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## **A historical GIS for the comparison of past and present views: Bologna, yesterday and today.**

*Keywords:* Bologna, HGIS, historical maps, historical views, photographs, georeferencing.

*Summary:* Digital regeneration of ancient cartography is an interesting way to allow new chances of viewing and using its historic and geographic information, by modalities that cannot apply to analogue supports. In particular, the creation of a HGIS (Historical Geographic Information System) is a way to make ancient maps suitable for a wide range of applications, from land management to researches on landscape and urban development, from archival researches to tourism promotion.

The present study aims to demonstrate the usefulness of GIS tools to collect and link together historical maps and other archive data, *e.g.* drawings and photos. Some eighteenth and nineteenth century maps of Bologna were georeferenced and used as a base for a HGIS, together with the current cartography. In order to enrich the environment with historical views of the city, the GIS was populated with a great number of historical pictures (drawings, engravings, photos, postcards), each one linked to the relative historical map by means of a hotspot (representing the viewpoint from which the picture was probably taken). Together with each historical picture, a current photo of the city, taken from the same point of view, can be retrieved and visualized, in order to compare the ancient portrait of the city with its present-day appearance. This HGIS, providing a simple and interactive use, offers a new look at the ancient and modern city, turning to be a useful tool for researchers, historians and archivists who reconstruct the evolution of the city, as well as common people interested to rediscover in a unusual way the history of Bologna.

### **Introduction**

Digital recovery of ancient cartography is a theme of increasing interest in the scientific community, as more and more studies show. In fact, conversion in digital form of Cartographic Heritage firstly allows preservation from aging of ancient cartography, valorisation of its fundamental information content and sharing with a wide and eventually non-expert public. Secondly, digital processing of ancient cartography allows new chances of viewing and using historic and geographic data it preserves, by modalities that cannot apply to analogue supports; the derived product appear useful to archivists, historians and researchers for their studies, as well as tourists and common people for cultural purposes. In particular, the GIS (Geographic Information System) environment allows fast and efficient management of Cartographic Heritage in digital. In fact, a so-called “Historical GIS” (HGIS) can profit by all potentialities of GIS systems, such as georeferencing of data and management by means of layers, quantitative analysis by means of *ad-hoc* tools, integration of different kinds of data (*e.g.* texts or images) differently aged and coming from different sources, consultation of data over space and time,

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sharing with other users. As a matter of fact, in recent years several Historical GIS projects have been developed at both national and urban scale, in order to manage amounts of data related to specific geographical areas or investigate a specific topic over space and time (Bitelli et al. 2016, Gregory and Healey 2007, Larson 2003, Schlichting 2008).

The present study aims to show a possible utility of GIS tools, realizing a prototype of Historical Geographic Information System for Bologna (Italy), the city possessing a great historical cartographic and cultural heritage (Ricci 1985, Roncuzzi and Roversi 1983). The purpose of such a GIS is the comparison of past and present views (taken from drawings, engravings, photos, postcards), georeferenced on some eighteenth and nineteenth century maps, which allows an unusual trip over time (from the beginning of the 18<sup>th</sup> century to the present) for the rediscovery of the ancient city and the comparison with the modern one.

### Materials

In order to construct a HGIS for the city of Bologna, covering a lapse of time of 300 years, some maps, dating back to the 18<sup>th</sup> and 19<sup>th</sup> centuries, were collected. All these maps are planimetric representations of the city inside the third wall perimeter (i.e. the part of the city today framed by the boulevards), and come from precise surveying methods.

In chronological order, the analysed maps are:

- *Pianta della città di Bologna*, by Gregorio Monari and Antonio Laghi, 1711-12 (today preserved at the State Archives of Bologna) (Bitelli and Gatta 2012);
- *Città di Bologna posta in pianta*, by Gregorio Monari and Antonio Alessandro Scarselli, 1745 (a 1:3 copy of the previous map, today preserved at the Archiginnasio library of Bologna) (Ariotti et al. 2014);
- Gregorian Cadastre of Bologna: primary map (ante-1831), 1<sup>st</sup> update (1873), 2<sup>nd</sup> update (1890-1901); all these maps are today preserved at the State Archives of Bologna (Bitelli and Gatta 2011).

As current map, the numerical 1:2000 map of the Municipality of Bologna (CTC) was used.

