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Historical GIS

Abstract: The historical GIS is, without any doubt, a powerful means of communication of historical phenomena for the public and also of collecting georeferenceable historical source through crowdsourcing activities, but the complexity of the data model underlying a GIS can also distance the public from understanding the complexity of the phenomena themselves. From this point of view the role of the Digital Public Historian is essential: not only will he/she have to be able to construct a GIS with a methodologically correct data model, but he/she will have to find the right ways of communicating it in order to make the GIS an effective tool of understanding and sharing the past.

Keywords: GIS, web GIS, cartography, historical maps

Introduction

Digital Public History (DPH) as a discipline involves a set of technologies for data acquisition, storage, processing and distribution used in order to interact effectively, consciously and transparently with the public on issues related to history. This includes the management of geographic information and in particular map creation. A map is a very effective and familiar medium to show special types of information. For example, on a map we can evaluate with immediacy and clarity both general and particular features, as well as the relationship among different types of objects. Since information technology began to deal with geographic information in the late 1960s, the communicative power of a map has been enriched by important components, mainly from the point of view of graphics and DataBases. The DataBase approach has enriched the potentialities of abstraction and analysis made by the geographer: what in the past was only drawn on a paper, now can be put in a DataBase and this has given rise to important considerations on the nature and the characteristics of the object itself. Since the 1990s, the incredible technical potential of telematics – that unifies IT and telecommunication methodologies trying to integrate remote information processing and transmission systems – and its social applications transformed the management and the use of geographical information as a powerful tool easily used by the public, as shown by GoogleMaps, OpenStreet Map and similar initiatives.

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GIS for DPH: Opportunities and Problems

The union between traditional cartography and informatics has produced the Geographical Information System (GIS), that can be defined as a coordinated set of resources (data, skills, logistic, IT tools, network infrastructure) dedicated to the acquisition, integration, processing, distribution and presentation of geographical data.[1] Despite traditional cartography, the data processed by a GIS are grouped in classes or layers, each one containing the description of data of a unique type (e.g. only roads, only buildings). The GIS manages two main types of layers: vector or raster model. Vector model: in the layer defined entities are represented as well, geometrically described by a "feature," i.e. points, or lines or areas, with several attributes. For example, an area representing the shape of an administrative entity with the values of its population is a typical basic GIS representation of the administrative entity itself. Raster model: a geographic phenomenon is represented by a quantity, in general continuous, defined in a certain domain, sampled to a regular grid. For example, by regularly dividing a large area into small squares, the set of numbers that define the elevation of each square is a raster.

The presentation of a map is the most common feature of a GIS and involves different tools, such as the selection of one or more layers, both vector and raster, the flexible use of symbology, the possibility to zoom and pan to best frame the area of interest, the selection of background layers (Google Map, Open Street Map, etc.), the automatic selection of what to represent and how to show it according to the scale, in order to always have optimal management of the graphic space available (a PC display, a large paper, a smartphone).

GIS tools also allow the user to interact with the map, such as selecting a feature to obtain information about the attributes of the feature itself, other documents (text, photo or video) or from atlases. If in a GIS the data displayed are historical, either because they are taken directly from sources, or because they are re-elaborated in a more complex and mediated way, the interaction with the user is obviously based on layers dedicated to historical concepts and/or information: for example the extension of a country/political power over time in relation to the population and the Gross Domestic Product; the distribution of the fortifications in relation to the position of churches, villages, houses but also rivers, valleys, mountain passes and other geopolitical realities. However, as explained below, the possibilities of the research depend on how the GIS data model is conceived and built.

Unlike traditional cartography – where the different types of objects are drawn on the same support, – in a GIS each object type is managed separately in a dedicated layer.

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1 Burrough et al, *Principles of Geographical Information Systems*; Longley et al. *Geographic Information Systems and Science*.

Let's put emphasis on the word *managed* instead of *drawn*, because a GIS is devoted to process data, not necessarily to draw them, even if a map is almost always produced. Separate management of different layers gives the user the possibility to construct maps for different purposes and allows the exchange and re-use of data among different operators. In this way a historical GIS can allow different users to map certain phenomena according to the query.

