Source: Extract from geographic base data of the surveying and cadastral authority of Lower Saxony, © 2015 LGLN. Additional features: State boundary (red line) © GeoBasis-DE/BKG 2015, fortified 500 m wide protective strip (red) and 5 km wide restricted zone (light red) (own work)

IV. CONCLUSIONS

It is important to remember that maps do not always represent an objective reality, and that there can be manifold problems in the interpretation of maps, especially historic maps. In the case at hand, some topographic features may have been deliberately omitted or distorted on the GDR maps (i.e. real features at the border strip such as fortifications and military objects). Furthermore, developments in land use that take place between map editions cannot be directly illustrated. Clearly, a map is only a snapshot at a particular point in time. Data availability, accuracy, geo-referencing and digitization may provide further challenges for the analysis of historic land use development. These issues will be addressed in later project stages.

To date, a part (about a quarter) of the German case study area has been analysed for all available timeframes including statistical analysis of landscape change due to separation and reunification. We found, that historical maps offer a great chance to monitor related changes with a high accuracy. Corresponding research is underway for the Korean Demilitarized Zone (DMZ) to learn about potential future processes and to compare them to German experiences [5].

Fig. 3. Status 1937: Plane survey sheet (Messtischblatt) 1:25,000, ed. 1909 with suppl. 1937. © Saxon State and University Library Dresden (SLUB)/ German Photographic Collection (Sächsische Landesbibliothek – Staats- und Universitätsbibliothek Dresden (SLUB)/Deutsche Fotothek). Additional feature: State boundary (red line) © GeoBasis-DE/BKG 2015.

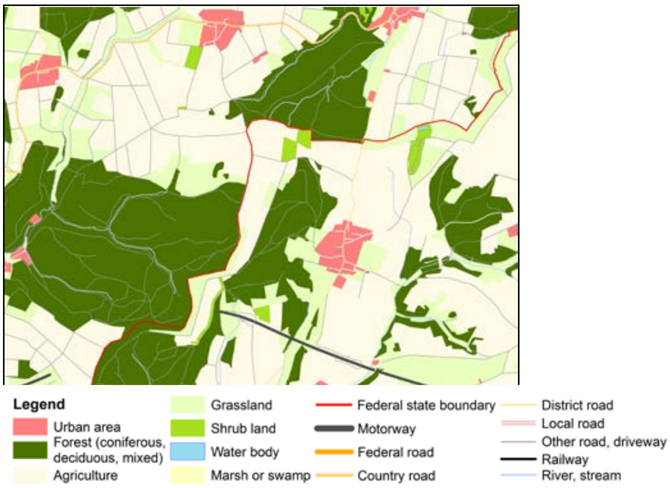

Fig. 4. Status 2014: Authoritative Topographic-Cartographic Information System, Digital Landscape Model (ATKIS-DLM), © GeoBasis-DE/BKG 2014. Additional feature: State boundary (red line) © GeoBasis-DE/BKG 2015.

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Vectorisation of Historical Maps

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***Abstract*—More and more libraries start digitizing their historical maps. This development offers new ways of working with the data of those maps. The OHDM project adds information stored in historical maps to current online maps. We propose a way to automatically extract buildings and streets from a set of maps in order to integrate the recognized objects into the OHDM database. We use color segmentation to find most buildings and roughly half of the streets, while the other streets are extracted via edge detection and a multi-step filtering method. First results look promising, even though there are still many ways to improve the robustness of the algorithms.**

I. Introduction

Open Historical Data Map (OHDM) is a project to offer services like Open Street Map (OSM), enhanced with historical data. Historical maps are the major source for historical spatial data. Most libraries that manage such maps already have at least plans for digitizing them. Those scanning processes produce raster data in JPEG or TIFF format. OHDM requires vector data, though. Our goal is to extract streets and buildings from historical maps and convert these objects as vector data so they can be imported into OHDM. Thanks to Berlin state library we had access to a set of historical maps drawn by Colonel Johann Friedrich von Balbi in the time between 1748 and 1749. These maps show some parts of northern Germany.

II. Related work

There are some publications dealing with image recognition in maps [1], [2]. But due to the fact that the maps we use are drawn by hand, the given algorithms are just marginally applicable to our problem. Furthermore, there are significant differences between the maps from different drawers regarding color, scale, geometry, level of detail, etc. Therefore, we had to develop a custom approach based on the maps drawn by Balbi.

III. Extraction algorithms

As all buildings have roughly the same reddish color, we decided to use a color based approach. For every pixel we check if its color value lies within a certain range. If not, this pixel is eliminated. Morphological operations are used to improve the quality of the segmented regions. In roughly half of the maps the streets are highlighted with an intense yellow color. Extracting those streets can be done with a similar technique like the one we used for extracting buildings. Apart from some edge cases, our first test results were promising.

In the other half of the maps, the street color doesn't differ from the map background itself, so a color-based approach doesn't work in those cases. Therefore we developed an algorithm which uses the edges resulting from a Canny edge detector [3] as input. For each edge, a multi-step filtering process is applied, which checks for the following requirements to be met: low curvature, minimum length and a special neighborhood relationship. Only edges meeting all these features are treated as street edges. In an additional step, we check whether there's an outstanding number of edges with the same length and orientation (e.g. tree edges) via clustering [4]. If such a cluster exists, its edges get eliminated too.