For the aim of the present study, a great number (about 160) of additional historical documents (dating back to the 18<sup>th</sup>, 19<sup>th</sup> and beginning of the 20<sup>th</sup> centuries) were included in the HGIS. They are views of portions of the city, in the form of drawing, engraving, photo or postcard, coming from collections of Institutions or private citizens (e.g. Costa 2003, Fondazione Cassa di Risparmio in Bologna 2006a and 2006b, Osterman 2000). Finally, also current photos, taken from the same perspective of the historical images, were placed into the HGIS to highlight the changes.

### Construction of a HGIS for Bologna

#### *Georeferencing of the historical maps*

In order to include the historical maps in a GIS, they were digitized, analyzed concerning their metric quality and georeferenced in a common cartographic reference system (UTM-ED50). To have Ground Control Points (GCPs) suitable for georeferencing, a previous historical search was performed, in order to assess which buildings of Bologna have not changed since the beginning of the

18<sup>th</sup> century. This way, about 80-100 GCPs were recognized and used to georeference each historical map; the coordinates were taken from the current CTC of Bologna. Approximate scale and residuals of georeferencing, expressed as RMSE (Root Mean Square Error) on GCPs, are reported in Table 1, derived from the already cited papers.

The results from the study of map deformation and georeferencing show accurate surveying and draft stages for all maps under examination, also the two 18<sup>th</sup> century samples. Therefore, they were considered suitable to be used as cartographic base for the construction of the HGIS, once georeferenced.

Map	Approximate scale	RMSE on GCPs [m]
<i>Pianta della città di Bologna</i> (1711-12)	1:1100	4.1
<i>Città di Bologna posta in pianta</i> (1745)	1:3300	5.5
Gregorian Cadastre, primary map (ante-1831)	1:1000	1.2
Gregorian Cadastre, 1 <sup>st</sup> update (1873)	1:1000	0.8
Gregorian Cadastre, 2 <sup>nd</sup> update (1890-1901)	1:1000	0.8

Table 1: Approximate scale and georeferencing errors for each analysed historical map.

### *Insertion of ancient images of the city*

In Bologna exists a great cultural asset made of images of the city (drawings, engravings, photos or postcards), made over time. This fact suggested placing some of these views in time and in place in the GIS environment, to realize a more realistic image of the ancient city, beside the planimetric representation given by the maps. To the aim, about 160 images of Bologna, dating back to the 18<sup>th</sup>, 19<sup>th</sup> or beginning of the 20<sup>th</sup> centuries, were collected and included in a database.

In a GIS environment (Intergraph<sup>®</sup> GeoMedia<sup>®</sup> software was used), for each image the theoretical viewpoint was recognized on the historical map of closer age, and highlighted by means of a vector point. This way, five vector layers of points were created, one for each historical map. Each vector layer contains name and location of all theoretical viewpoints referable to the specific age, with information on each historical image (*e.g.* kind of image, author, year, and place of storage of the original, direction of view) and a hyperlink to the digital copy preserved in the external database. At the end, 135 theoretical viewpoints were recognized, some of which referring to more than one historical image.

Finally, a current view was linked to each viewpoint; it consists in a photo taken from the same position and in the same direction of the ancient image/s associated to that viewpoint. This way, from each hotspot it is possible to retrieve both the ancient view/s and the current one. In case of viewpoints with more than one ancient image, also a video showing the passage from one period to another, up to the present, was created and linked to the hotspot. The result is a GIS where past and present views of Bologna, localized on historical and current maps, can be immediately accessed and compared (Figure 1). Furthermore, thanks to specific tools of the GIS environment, different kinds of search and analysis are allowed.