GIS have a lot of advantages over traditional cartography, which include the possibility to manage an unlimited number of different layers and to describe entities with an unlimited number of attributes. For example in *Mapping Decline: St. Louis and American City* there are four interactive series of maps dedicated to white/black people residencies,[2] the relationship between race and property, the municipal zoning and the urban renewal: all this "layers" can be animated by a chronological slidebar and/or they can be put in relation with municipal borders, the presence of roads or highways or the disponibility of documents. The data considered in this project are numerous and of different kinds, but the geographic database that supports their visualization is able to receive other data too: this is because with the GIS we have the possibility of carrying out heavy processing operations and quantitative analysis and applying, where possible, evolutionary models. Another important feature is the strong expressive capacity in drawing a map, due to the possibility of selecting the most suitable object type (layer) and to use a quantity of graphic tools (color, symbols, lines, 3D models, etc.). Additionally, a GIS can access Internet resources so that it also be allowed access to data and processing resources; it is also suitable to involve people with different levels of expertise distributed globally and it encourages exchange experience and resource sharing, thanks to the User Interface that adopts the well known metaphor of the map. From this point of view, historical GIS is a powerful tool to illustrate effectively and to various audiences (students, communities, institutions) not immediately evident but historically significant relations between phenomena.

Nevertheless, the enormous potential of GIS applied in the historical field is not exempt from considerable problems, partly inherited from the past, or rather from the traditional relationship between geography and history, and on the other hand related to the peculiarities and the complexities of a geographical database.

Looking at traditional historical maps we will notice that they usually describe a situation as a picture: reality is frozen in a certain moment, while for the historical data the concept of evolution is critical. This impasse could be overcome in a GIS creating different layers or working on data attributes, but the operation is not easy and implies a profound reasoning on the quality of the data model (for example by establishing a predetermined chronological range). Indeed it is easier to find historical GIS

2 "Mapping Decline St. Louis and the Fate of the American City," http://mappingdecline.lib.uiowa.edu/; GIS that accompanies the book Gordon, *Mapping Decline*.

projects with a reduced dynamic time component, processed from sources that "take a picture" of a situation in a given moment, rather than illustrate it over time.[3]

Both the vector model and the raster model are not perfectly suitable to handle elements with undefined boundaries:[4] for example, they describe very well administrative limits in the modern sense of the term, but not the uncertain and variable realities of the castreous districts in Europe in the twelfth century. This uncertainty can be visualized in a GIS using particular symbologies that express probability criteria, but this relies on blind trust from the user, because the critical reading would imply a profound knowledge of the methods used by the GIS authors.

In short, the processing of historical data in a GIS makes it possible to effectively represent the complexity of the unfolding of a historical phenomenon over time in an area; however, the operational choices that have to be made in order to create the data model and to obtain a good visualization of temporal passages and/or spatial uncertainties does not allow, or rather does not facilitate, the awareness of the complexity underlying the GIS itself. This makes the GIS a powerful tool for representing historical data, but a problematic tool for a conscious public participation.

DPH: The Actors

In DPH initiatives various roles are active: scholars, lecturers, researchers, disseminators, archivists, conservatives, etc. A possible classification is to consider, on the one hand, the professionals of history (those who work daily in sectors where history as a discipline is a prevalent issue), who can make use of infrastructures and technical skills of a certain importance and, on the other hand, the non-professionals, typically the common public, who generally operate only with their own device (smartphone, tablet or personal computer) and have very different needs. Between these two types of users the public historian could find its maneuvering space. In order to understand it well, we first examine the two most common work paths that can be found on the net: the top-down (from professionals to the public) and the bottom-up (from the public to professionals) flows.

3 For example, the "Atlas électronique du Saguenay. Lac-Saint-Jean" shows individual maps for each significant moment of the past (http://uqac.ca/atlas/saguenay-lac-saint-jean).

4 Cohn, "Representing Regions with Indeterminate Boundaries," 957–961.

The Top-Down Flow

The top-down flow can be considered the expression of scholars' commitment to research and to transferring their knowledge to others. From this point of view, the GIS applied to history has greatly expanded the potentiality of history in creating new research paths, in teaching or rather in editions of historical texts integrated with geographical data.

