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GlamMap: visualising library metadata

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Abstract:
Libraries provide access to large amounts of library metadata. Unfortunately, many libraries only offer textual interfaces for searching and browsing their holdings. Visualisations provide simpler, faster, and more efficient ways to navigate, search and study large quantities of metadata. This paper presents GlamMap, a visualisation tool that displays library metadata on an interactive, computer-generated geographic map. We provide detailed discussion of how GlamMap benefits the work of librarians and researchers. We show how geographic representations help librarians to perform tasks such as collection assessment and how geographic information helps researchers to identify important scientific resources.

1. Introduction

Today's libraries provide online access to millions and millions of bibliographic records. Librarians and researchers require tools that allow them to manage and understand this enormous amount of data (Börner & Chen 2002b). Most libraries only offer textual interfaces for searching and browsing their holdings. Search results are displayed as lists of text, with a restricted amount of items per page. Such lists are difficult to navigate, do not allow users to get a general overview of libraries' holdings, and finding an item can be time-consuming (Shneiderman et al. 2000; Börner 2001).

Visualisations provide a means to overcome these difficulties. Graphical representations are known to provide quick access to bibliographic data, to reduce search time, to facilitate the browsing and identification of relevant metadata, and to provide a quick overview of the coverage of libraries (Börner & Chen 2002b, 2002a). There are different ways to visualise library metadata. A rather intuitive way is to represent such data *geographically*, by depicting, for example, the place of publication of documents on a geographic map. Research on geographic representations of library metadata is guided by the assumption that humans will benefit from information services that allow them to specify geographical scope (Cai 2002, p. 171; National Research Council 1999). However, there is little research that shows exactly how geographic visualisations of library metadata benefit the work of librarians and researchers.

In this paper, we present research on GlamMap, a visualisation tool for library metadata. GlamMap aims to support the navigation of large amounts of metadata by representing these data on a geographic map. In particular, GlamMap visualises diverse sets of bibliographic metadata (such as place of publication, library holdings, author, title, year, publisher) on a two-dimensional, interactive, computer-generated map, which can be navigated and explored by users in multiple ways. We will discuss the functionalities of GlamMap and describe how GlamMap supports the work of librarians and researchers. This will allow us to specify precisely how geographic visualisations of library metadata aid librarians and researchers in performing various important cognitive tasks.

The paper is structured as follows. In Section 2, we introduce the reader to the field of information visualisation and discuss the functionalities of GlamMap. In Section 3, we present use cases that show how GlamMap benefits the work of librarians. We show how geographic visualisations of library metadata aid literature search, collection assessment, and the clustering of bibliographic records. In Section 4, we describe how GlamMap benefits the work of researchers. We show how geographic representations of bibliographic metadata help researchers in the field of history and philosophy of science to navigate and identify important resources and to study the dissemination of scientific knowledge. In Section 5, we conclude by discussing the current system as well as future challenges.

2. GlamMap

In recent decades, visualisation technologies have become increasingly important in the sciences: medical researchers use 3D visualisations to explore vascular structures (Preim & Oeltze 2008), biologists visualise protein DNA-Interactions (Van Mameren, Peterman & Wuite 2008), and geologists employ interactive visualisations

to interpret simulations of earthquakes (Kellogg et al. 2008). The study of visual representation and analysis of data is conducted within the disciplines of *information visualisation* and *visual analytics*.

Information visualisation. What is information visualisation and what is its value? Card, Mackinlay and Schneiderman (1999, p. 6) define information visualisation as "the use of computer-supported, interactive, visual representations of data to amplify cognition." Visual representations *amplify* cognition by functioning as so-called external cognition aids: artefacts external to the mind that support the performance of cognitive tasks (Ibid., pp. 1–6, 15–17). Maps, for example, represent large amounts of data in an easily accessible form (Tufte 2001). As such, they increase human memory resources and help to reduce the effort to search for information. In addition, visualisations enhance the recognition of patterns and allow for the quick monitoring of data; interactive visualisations also allow for the manipulation of data. By virtue of these characteristics, visualisations aid humans with complex cognitive tasks such as discovery and decision making (Card, Mackinlay & Shneiderman 1999; Fekete et al. 2008). Visual analytics further aids such tasks by combining visualisation with automatic data analysis, so that "humans and machines cooperate using their respective distinct capabilities for the most effective results" (Keim et al. 2008).

While such visual techniques have become common practice in the sciences, they are little employed by libraries, despite similar increases in available data. OCLC's WorldCat (2013), for instance, contains over 2 billion holdings of over 300 million bibliographic records, but currently only offers a textual user interface for searching and browsing these. The same is true for many national libraries, university libraries, and online services such as Europeana (2013) and Trove (2013). Although such institutions and services provide advanced search options, they display search results as lists of text, which are difficult to navigate.

