London Calling: GIS, VR, and the Victorian Period

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Abstract

The Bolles Collection of Tufts University represents a comprehensive and integrated collection of sources on the history and topography of Victorian London. Texts, images, maps, and three-dimensional reconstructions are all interconnected forming a body of material that transcends the limits of print publication and exploits the flexibility of the electronic medium. The Perseus Digital Library has incorporated Geographic Information System and Virtual Reality technologies in a set of tools intended to help readers synthesize and visualize the numerous temporal and spatial interconnections between Bolles Collection materials. The tools, which are applicable to any large assemblage of related documents, also help readers grasp the complex temporal-spatial interactions that shape historical materials in general.

1. Introduction

One of the current research projects of the Perseus Digital Library is to explore the extent to which geographic and virtual reality visualization tools can help readers grasp the complex temporal-spatial interactions that shape many (especially historical) documents. For cultural digital libraries, time and space are crucial categories of information. In collaboration with the Tufts University Digital Collections and Archives, the Perseus Digital Library has established a testbed using a collection of documents related to Victorian London. The testbed provides a dense and focused set of temporal and geospatial data embedded in texts, maps, and images. The Perseus Digital Library has developed automated methods to link the information contained in the collection.[1]

The Edwin Courtlandt Bolles Collection on the History and Topography of London is an assemblage of more than 350 maps, 400 books, 1,000 pamphlets, and 8,000 images now in the care of the Tufts University Digital Collections and Archives. Of the assemblage, 30 maps, 25 books and pamphlets (ca. 10 million words), and all 8,000 images are currently available online. Many of the documents are unique and thus add value to the Collection. Yet ultimately, the greatest value lies in the aggregate knowledge culled from every document, rare and common alike. Thus the Collection's greatest strength is its vast size. Fusion of the data contained in the numerous documents makes it possible to visualize both vividly and accurately a city that has acquiesced to the march of time.

The Collection includes a number of "extra-illustrated" editions (books for which Bolles provided supplementary illustrations) such as *Old and New London*, a six volume series from

the 1870s by Walter Thornbury and Edward Walford. Bolles supervised the addition of 7,500 images and the linkage of each image to a specific section of the text in the series. The volume of pictures was so great that the images could not be rebound into the original books. The result was a paper hypertext: underscores in colored pencil mark segments of the text for which extra-illustrations exist. These supplemental illustrations improved readers' visualization of the topography described in the texts.[1]

The quantity of information in the Bolles Collection can easily overwhelm attempts at synthesis when document interconnections are pursued exhaustively and without structural assistance. For this reason, the Perseus Digital Library has leveraged the power of its document management system with current Geographic Information System and Virtual Reality technologies.[2] This marriage of technologies has resulted in a pair of dynamic interfaces that aid in the synthesis and visualization of Bolles Collection materials. Transitions between city-level cartographic images and street-level virtual environments are handled using geographic coordinates to provide registration between the Collection's maps and digital models. The two interfaces are tightly integrated with one another and with the Library's existing search tools. Automatically generated links trigger searches in the Bolles Collection (and in the Perseus Digital Library generally) for sources directly related to currently displayed content.

2. The Geographic Information System Interface

Within the Perseus Digital Library, Bolles Collection texts, images, maps, and virtual reconstructions are linked together by the GIS in much the same way that Bolles himself linked the various texts, maps, and illustrations in his collection. The GIS and document management system of the Perseus Digital Library can scan documents in the Bolles Collection for toponyms and then generate both static and dynamic maps illustrating the places cited in the documents. The system can also access panoramic views and virtual reconstructions of places cited in a document, allowing the reader to visualize the geographic focus of the document for a particular time period. Moreover, the system allows readers to go from locations on a map to the Collection's materials which cite them.