An example of a GIS elaborated on a literary work that has clear research purposes, but which obviously is also free access to everyone, is "Mapping Dante."[5] This website hosts the first interactive digital map with the places mentioned in Dante Alighieri's *Divine Comedy* and is a very good exemple of geo-criticism and literary mapping, developed by Price Lab for Digital Humanities at the University of Pennsylvania. Users are able to visualize and sort places according to a number of literary, cultural, and geographical categories, in order to explore the connections between Dante's text and geography.

With this GIS a teacher or a scholar can use the maps to pursue his/her own research but also clearly explain to students or the public the importance of Dante's vision of the world by selecting different layers or by making specific queries. There are many examples of this type of GIS.[6] Here we outline one of our DPH projects – TraMonti – carried out by a team from the University of Pisa and ISTI-CNR of Pisa in 2011.[7] TraMonti aimed to enhance and promote the historical-archaeological heritage and oral memory of Val di Vara (Ligury, Italy) through surveys and research and the construction of a website. The GIS includes an archaeological historical census to identify the remains of human activity from prehistoric to ancient times, the settlement revolution that took place during the Middle Ages, the relationship between the medieval network of the castles and the roads, the evolution of the settlement from the modern to contemporary ages, and the most recent structures and productive activities, in particular manufacturing, mills, crushers and quarries. The material surveyed was then enriched with photographic documentation and interviews to retrieve the memories of the oldest inhabitants of the valley.

A dynamic map can be created with three layers that can be displayed independently: elements from the archaeological census, elements derived from historical documentation, and some tourist routes. Points are used for the first two levels and lines for the third. Each item on the map is linked to a structured card that describes its content. The three thematic levels are superimposed on Google Land, but you can also use OpenStreetMap, Google Satellite or Google Map. The basic display functions

5 "Mapping Dante: A Study of Places in the Commedia," https://www.mappingdante.com/.

6 Knowles and Hillier, eds, *Placing History*.

7 Salvatori, "Un progetto di Public History nel cuore della Liguria," 12–32, http://tramonti.labcd.unipi.it/; GIS http://tramonti.labcd.unipi.it/val-di-vara/mappa-dei-beni-culturali/.