This state of affairs is changing, however. For example, OCLC and Europeana are both developing geo-spatial interfaces for accessing their collections, prototypes of which are already available. While these new ways of interacting with their collections can already aid users, in terms of visualisation techniques these efforts are still rather crude. GlamMap is a new project with the ambitious aim of providing the GLAM (Galleries, Libraries, Archives, Museums) sector with easy access to the *latest* in visualisation research. This aim will be realised in the form of an Open Source web application for the visualisation of GLAM collections. GlamMap will enable GLAM actors to provide visualisations of their collections of books, paintings or movies in a flexible, insightful, cost-effective and user-friendly way. These visualisations benefit various kinds of users, including librarians and researchers.

GlamMap. GlamMap is a geo-spatial visualisation tool that allows users to visualise metadata of cultural heritage artefacts on an interactive, two-dimensional geographic map. Figure 1 shows the graphical user interface of the current prototype, visualizing 7,100 bibliographic records from books in logic published in Europe between 1700 and 1940. This bibliographic dataset was obtained semi-manually from Wilhelm Risse's *Bibliographica Logica* (Risse 1965), a standard reference work on the history of logic.

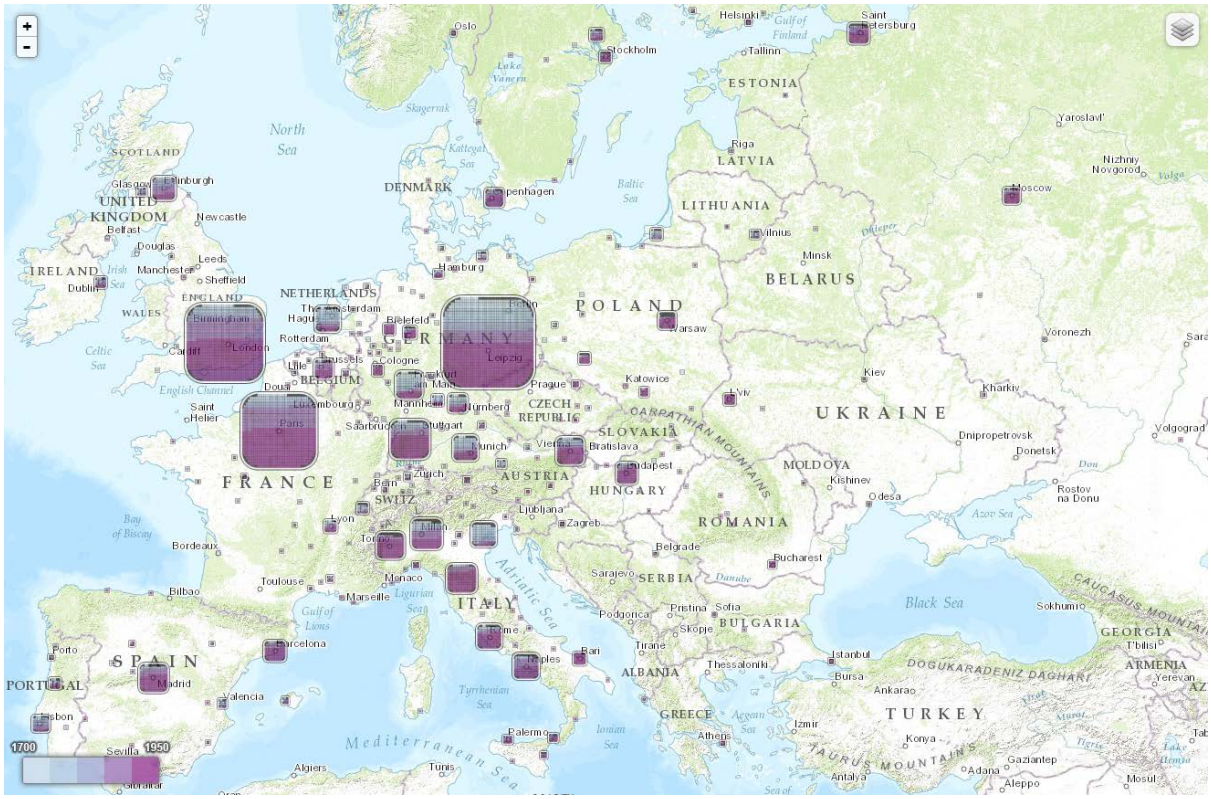

Figure 1: 7,100 logic books clustered by place of publication and colour-coded by year of publication.

In the Risse visualisation (Figure 1), documents are assigned a geographic location on the basis of their place of publication. The size of the squares represents the *quantity* of documents published in certain geographic areas or places. The colours of the squares range from light blue to dark purple. Differences in colour represent differences in the *year of publication*: documents published in the early eighteenth century are represented by light shades of blue, whereas shades of purple represent documents published in later periods. The size of the squares and the colour scheme thus reveal different types of data.