The goal in building a Geographic Information System (GIS) around the Bolles material was to create a visualization tool akin to Bolles' own "extra-illustrated" editions. The project focus was on the historic maps in the Bolles Collection. In building a GIS around the Bolles maps, the Perseus Digital Library has created a testbed for interaction between the different types of documents in the archive. An interactive map interface provides a context for materials in the Collection on a number of levels. For example, maps allow one to visualize the extent of a city ward or borough, or to place a picture of a feature in its greater spatial context, as well as to provide a spatial context for a building which is described in a text. The map interface also provides a mechanism for accessing materials in the Collection through chronological and spatial queries. For example, one might ask whether the Bolles archive contains materials that describe the Tower Ward in London before and after the Great Fire.

Initially, when the Perseus Digital Library set out to build a GIS for Bolles materials, there were two basic questions that the system was to address. These are common types of queries that are often applied in geospatial information retrieval: "what" and "where" queries. For example, a "what" query might be phrased: "What texts, images, or other objects related to location X can be found among these materials?" or "what other names might this place have?"

A "where" query might be phrased: "Where in London is the Leman Street that Thomas Archer writes about in *The Pauper, the Thief and the Convict*? For the Perseus Digital Library, the key to building a GIS system around historical materials, or any materials for that matter, is to geographically reference the data. Geographically referenced data permits information retrieval from a digital library environment using geospatial queries and descriptions of geographic locations. Classes of information about a geographic location are mapped to a footprint, which in the case of the Bolles Collection is a set of latitude and longitude coordinates in the UK Grid system.

The tool that maps information to a geographic context is a metadata schema. Through metadata mapping, a spatial query can locate information that corresponds to, overlaps, or is contained by a spatial extent. The Bolles schema is composed of four elements: 1) a geographic placename, 2) a geographic location represented by a point, line, bounding box, or a complex polygon, 3) a type designation, and 4) a date designation. These core attributes permit the connection between spatial data, various types of image data, and textual geographic location data. Consequently this permits the construction of the Bolles London Map Browser that can execute some basic "what" and "where" type queries.

The Bolles Collection texts have been digitized and marked up as Text Encoding Initiative (TEI) conformant SGML. These texts have been simultaneously encoded with geographical, temporal, and prosopographical information, allowing them to be mined for data to fill out the metadata schema. This data together with an authority list of geographic locations, built by Perseus from standard sources of geographical information in the Bolles Collection, permit historical objects to be placed in real space. Standard sources include map gazetteers and modern data such as the Bartholomew London Database. This framework enables the Perseus Digital Library to automate the identification of geographic locations in any Bolles text. These toponyms are then translated into geospatial coordinates for display in the Bolles London Map Browser. This interface permits querying and visualization of an area in London for many of the city's textual descriptions contained in the Bolles Collection.

Spatial queries that ask "what" and "where" are not always sufficient to access and retrieve historical data. Ideally, a spatial query of historical material should also have the option of adding a temporal component because texts, images, maps, and virtual reconstructions that represent or describe historical people, places, or events must be understood in both temporal and spatial contexts. In cases of city-level topography, objects naturally move from place to place over a span of time. For example, if one formulated a query with a spatial extent that covered the city of London without regard to time, the query result would include objects that may or may not exist on a standard modern map. Thus topography changes with time and, in city-level queries, there is a need to define spatial extents in terms of dates. The GIS interface must allow users to query maps of Whitehall over an arbitrary span of time, or to map features in the city of London corresponding to the time during which the events in Bleak House take place.

Figure 1. Bolles London Map Browser: the map view interface and temporal-spatial browsing tools

Map View	Map Information	
	map title	The London directory, or a new & improved plan of London, Westminster, and Southwark; with the adjacent country, the new buildings, the new roads, and the late alterations by opening of new streets & widening of others
	map publisher	Sayer, Robert, publisher --Bennet, J, publisher
	map publication date	1780
	map size	54 x 44 cm (21 x 17 in)
	map characteristics	color, index, cloth
	notes	
	other info	