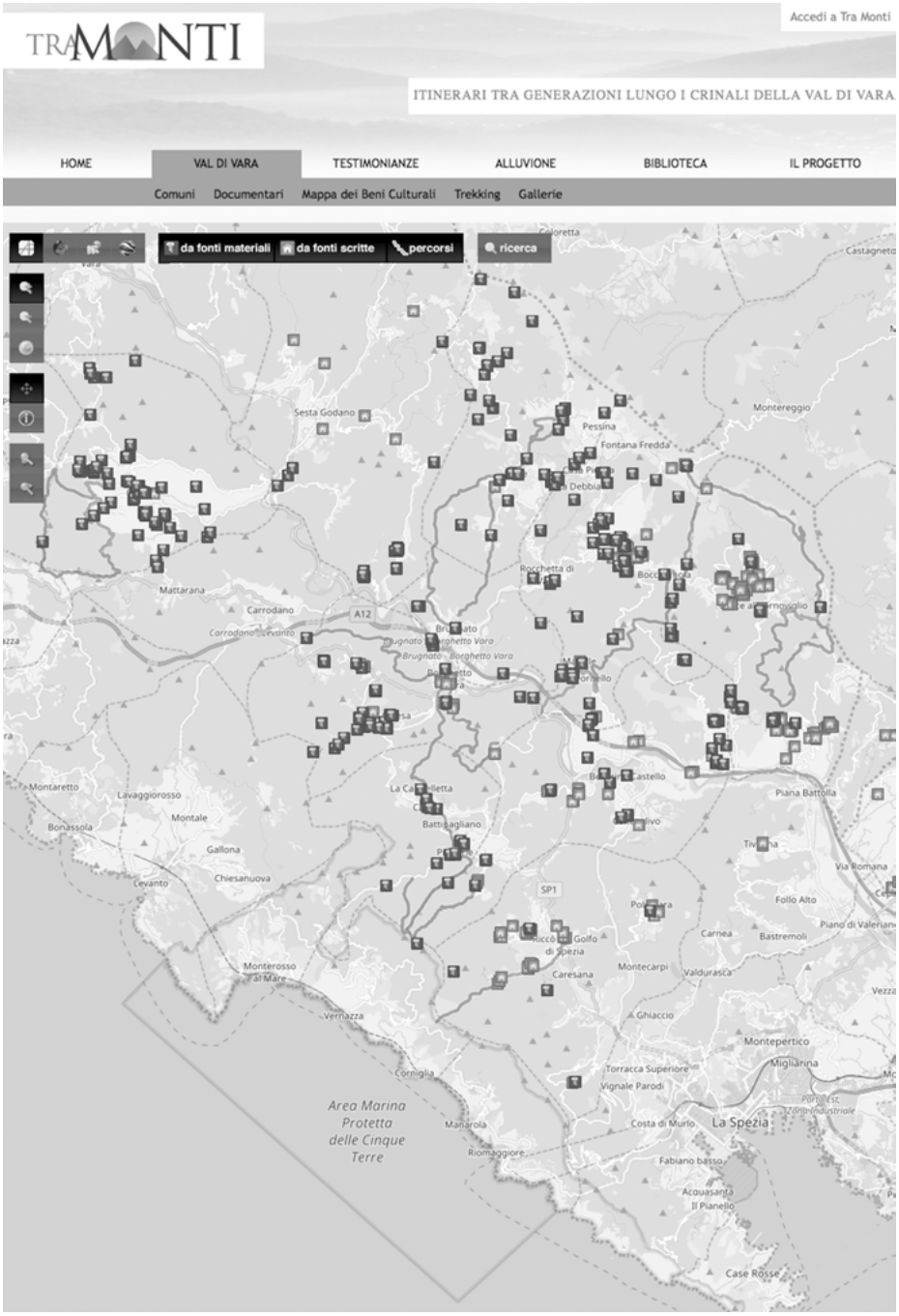

Fig. 1: "TraMonti" project Web GIS. Salvatori, "Un progetto di Public History nel cuore della Liguria".

are available and queries can be made on layers' attributes. Inside the project site the GIS allows an interaction with the public limited to the query of historical-archaeological emergencies in the valley and to the identification of preferential paths. It aims to be a service to particular categories of public: administrators for example or tourists; however, none of them can put their hands directly on the service in order to modify it or add data. However, all the tools are included in a website that collects and presents other materials from past and recent local history, some of them spontaneously collected among the population: the map of the cultural heritage of the territory does not exist as an autonomous object, separate from the context but as an element, among others, of a DPH project. In short, the GIS in the "Tramonti" project is only one element among others of a set of contents that allows and favors the sharing and discovery of one's own history by the inhabitants of a valley.

A Bottom-Ip Case

Of particularly interest is the bottom-up flow, where the public can produce historical georeferenced data. Potentially, the impact and the social importance of this new opportunity could be very high, because it gives voices to groups, minorities, realities that do not feel sufficiently represented in the official historiography, and it can facilitate cultural innovation policies at different levels of citizens' involvement.

In a DPH GIS project using on a bottom-up flow, we have a data flow created by people who use special applications on the web on their device, to build archives of information, typically stories, pictures, videos, oral records and geographical data, or even to add information to an already existing data set. A classic example of this kind of activity is the possibility given by Google Maps to add a missing place, or a shop or a label or also to create a "personal" map to share with others.

One example among many is the map of the US Civil War made in Google Maps by an anonymous author.[8]

Smartphones and other devices often have integrated tools for acquiring geographic information to associate with the database in a semi-automatic way. For example, photo cameras integrated in smartphones usually combine images and movies with the date and time of shooting and, thanks to the GPS system, they also show an accurate geographical position that could be put automatically in the DataBase. Often these devices also allow data transmission to storage and to publication sites. If the GIS is designed to provide services through the web (webGIS), it can create and deliver a map that displays positions, metadata and labels of all the items spontaneously

8 https://www.google.com/maps/d/u/0/viewer?hl=it&mid=11fCNn0u_5ZqXHjuS3DEpgxehc3c&ll=38.175729132316896%2C-95.8510205&z=3.