GlamMap further provides users with *interactive* visualisations. By clicking on the map, users are able to zoom in on certain geographical areas or places. Zooming in refines the view, splitting the squares into multiple smaller squares, until ultimately each square represents a single city. Users can search, filter and group the metadata by clicking on geographic regions or places. This allows them to determine which books were published when and where (Figure 2). In addition, users can search and filter the metadata by specifying the author(s), title and the year of publication of documents.

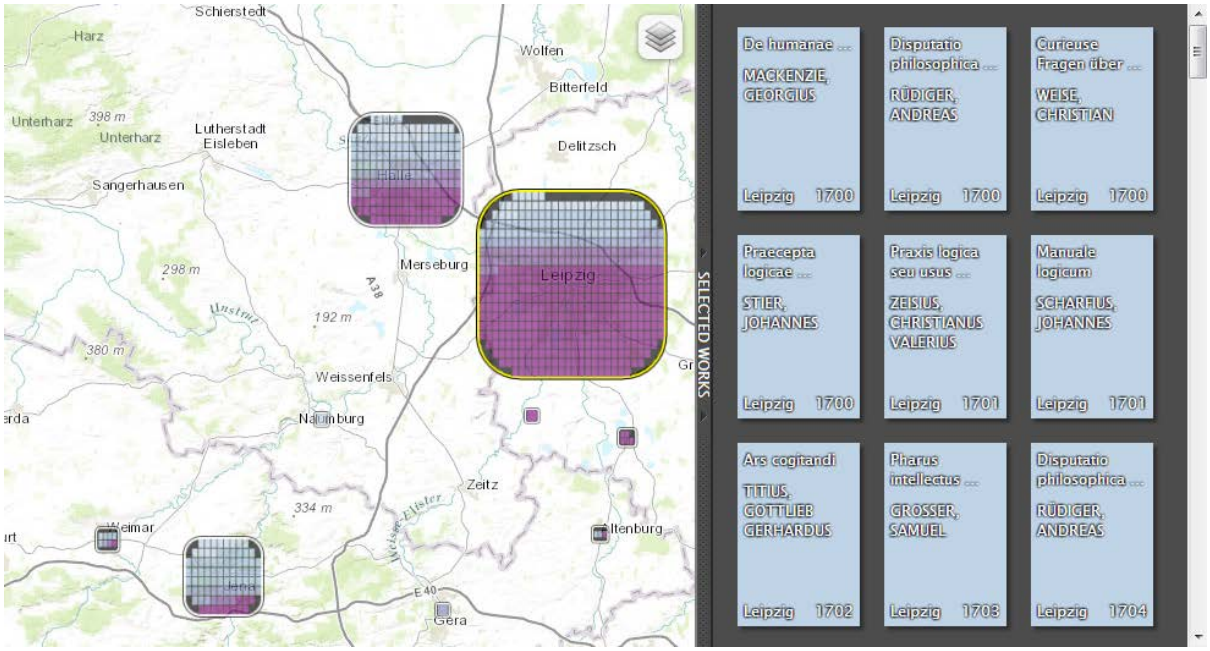

Figure 2: Clicking on a cluster of books displays their metadata in a panel to the right.

We have described the core functionalities of the current prototype of GlamMap. In the next stages of development, we will integrate an automatic harvester, providing users with quick and easy access to datasets provided by libraries. The eventual system will be flexible and extensible, so that new visualisation techniques and new, big data sets can be added easily. To achieve these aims, we are collaborating with the providers of some of the largest online repositories of bibliographic data: the European Library (2013) and Europeana through the eCloud project; the National Library of Australia (Trove); and OCLC (WorldCat).

Related work. Although few libraries allow users to visualise their data, there is a significant amount of research on the visualisation of digital library search results and on graphical interfaces for digital libraries (cf. Börner, Dillon & Dolinsky 2000; Börner 2001; Börner & Chen 2002a; Shneiderman et al. 2000; Marks et al. 2005). The objective of these studies is to develop visualisation techniques and tools that allow users to quickly investigate and understand the massive amounts of data stored in digital libraries. However, few of these tools provide *geographical* visualisations of library data. Notable exceptions include the Alexandria Digital Library Project (Smith 1996; Ancona et al. 2002), which should allow users to search catalogues by defining geographic regions. Similarly, GeoVIBE (Cai 2002) is a geographic information and retrieval tool that facilitates spatial search queries and provides users with visualisations of how collections of documents are related to different geographical areas. There are also a few libraries that do give visual access to their collections. The Digital Public Library of America (DPLA 2013) offers an online interactive map of the United States on its website to explore its collection. OCLC's mapFAST prototype does similarly for WorldCat, as does Europeana's 4D interface (e4D) prototype for Europeana.