Map View	Map Information	
	map title	A new and correct map of London, Westminster and Southwark, exhibiting the various improvements, to the year 1824. The Isle of Dogs with the East India and West India docks, Limehouse, Poplar, Blackwall, Deptford, Greenwich &c, &c
	map publisher	Rowe, R, publisher
	map publication date	1804
	map size	44 x 79 cm (17 x 31 in)
	map characteristics	color, index, cloth
	notes	
	other info	

Figure 2. Bolles London Map Browser: the map metadata viewer

The Bolles London Map Browser is made up of three parts: the map view interface (Figure 1), the map metadata viewer (Figure 2), and the spatial and temporal browsing tools (Figure 1). The initial map view is comprised of modern street, building, and land usage data layers and orients the user in (modern) London. The map interface is fully interactive: users may pan or zoom the map view and plot buildings and streets from a gazetteer of building and street names. Users may also query the contents of the Perseus Digital Library for other resources, such as texts, images, or reconstructions, that pertain to a particular building, street, or area of the city.

Once a visitor has focused the map interface on an area of particular interest, there is an option for locating that spatial area on any of the 18th and 19th century maps in the Bolles Collection map archive. The resulting spatial query offers a thumbnail view of that area as it appears on each Bolles Collection map in chronological order. Cataloging data, such as the publisher, date of publication, and physical characteristics, is also provided for each map.

Visitors may select the map they wish to view by clicking on a thumbnail. The selected map then loads in the map interface for interactive browsing.

3. The Virtual Reality Interface

One particularly interesting work in the Bolles Collection documents the architectural façades of nearly eighty London streets as seen by John Tallis in the late 19th century.[3] In most drawings, such as that of King William Street (Figure 3), Tallis split the paired façades into two rows. Within each row, he drew the opposing façade in proper alignment and mirror opposition to its pair. Tallis also included a small illustration and a map detail in the margins to provide a context for the façades. These architectural drawings have offered an excellent opportunity to showcase the benefits provided by an implementation of virtual reality technologies. These benefits include the augmentation of the Bolles Collection, an improved visualization of the façades, and an improved integration with contextual materials.
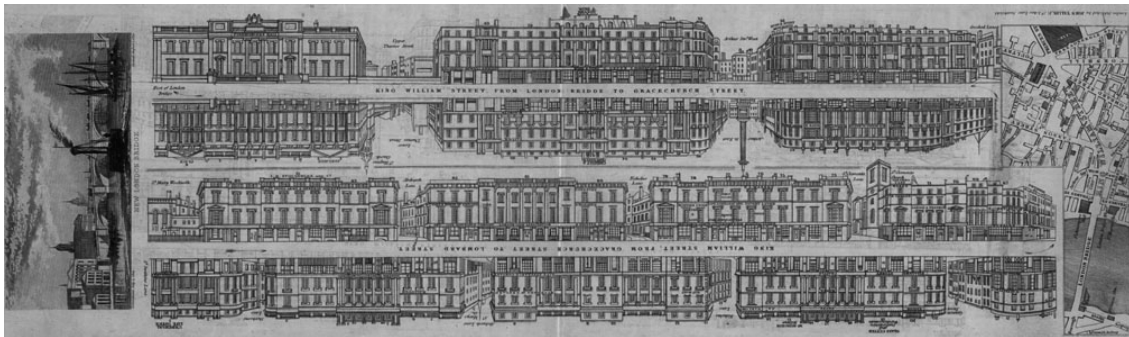

Figure 3. Architectural façade of King William Street as drawn by John Tallis, 1815-1876

Simple digital models of each street lie at the heart of the virtual reality implementation. These models are derived from the same modern reference map (Bartholomew London Database) used to anchor the GIS interface discussed previously. The digitized and georeferenced streets are imported into a CAD file where the vectors establish accurate geographic coordinates for the façades and virtual cameras (Figure 5). The architectural drawings, however, rarely document entire roadways as they have been recorded in the reference map. Consequently Tallis' map details are also imported into the CAD file, where they are scaled, positioned, and rotated such that they correspond with the reference map. Using the appropriate map detail as a guide, the streets are truncated to the proper length and then offset to align with the architectural frontage on either side (Figure 4). The "frontage lines" are broken at the point where adjacent façades abut. The resulting groups of lines are extruded into planar objects (Figure 5). Since these are correctly oriented and sized, scanned images of the façades are simply mapped onto the planar architecture to finish the models.