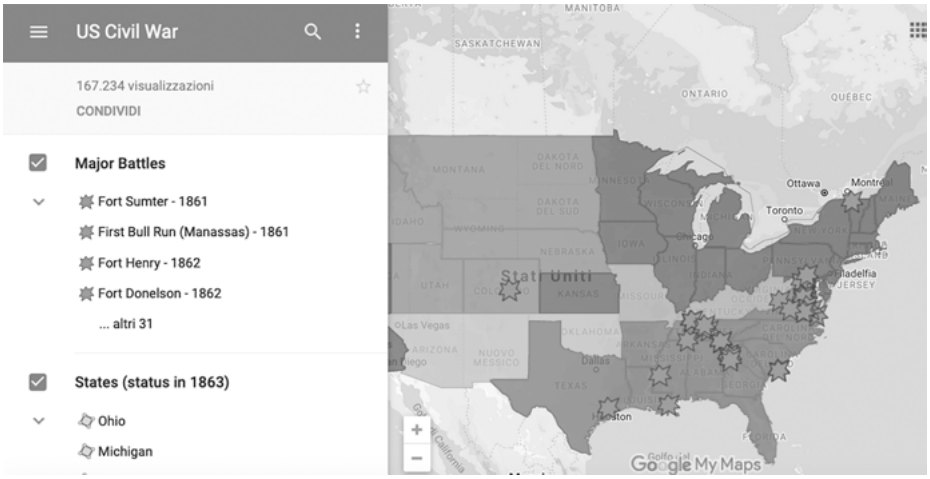

Fig. 2: US Civil War GIS on Google Maps, https://www.google.com/maps/d/u/0/viewer?hl=it&mid=11fCNn0u_5ZqXHjuS3DEpgxehc3c&ll=38.175729132316896%2C-95.8510205&z=3.

uploaded by people. In "Honoring our Veterans" by ESRI, for example, it is possible to insert the picture, name and hometown of a veteran, adding a description of his life and automatically the geographical position.[9]

In a DPH project, founded on crowdsourcing activity, it is therefore possible to "ask" the public to communicate data of historical interest to a webGIS and thus construct in a collective and shared way a coordinated repository of georeferenced historical information. An example is the mapping of city epigraphs, the places of a territory that have been visited and portrayed by a particular artist, or the places of memory of a particular phenomenon. Two examples among many. The British Library engages the public's help in geoferencing historical maps:[10] people can place historic maps over the latest maps and so compare the past with the present and the contribution helps the British Library make its maps fully searchable and viewable. The Tate Museum in the "Artmaps" project features georeferenced artworks that anyone can relocate or enrich with comments.[11]

9 https://storymaps.esri.com/stories/honoring-our-veterans/index.html.
10 Http://www.bl.uk/georeferencer/.
11 "Artmaps," http://www.tate.org.uk/about-us/projects/art-maps.

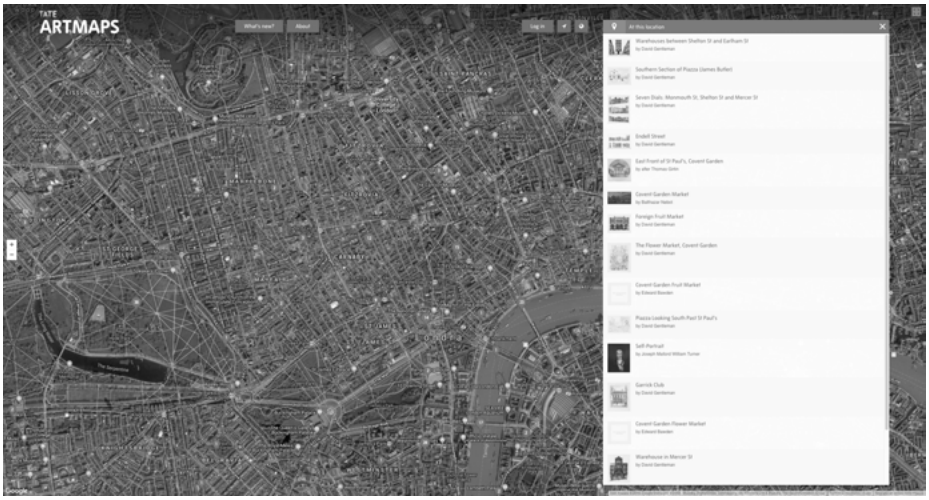

Fig. 3: "Artmaps" project Web GIS. Gabriella Giannachi, *Art Maps Project,* on the Tate site https://www.tate.org.uk/about-us/projects/art-maps.