IV. Results

Fig. 1a shows an example segmentation of buildings with the proposed method. Most of the buildings get segmented correctly. Further work still needs to be done in order to enhance the true positives (e.g. separation of connected objects) and remove the remaining false negatives (especially borderlines, as many of them have the same color as buildings). Additional features like shape and size of the segmented regions must be processed in order to achieve these aims. The same applies to the colored streets.

The results of the extraction (Fig. 1b) of pale streets look slightly worse because of the lack of an outstanding feature like color. Still, in most of the maps a good amount of street edges could be extracted. There are many ways to improve the algorithm via adding more filters. For example, an analysis of the surrounding color can be used to remove borderlines and rivers.

V. Conclusions

We proved that an automatic extraction of objects in historical maps is possible. Our method was developed based on the Balbi maps, which were also our test data. Therefore, further research needs to be done to find out how our ideas can be generalized, so that they are applicable to a wider range of input data. Another major task will be the estimation of the spatial position of the vectorized objects. That certainly will result in a semi-automatic solution, as historical maps have no global coordinate data at all due to the absence of such concept in the time of their creation.

(a) (b)

Figure 1: Processing steps for the extraction of buildings (a) and streets (b)

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Open Historical Data Map (OHDM) - work in progress

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Open Street Map (OSM) is an example how a huge crowd of enthusiastic volunteers can create an accurate and up-to-date global map. We are going to offer a similar system with some more services but with historical data. That is Open Historical Data Map (OHDM).

OSM only stores very simple geometries (points and ways). OHDM also stores more complex geometries and also geographic objects, see figure 1. Geographic object are e.g. buildings, streets, boundaries of countries. They have a life-cycle: They are created, changed and seize to exist sometimes. Objects and geometries are related but not the same. The obelisk on the Place de la Concord in Paris was moved there in 1835. It was created centuries ago in Egypt, though. That object (obelisk) changed its position (geometry) but is still same object (obelisk). See figure 1 for a very simplified view of the core idea of the OHDM data model.

OSM geometries are created by volunteers. We follow the same approach and implement editors. There are yet two prototypes: a web editor (based on OpenLayers) and another on Android. An iOS edition is planned.

Geometries of streets or buildings tend to be stable over centuries. Their names or usages change more frequently, though. Editors can be used e.g. to add an old name to an still existing street or to explain former usage of a still existing building. Editor can also be used to chart geometries which do no longer exist on Earth surface[Leh16].

OHDM stores vector data in a PostGIS database. We use GeoServer[1]) to offer a maps with the standardized WMS interface[Fra15,Thi15].

Basis of route finding algorithms are vector geometries of streets and an average speed. More information are required when dealing with historical data, see [Bos16]. Military campaigns, epidemics and other regional disasters made it even impossible to pass an area. Average speed strongly depended on status and available money (A noble could travel easier, faster and more safe than a peasant e.g. in the Middle Ages). Crossing borders or countries was and is regulated by (sometimes cruel) laws which depend(ed) on nationality, race, religion, gender and even age. (Only retired East Germans were allowed to travel to western countries before 1989.)

We also extract vector geometries from digitalized old maps in co-operation with Berlin State Library.

OHDM will offer (1) tools to add historical spatial data, (2) historical maps and a (3) a historical route finder (fig 2). OHDM concepts are clear and the first implementation steps are made.

[1] geoserver.org

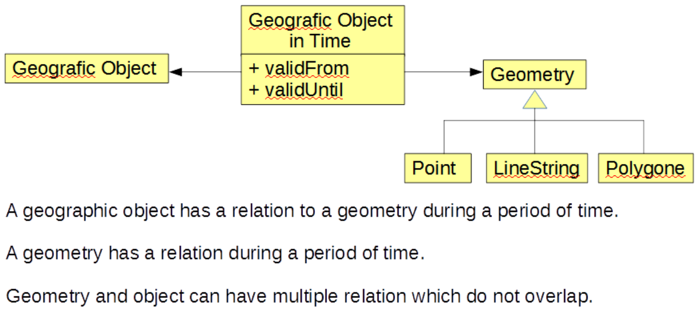

Fig. 1. Data model - core concept

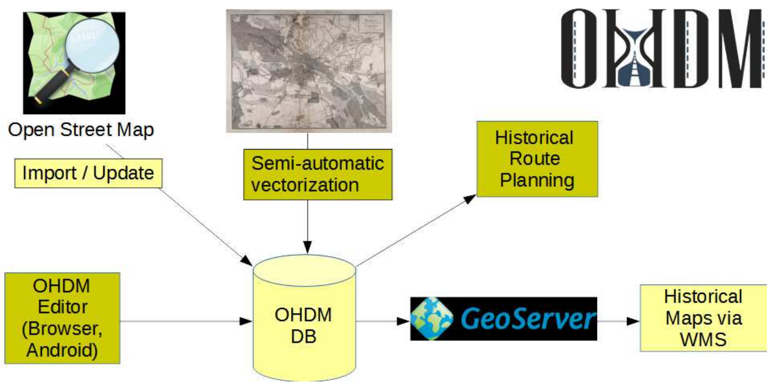

Fig. 2. OHDM Components

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