Figure 4. CAD file showing modern georeferenced streets and "frontage lines" overlaid on Tallis' map detail

Figure 5. CAD file showing digital model of King William Street with extruded "frontage lines" and virtual camera positions overlaid on Tallis' map detail

The completed digital models are new documents which augment the Bolles Collection. They also serve as the source for additional digital content such as still images, movies, and immersive environments which further build the Collection. The benefit of modeling is clear. From every one Tallis drawing, no fewer than four new digital documents are generated. Moreover, the digital works dispense with the physical and logical constraints that led to the segmentation and the inverted arrangements of the printed façades. The digital works therefore present more realistic views that are immediately comprehensible. And they better portray the relationships between the façades and the directions they take. But probably the most significant aspect of the virtual reality implementation is its improved integration with contextual materials. Tallis used graphics embedded in the margins. And, in essence, this technique persists today with software that saves interactive content in monolithic files. Instead, the approach of the Perseus Digital Library has been to build discrete but interrelated virtual reality files for the Bolles Collection in conformity with the Library's existing document model. An interactive interface that dynamically responds to user action has also been built to manipulate these files and all other types of content based on metadata (Figure 6). The interface displays virtual reality files along with automatically generated hyperlinks to contextual materials. These plot the displayed content in the GIS interface and trigger searches for directly related sources in the Bolles Collection and in the Perseus Digital Library generally.

The interface functions on the search tool, which is docked along the left side of the monitor by default (Figure 6). On smaller screens, the search tool can be detached and moved aside to allow easier viewing of the virtual reality files. A standard search box allows users to enter typed queries; the type of virtual reality file to return can also be specified. Alternatively, a "QuickSearch" option allows users to retrieve virtual reality files based on a list of countries for which content exists. Both search types return the query keyword(s), the type(s) of virtual reality file requested, and the search results configured as a list of hyperlinks. Unless a search result exists, there will be no virtual reality files to display. In accordance with the Perseus Digital Library's standard practice, a displayed file is accompanied by a caption, a list of keywords formatted as document search hyperlinks, image credits, and a copyright notice. Displayed files are also accompanied by hyperlinks that plot the file's location using the Bolles London Map Browser and trigger a text search for documents citing the content.