The Time Dimension

In a map it is possible to frame the geographical space by choosing the area and the scale, so that we define the "part of the territory" visible on the screen; similarly, in a historical context, it is important to define the time interval which the map refers to. As mentioned before, the maps that we normally use derive from an ancient cartographic tradition that considers the map as a picture of a situation, taken at a certain time, deliberately ignoring the before and the after. This probably is due to the impossibility, in the past, of representing on a piece of paper the temporal evolution of entities.

However, the most important dimension of history is time and, just as it is possible to graphically represent the spatial dimension, it would be an essential outcome to graphically represent time together with space. This is often a difficult technical challenge.

In the modeling phase, managing the time and space variables could be a difficult task, due to the nature of historical data and in particular the lack of accuracy. In cases where historical data is accurate and clear, for both the dimension of space and time, using GIS is straightforward. For example, if we know the buildings (and their locations) where one or more people were affected by an epidemic, it is easy to map that data. Modelling this kind of data in a GIS is simple because we are sure of the geographic data (houses), numerical data (sick people) and temporal data (year). The simplicity and clarity of the original data obviously makes the interaction with

the public more transparent, in the sense that it does not hide mediations or interpretations of the data themselves.

There is also the case where the data are accurate in space, but with uncertainty relative to time, such as we might encounter when mapping the different walls or parts of a wall of a castle. The challenge is how to compare restorations made in different periods, for example, those identifiable in a delta temporum (mid-thirteenth century) or other restorations or modifications occurring earlier or later (before the thirteenth century or after the eleventh century). In this case the geographic representation is simple, but the temporal data model should be able to describe uncertainty and give appropriate consistent answers to user queries. In this case it is essential to provide the public with greater transparency and clarity, and the reasoning underlying the data model; in the case of the participation of the public, it is also necessary to provide users with clear input forms in which the time choices are unambiguous and well explained.

There are also cases where data are accurate in time but uncertain in their positioning – e.g. in a year a number of settlements were attested in a place, but today those places do not exist anymore, either in whole or in part. They cannot be placed with accuracy on a map but are still positioned within an area. In this case, modelling time is easy, but we have to invent a suitable model for space, and obviously the map we create must emphasize the uncertainty. In this case the public can be useful in finding a correct geo-reference for a place, thanks to local memory, to the relevant knowledge of a territory that only a resident of a community can have. However, interaction with the user is not easy, as they may be asked to provide hypothetical geo-referencing that however should then be confirmed using strict methods and comparisons.

Often historical change is represented as a "map collection," even an ancient one: maps which refer to different dates may be displayed in a variety of ways, so as to convey the evolution of a historical phenomenon.[12] In a more sofisticated example GIS can use animation tools to show the evolution of a phenomenon; they are based on a time bar or a clock, in general reproduced on the map, that moves in the temporal dimension. Over time the entities on the map change position and shape, others appear, and others disappear, as in HGIS de las Indias.[13] The transition between the images can be gradual (fading, venetian blinds, etc.) in order to simulate the swiftness of evolution, depending on the kind of phenomena depicted. Interestingly, the solution used in the Firenze in Guerra's Collection project inside Historypin for the seventieth anniversary of the liberation of Florence, saw photos crowdsourced that were added on the google map of the city and put in the exact places where they

12 "Euratlas," https://www.euratlas.com/; "Timemaps," https://www.timemaps.com/.