GlamMap's geographical visualisation differs substantially from GeoVIBE's. In the latter, one interactively defines (textually and visually) which subset of items to display on the map, but the visualisation on the map then has a fixed level of detail. GlamMap instead adds more detail as the user zooms in, like the 2D visualisations of DPLA, mapFAST, and e4D as well as Alexandria's 3D visualisations. GlamMap's

visualisation is richer, however, and it uses a more advanced zooming technique that helps users to preserve their mental map during the change in visualisation. On DPLA's website, for instance, equal-size orange circles with numbers in them show how many matching items are located in each state. After zooming in on the map, the circles split to represent smaller areas such as counties, but it is hard to determine which county-circles resulted from which state-circles. In GlamMap each item is shown individually (colour-coded by another attribute such as publication date) in square *clusters* of differing sizes. Holding the mouse cursor over a cluster provides a preview of the sub-clusters that will result from zooming in. Hence, when the clusters split, one can comparatively easily follow which of the new, smaller squares correspond to the original square (Figure 3).

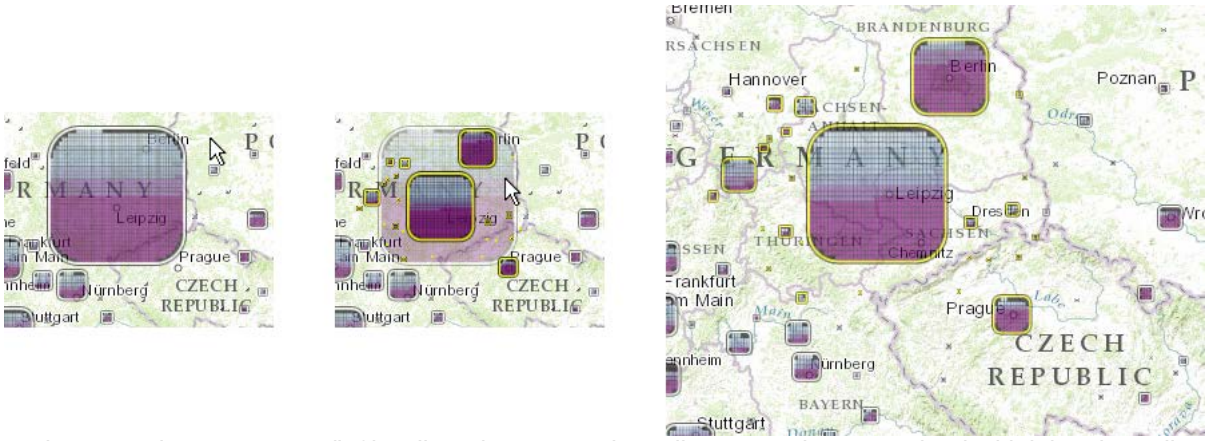

Figure 3: Bigger squares (left) split up into several smaller ones when zooming in (right). The split can be previewed (center) to not lose track of where things go when zooming.

3. Use for Librarians

Today, libraries and other actors from the GLAM sector struggle to cope with serious budget cuts. At the same time, they face exponentially growing demands for new and more user-empowering digital services, while trying to guarantee continued quality and amount of traditional services. GlamMap can answer a number of aspects of this struggle at once. We will highlight two use cases for librarians, *internal* and *external*. In the internal cases, GlamMap aids librarians in management tasks such as collection assessment; in the external cases, GlamMap enables library users to perform (cross-repository) collection assessment relevant to them. In both cases, libraries' resources are freed and we show how geographical information matters to this end.

Case 1: At a glance

(A) *Library management: Collection assessment (internal)*. Following the success of *The Matrix*, public demand is growing for information on the philosophical influences on the movie, in particular about Plato's dialogue *The Republic*. Ingrid, the manager of a consortium of libraries located in New South Wales, wants to make sure that the subject area '(Republic) Plato' (excluding Plato's dialogue itself) is duly covered in all areas served by her consortium. Because of

recent budget cuts, Ingrid can buy material only if the '(Republic) Plato' subject area is not already covered in bordering states of Australia. Besides, her team is very small, and chronically overworked. Ingrid's team needs to know quickly, cheaply and effectively what can be found where and in what amount. Machine-automated methods can improve the situation, but if these methods do not involve visualisation, they are of little use because they are not insightful. GlamMap solves the problem (Figure 4).