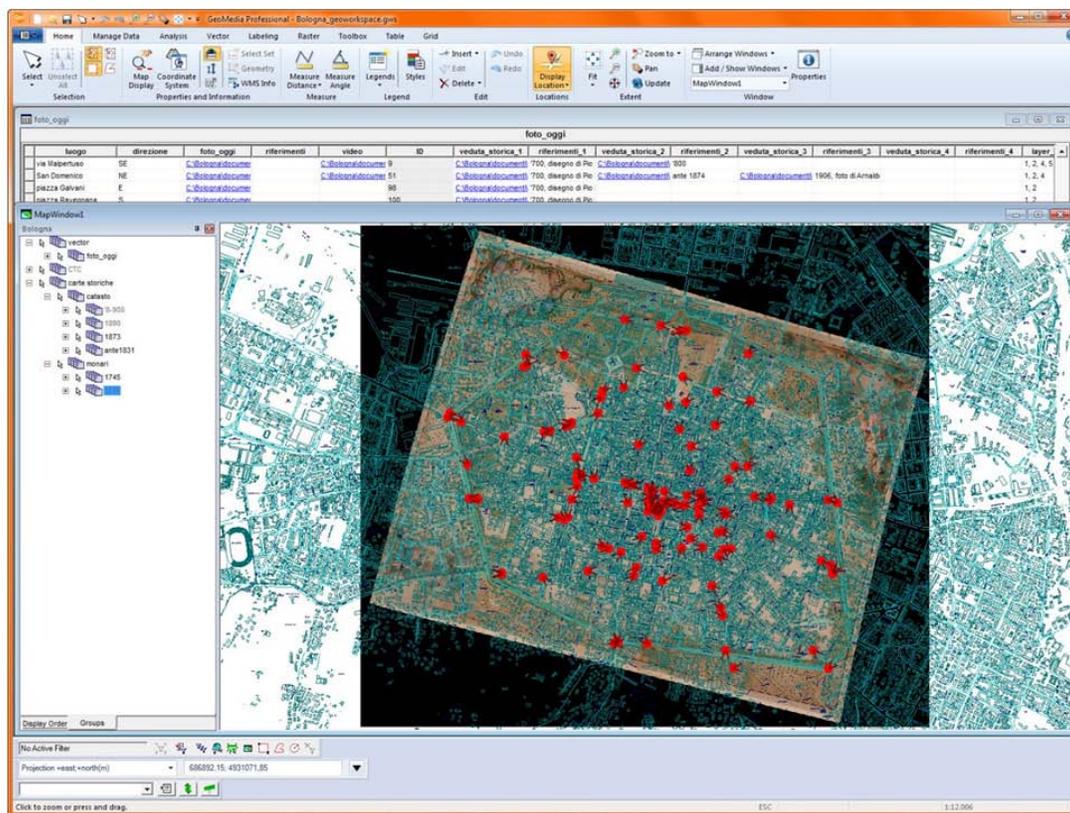


Figure 1: A screenshot of the HGIS for comparing past and present views of Bologna: the map by Monari and Laghi (1711-12) and the current numerical CTC are overlaid with all viewpoints (in red, with a V to indicate the direction).

### Transposition to Earth Viewers

In order to provide a simple and interactive use of the HGIS also for common users, even without knowledge of GIS, transposition to Earth Viewers (in particular Google Earth) was tested. Raster and vector layers were exported in .kml: the layers of viewpoints through GeoMedia® tools and raster maps by means of MapTiler, changing previously the reference system (from UTM-ED50 to UTM-WGS84). A symbol of a photo-camera was used to localize each hotspot, with a different colour for each historical period under examination (Figure 2). The layers were grouped according to the historical period (each map with the related layer of views and the layer of current views) and the groups were ordered according to a temporal criterion. This way, turning on the group of a given period, it is possible to display the historical map on the satellite images of Google Earth and open the historical and the current views simply clicking on the symbol of the cameras (Figure 3). Finally, a layer for the viewpoints which two or more historical images are associated to was created: it contains the links to the videos showing the passage from one period to another, up to the present.

Thanks to the well-known Google Earth environment, the created HGIS turns to be a useful tool not only for researchers, historians and archivists who reconstruct the evolution of the city, but also for all people interested to rediscover in an unusual way the history of Bologna. Moreover, sharing of the product among the Web users could increase spreading of knowledge about consistency and importance of Cartographic and Cultural Heritage of Bologna.