13 "HGIS de las Indias," https://www.hgis-indias.net/index.php/webgis.

were taken in 1944; people had the possibility to fade the old picture and replace it with the google street view of today.[14]

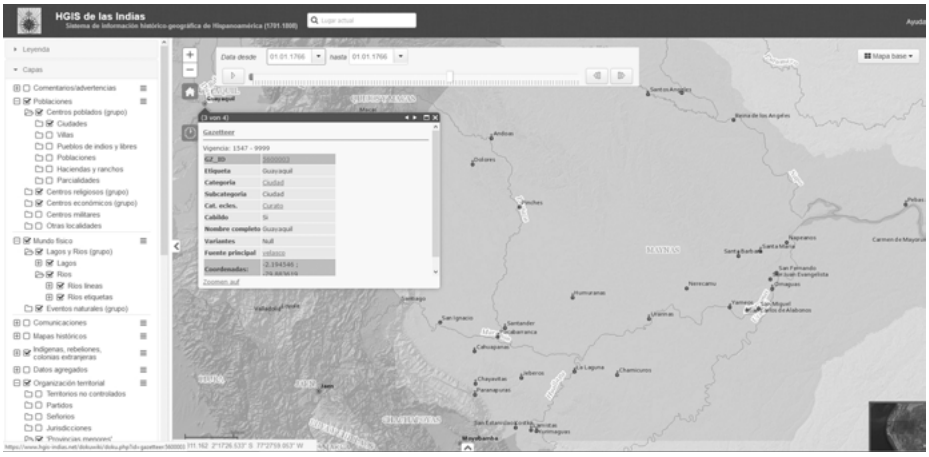

Fig. 4: "HGIS de las Indias", https://www.hgis-indias.net/index.php/webgis. Gil, T., and L. Barleta. "Digital Atlas of Portuguese America" presented at DHLU 2013, Proceedings of the Third Conference on Digital Humanities in Luxembourg with a Special Focus on Reading Historical Sources in the Digital Age, Luxembourg, December 5–6, 2013.

In another possible solution, GIS can build historical maps dynamically. Historical data are stored in a database and each entity has its geographic position, shape and attributes marked with a start time and end time concerning validity; given a certain date, the software selects and represent the entities with their characteristics at the date, so that the map you see does not exist as a real map, but is an actual map of an old stage.[15] This is a product of the highest quality and of great technical complexity, useful for showing historical changes to the public, but hardly suited to encourage their participation.

Conclusions

Setting up a DPH applications when the historical GIS component is concerned involves a great deal of work for data preparation: in the retrieval of textual historical information and historical maps, in extracting data that have to be structured and

14 https://www.historypin.org/en/firenze-in-guerra-s-collection/geo/43.771594,11.254386,5/bounds/29.917453,-0.416528,55.028419,22.9253/paging/1.

15 Gil and Barleta, "Digital Atlas of Portuguese America."

formalized and in the management of historical maps with a current and homogeneous cartographic criteria.

To set up geographical databases with historical information, we have to begin by creating a data model, where the entities are unequivocally defined and, in the geographical case, are geometrically represented by a primitive point, line or area. When the data are taken from historical maps, we face problems of geometric accuracy due to the fact that the old maps are often highly symbolic and limited by the instruments of their time. Complications also arise from the evolution of certain concepts, e.g. the very definition of an entity's edge, and because the same entity could be labelled differently in different epochs (e.g. a city, could have been previously a hospital and even before that a military camp). This uncertainty clashes with the rigidity typical of the data model supported by a GIS. Such issues imply, for the authors of a historical GIS, a great clarity of method and an equally clear transparency of choices in publishing the result of their work. If we move from a scientific publication to the management of a GIS in a DPH project, such attention and accuracy must be even more accentuated. The historical GIS is, without any doubt, a powerful means of communication of historical phenomena for the public and also of collecting georeferenceable historical source through crowdsourcing activities. But the objective difficulties in understanding a data model underlying a GIS makes GIS itself a powerful filter that can, if not well managed, distance the public from understanding the complexity of the phenomena themselves. From this point of view the role of the Digital Public Historian is essential: not only will he/she have to be able to construct a GIS with a methodologically correct data model, but he/she will have to find the right ways of communicating it in order to make the GIS an effective tool of understanding and sharing the past.

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