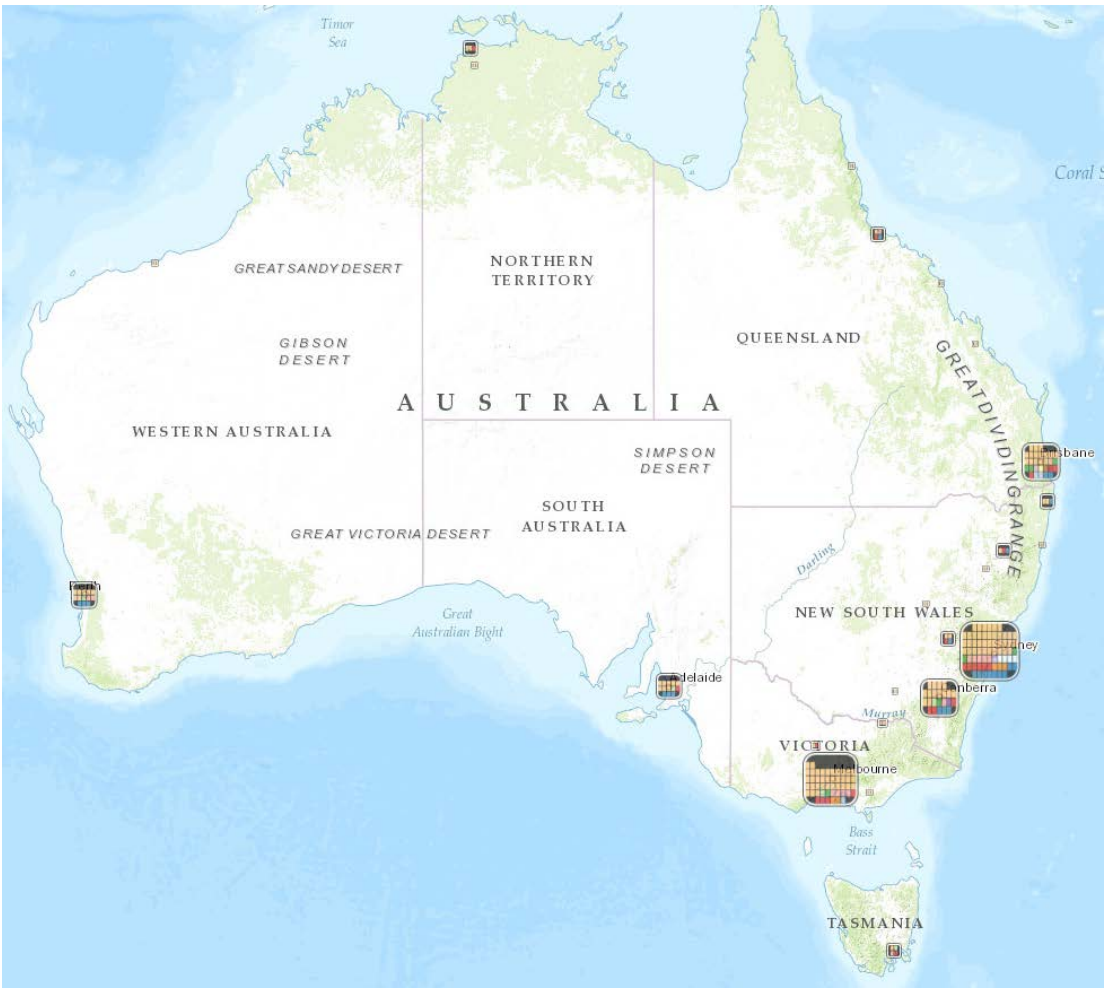

Figure 4: Library holdings in Australia of books with the subject '(Republic) Plato'. Different works are given a different colour.

(B) User services: Collection assessment (external). Hein, a Dutch researcher in 19th century philosophy, needs to be able to search the full-text of Bolzano 1837. No modern digital edition exists, while the original work is printed in Blackletter Gothic (*Fraktur*). Scanning and OCR-ing the printed critical edition poses copyright problems, while scanning and OCR-ing *Fraktur* printing in a user-friendly way requires specialised software Hein cannot afford. To solve this problem, Hein needs to know whether there exists any copyright-free edition of the work in Latin script, and which libraries in his country have it, since getting the book from abroad will cost far more and take longer.

In the terms of the hierarchical model FRBR (Functional Requirements for Bibliographic Records) by the IFLA (International Federation of Library Associations and Institutions), which distinguishes a *work* (*The Aeneid*), its

expressions (Fitzgerald's translation of *The Aeneid*), *manifestations* (a particular paperback edition of Fitzgerald's translation of *The Aeneid*) and *items* (a copy of a particular paperback edition of Fitzgerald's translation of *The Aeneid*) (Mimno, Crane & Jones 2005; Hickey, O'Neill & Toves 2002), Hein needs to identify a particular manifestation of an expression of the *Wissenschaftslehre*. For Hein's purposes, the manifestation level is more important than the expression level, because even if a particular expression might be methodologically more sound for the scholarly purpose of studying the text (e.g. an expression in which textual errors have been corrected), having a searchable, OCR-ed text with errors in it is much more valuable to Hein than having only a non-searchable paper copy without those errors. This is because Hein will use more than one resource: he will typically compare the relevant passages obtained by searching the text of any expression he can obtain digitally with the same passages in the paper *Gesamtausgabe* for sound methodology.

Info on scripts in bibliographic records is usually offered occasionally as semi-structured data, for instance in a field for general notes rather than in specific script or alphabet fields.[i] This case shows that a separate field for language script would be an important addition to library cataloguing practices. We shall suppose that this cataloguing practice exists and that Hein is able to filter the information without additional manipulation.