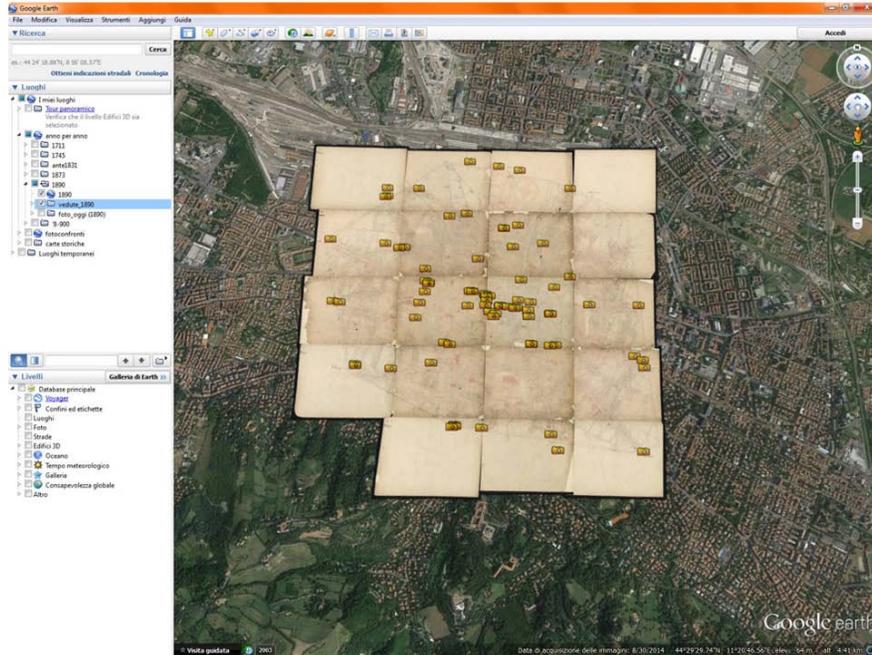


Figure 2: A screenshot of the HGIS transposed to Google Earth: satellite images overlaid with the 2<sup>nd</sup> update of the Gregorian Cadastre (1890-1901) and the related layer of viewpoints; from each viewpoint (represented by the symbol of a camera) it is possible to retrieve past views of Bologna of the end of the 19<sup>th</sup> century, and the present ones taken from the same perspective.



Figure 3: Above: Google Earth images overlaid with the primary map of the Gregorian Cadastre and the layer of viewpoints. Below: an example of images linked to a viewpoint (*Chiesa delle Lame* in *Riva Reno* street): a) first half of the 19<sup>th</sup> century (drawing by Antonio Basoli, collection of the *Accademia di Belle Arti*, <http://www.storiaememoriadibologna.it/bologna-1253-luogo>), b) around 1930 (postcard, *Genus Bononiae* collection, <http://collezioni.genusbononiae.it/products/dettaglio/7514>), c) today.

### Future developments

The tool above described can be used for not only research aims, but also tourism or education purposes. For instance, an application of the research that is currently evaluated is the construction of a tourist route into the city, composed by stops coincident with the various viewpoints. At each viewpoint, a specific app on a portable device, or simply an illustrative panel, could report images, references and description of the ancient view/s of Bologna taken from that position, in order to let the tourists take a similar photo of the city and immediately compare it with the past view. Another useful application of the research could be to provide a tool to support multidisciplinary teachings in secondary or high schools; the possibility of proposing the tool to some schools of Bologna is under evaluation.

Moreover, some future improvements of the research are currently under examination:

- to perfect new ways to access data, *e.g.* according to alphabetical index of places, or chronological order of historical events which may be considered milestones for Bologna;
- to support the study of change of place names;
- to create an app for mobile devices, to localize the viewpoints with the related historical views and take current photos from the viewpoint where you are.

### Conclusions

The study proposed a prototype of HGIS for the rediscovery of Bologna, through historical maps and views from the beginning of the 18<sup>th</sup> century up today. The views (drawings, engravings, photos, postcards) were inserted in the GIS by means of hyperlinks starting from the viewpoints from which each image was probably taken. Beside them, current photos of the city, taken from the same perspective, were linked to the hotspots. The HGIS was transposed to Google Earth in order to test the possibility to realize a tool, accessible to users even without knowledge of GIS, for consultation of historical maps and past and recent views of Bologna.

This tool allows an intuitive and immediate access to historical maps and images, and appears flexible thanks to the possibility to be enriched with a variety and a multitude of other documents. For these reasons, it turns to be useful for institutions preserving historical images of the city, for archive and collection purposes. Not only: it lets new insights into the ancient and the modern Bologna, offering a new look at the city to historians, researchers and archivists who reconstruct the evolution of the city, as well as citizens and tourists interested to rediscover in an unusual way the history of Bologna. To the latter aim, an application of the research that is currently evaluated is the construction of a tourist route into the city, by means of a specific app on portable devices or illustrative panels.

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