The bulk of the interface consists of seven tabbed "index cards" (Figure 6). The two left-tabbed cards ("Start" and "Help") provide general information about the interface and assistance on how to use it. The right-tabbed card ("Documentation") provides a detailed account of the construction and the sources of the models. Each of the four remaining cards ("Still Images," "QuickTime," "Virtual Reality," and "Drawing Files") frames a particular type of virtual reality file. The still images can be displayed either individually, where they are accompanied by the standard contextual links, or in tables of thumbnails that can be navigated using a drop-down menu. The QuickTime content includes linear movies and networks of panoramas that simulate movement along the virtual streets (Figure 6). The Virtual Reality content consists of VRML environments that go beyond the virtual reality "bubbles" of QuickTime panoramas and allow users to explore wherever and inspect whatever they choose. The drawing files are the most significant content, from a research perspective, of the all the different virtual reality formats offered. These files are databases of size, shape, location, orientation, and more. Users can access the files online with commercial tools designed for their viewing, measuring, marking-up, and printing. The Perseus Digital Library is also making the files freely downloadable to allow their full exploitation in client-side software.
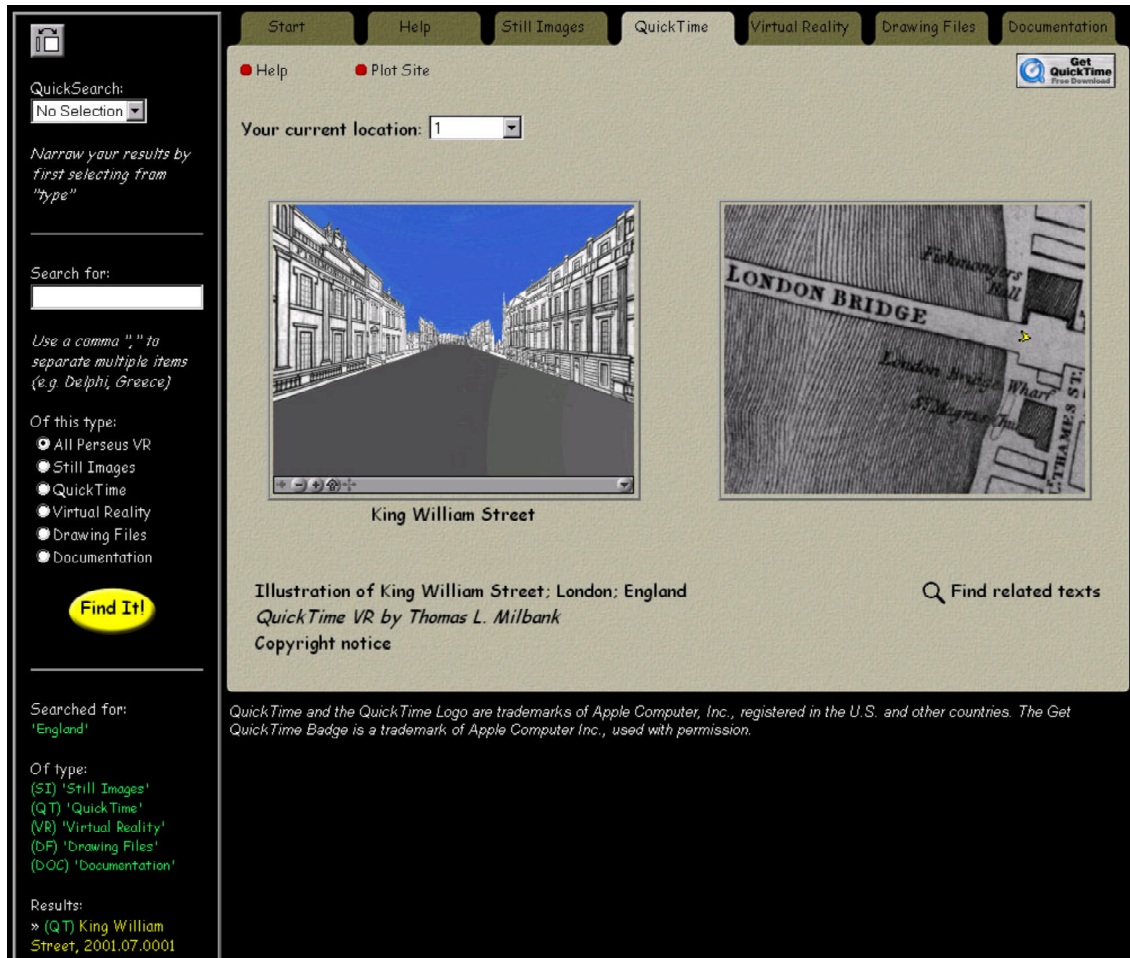
Figure 6. Bolles virtual reality interface: search tool and tabbed "index card" displaying search results and a QuickTime panorama of King William Street

4. Conclusion

The quantity of information in the Bolles Collection requires structural assistance for the document interconnections to be pursued exhaustively. To this end, the Perseus Digital Library has leveraged its document management system with Geographic Information System and Virtual Reality technologies. The result is a pair of dynamic interfaces that aid in the synthesis and visualization of Bolles Collection materials. Transitions between city-level cartographic images and street-level virtual environments are handled using geographic coordinates to provide registration between the Collection's maps and digital models. The two interfaces are tightly integrated with one another and with the Library's existing search tools, thus allowing immediate access to all contextual materials.

5. References

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