By using GlamMap, Hein can get the information he needs at a glance. This process goes in three steps: first, since WorldCat is the largest catalogue in the world, Hein searches for the title "Wissenschaftslehre" with the author "Bolzano" in WorldCat, under the assumption that this search gives him access to everything ever published (Figure 5); second, Hein filters for Latin script; third, he zooms in on the Netherlands to find which *relevant* hits are located in the country (Figure 6). This is a far quicker process than the process enabled by any textual interface. Hein discovers that the three expressions that might be relevant for him are present in Leiden.

Figure 5: Library holdings of Bolzano's *Wissenschaftslehre* from WorldCat.

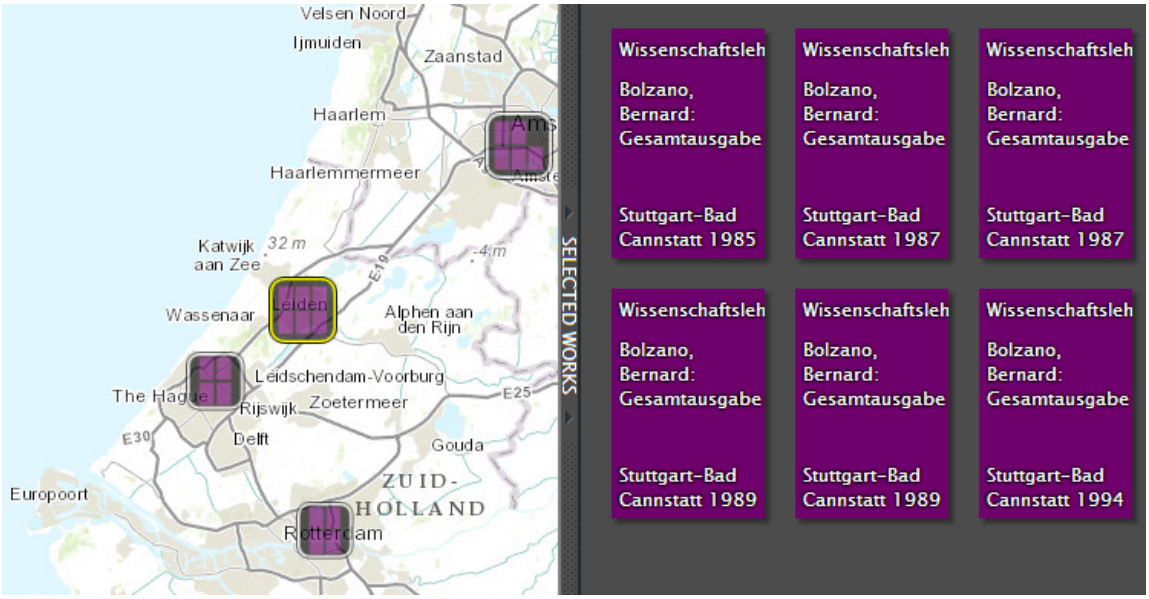

Figure 6: Filtering out books printed in Fraktur and zooming into his region, Hein finds the information he was looking for.

Case 2: Fuzziness

(A) Match user and service via a Graphic User Interface (external, non-academic) Carla, a professional opera singer living in Berlin, wants to find which music scores were published in certain specific years between 1781-1848 in (former) Bohemia, a historical country with capital Prague, part of present-day Czech Republic, or in its immediate surroundings. She also wants to find the nearest library to her where the scores she selects are available, if they are not online. The WorldCat User Interface does not meet Carla's needs: it displays 265,174 results for scores published between 1781 and 1848. This is too many results to be useful, and Carla cannot sensibly filter them. For instance, language filters do not help, because Carla does not care whether the score is (classified as) in Czech (46 results), German (18,460) or 'undetermined' language (102,111); Carla cares only about a certain culturally relevant area. The concept of a 'culturally relevant area' is fuzzier than the concept obtained by combining a certain language, country, city, and creator because Carla wants *whatever* has been produced in a certain historico-geographical area in an area of a diameter of at least about 100 km from Prague within the borders of the historical Habsburg Empire.

In contrast to the textual WorldCat interface, GlamMap enables Carla to find what she needs at a glance. GlamMap allows Carla to customise data input (choosing repositories via the harvester component) visualisation (via a user panel), and geographical map (choosing, e.g., a historical map of Bohemia instead of the modern map, to make sure that she identifies the correct historical borders of the area), resulting in Figure 7.

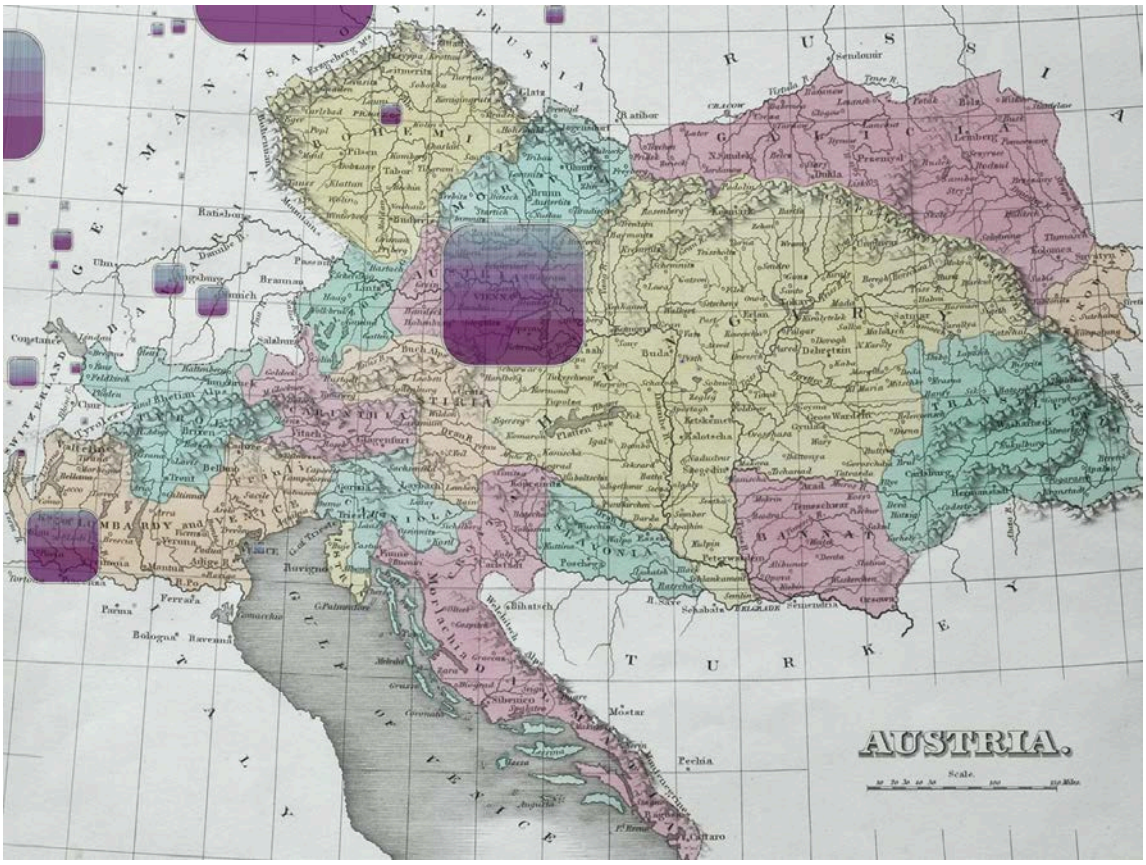

Figure 7: Musical scores from 1781-1848 listed in WorldCat, visualised on a historical map of the Austro-Hungarian Empire.

4. Applications: History and Philosophy of Science

What is the use of library metadata and visualisations of these data for researchers, besides finding literature they already know about? In this section, we show how GlamMap benefits scholars who study the history of logic. We do so by using our mapping of Risse (1965): a visualisation of four sets of metadata (place of publication, author, title, year) from 7,100 books on logic published from 1700 to 1940. Research on the history of logic is part of the discipline called 'History and Philosophy of Science' (HPS). In the following, we first introduce the reader to HPS by describing some of its main objectives and methods. We then show how GlamMap aids scholars in their research.

HPS is a discipline that studies the development and philosophical interpretation of the sciences in different times and places. The term 'science' is often construed broadly: it can refer to the natural sciences, but also to the mathematical sciences, the social sciences and the humanities. As is the case for the humanities in general (Borgman 2007, pp. 212-224), research in HPS is mostly interpretative and little data driven. Scholars use painstaking qualitative methods to study the development of scientific concepts, theories, and practices. Textual data, such as books, letters, and notebooks are core to research in HPS. However, in the last decades the study of artefacts such as images and art objects has significantly increased (Daston & Galison 2007;). The objectives of HPS are multifarious (Dear

2005; Galison 2008); nevertheless, HPS can, at the very least, be assigned the following aims:

To study the historical development and philosophical interpretation of

(i) Scientific *concepts*, e.g., the development of the concept of truth in logic.
(ii) Scientific *theories*, e.g., the development of term logic or syllogistics.
(iii) Scientific *practices*, e.g., the use of diagrams in proving logical theorems.

The study of (i)-(iii) requires scholars to navigate, order and identify large amounts of textual resources. These tasks are difficult and time-consuming, mainly because many relevant resources are not known. We can illustrate the difficulty by considering two influential textbooks on the history of logic (Kneale & Kneale 1962; Gabbay & Woods 2004–2012). These textbooks provide a general overview of well-known historical developments in logic. They typically describe logical concepts and theories developed by famous philosophers, logicians and scientists, such as Aristotle (384 BC – 322 BC), Leibniz (1646 – 1716), and Tarski (1901 – 1983).

Textbooks provide an invaluable starting point for studying the history of logic. However, scholars require more historical information. In order to study the historical development and reception of logical concepts, theories, and practices (i)-(iii), it will not suffice to describe the views of well-known famous authors. Rather, one must also investigate the views of so-called *minor authors*, i.e., authors that are not or are rarely studied by modern historians of logic. Furthermore, scholars gain insight into the reception of logical concepts, theories and practices by studying different kinds of materials by means of which knowledge was circulated and disseminated, such as books, journals, letters or articles. These tasks are difficult to perform because historians often do not know which minor authors published on a particular subject or how knowledge was circulated. In the following, we show how GlamMap helps researchers to carry out these tasks.

4.1 Minor authors, media and the dissemination of knowledge

Bibliographic metadata provide scholars with invaluable means to identify so-called minor authors and to understand how knowledge was disseminated in certain periods. For example, a simple search on the keyword ‘logic’ for books published between 1700 and 1940 on Trove provides us with more than 18,000 results, among which are many books written by relatively unknown scholars. Visualisations of bibliographic metadata allow us to easily browse, search, and investigate such large amounts of data. Thus, for example, through browsing the map of Risse (1965) one quickly discovers that books written by the English theologian Isaac Watts, who is relatively little studied by historians of logic, were quite often published in the eighteenth century (Figure 8).

Figure 8: Books by Isaac Watts cited in Wilhelm Risse's *Bibliographia Logica*.

According to the Risse dataset, 39 books by Watts were published between 1725 and 1875, whereas, for example, books by Immanuel Kant dealing with logic were published 32 times from 1762 to 1875. Moreover, what are today considered major and well-known works in the history of logic, such as Bolzano's *Wissenschaftslehre*, were sometimes published relatively few times (according to Risse, the *Wissenschaftslehre* was published a mere 3 times from 1700 to 1940). These examples show that our modern conception of what constitute important works in the history of logic does not always correspond to the number of times a book was printed in historical periods. Results such as these prompt further research questions. They may lead us to further investigate the importance of relatively minor authors (such as Watts) or, in cases in which influential works in the history of logic were (re-)published relatively few times, they may lead us to investigate how certain ideas were communicated and disseminated in historical periods.

In fact, the visualisation offered by GlamMap already provides a clue to the question of how ideas in logic were communicated and disseminated in the eighteenth and nineteenth century. Searching the map shows that although famous works in the history of logic were sometimes little printed, many ideas of major scholars were published in lecture notes or textbooks (Figure 9). This suggest that, as is the case in the twenty-first century, important ideas in eighteenth- and

nineteenth-century logic were often communicated through popular and simplified textbooks. Such a result is non-trivial and of great importance for historians. It shows us *which resources* we must study in order to understand the communication and dissemination of ideas.

Of course, a full understanding of the communication and dissemination of ideas requires more than a map of bibliographic metadata. It requires that we read and interpret books and study the lives of their authors. Nevertheless, the examples above indicate that visualisations of library metadata can help and guide the initial stages of research of scholars who are engaged with this task.

Figure 9: Textbooks in the Risse data set.

5. Conclusions

This paper introduced GlamMap, a new visualisation tool that displays library metadata on a geographic map. GlamMap facilitates the interactive exploration of geographic representations of large amounts of library metadata. This allows users to quickly navigate, search and understand this data. We have provided use cases that show how GlamMap helps librarians and users with literature search and collection assessment, and use cases illustrating how the tool enables historians of logic to identify important historical resources. These use cases indicate that geographic representations help users to perform complex cognitive tasks.

A fuller understanding of the benefits of GlamMap and geographic visualisations of library metadata will require more detailed user experiments. The visual web interface of GlamMap is currently still under development. In addition, an automatic data harvester is being developed for GlamMap, so that users can quickly and easily visualise datasets of their choice. Automatically visualising different sets of library metadata from different online repositories remains challenging, since these repositories all use different data formats, none of which directly contain the fields the user might need to visualise. For example, geographical locations are typically specified in text, not in latitude and longitude coordinates. The former cannot be converted into the latter without additional data manipulation due to spelling errors, the use of historical place names, the listing of publishers without their place of operation, and so forth. For the visualisation, a big challenge is the widely varying scale of data sets. For each figure in this paper clustering parameters were set manually, since our automated methods do not yet perform fully satisfactory. Furthermore, additional filtering and compression methods need to be developed to deal with hundreds of thousands of books simultaneously.

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[i] Note that in bibliographic records, script is normally associated with language (such as Cyrillic for untransliterated Russian); we are talking of a case of one and the *same* language, German, usually written in Latin alphabet, that happens to have been written in a different historical script (Gothic) in a certain period *for the same alphabet*. A much more complicated case is Mongolian (Batjargal et al. 2012).